STUDIES ON CHARACTERIZATION AND VALUE ADDITION OF *MORINGA* SEED OIL AND DEFATTED FLOUR IN DIFFERENT BAKERY PRODUCTS

by

Miss. Musale Shubhada Vijaykumar
(Reg. No. 2017/48)

A Thesis submitted to the
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI – 413 722, DIST. AHMEDNAGAR
MAHARASHTRA, INDIA

in partial fulfillment of the requirements for the degree

of

DOCTOR OF PHILOSOPHY

in

FOOD TECHNOLOGY

DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY

POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH
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in

FOOD TECHNOLOGY

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2021

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This is to certify that the thesis entitled, "**STUDIES ON CHARACTERIZATION AND VALUE ADDITION OF *MORINGA* SEED OIL AND DEFATTED FLOUR IN DIFFERENT BAKERY PRODUCTS"** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri Dist. Ahmednagar (M.S.) in partial fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY** in **FOOD TECHNOLOGY,** embodies the results of a piece of bonafide research work carried out by **Miss. MUSALE SHUBHADA VIJAYKUMAR,** under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged.

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LIST OFABBREVIATION

Abbreviations		Description
A.A.C.C.	:	American Association of Cereal Chemist
A.O.A.C.	:	Association of official Analytical Chemist
BD	:	Bulk Density
BU	:	Brabender Unit
Cal	:	Calorie
CD	:	Critical Difference
CF	:	Commercially Fat
cfu/g	:	Colony forming unit per gram
CPMSO	:	Cold Press Moringa Seed Oil
^{0}C	:	Degree Celsius
DBMS	:	Debittered *Moringa* seed
DDT	:	Dough Development Time
DFF	:	Defatted Flaxseed Flour
DMSF	:	Defatted *Moringa* Seed Flour
DPMF	:	Deoiled Peanut Meal Flour
DPPH	:	1-diphenyl-2-picryl-hydrazil
DRF	:	Defatted Rapeseed Flour
DSF	:	Defatted Soy Flour
DSSF	:	Defatted Sunflower Seed Flour
EFLM	:	Epifluorescence Light Microscopy
et al.	:	and others
etc.	:	Etcetera
EVO	:	Extra Virgin Oil
FFF	:	Full Fat Flour
FCRD	:	Factorial Completely Randomized Design
Fig.	:	Figure
FU	:	Farinograph Unit
g	:	Gram
GC	:	Gas Chromatography
GCMS	:	Gas Chromatography Mass Spectroscopy
GTR	:	Gas Transmission Rate
HEMSO	:	Hexane pressed Moringa Seed Oil
LDPE	:	Low Density Poly Ethylene
i.e.	:	That is

J	:	Joule
kg	:	Kilogram
kg/h	:	Kilogram per hour
kg/m^3	:	Kilogram per cubic meter
LDPE	:	Low Density Poly Ethylene
Ltd.	:	Limited
Mg	:	Milligram
MIT	:	Mixing Tolerance Index
Mm	:	Millimeter (s)
MOCP	:	*Moringa Oleifera* Cationic Proteins
MPKV	:	Mahatma Phule Krishi Vidyapeeth
MSO	:	*Moringa* Seed Oil
MUFA	:	Monounsaturated Fatty Acids
N	:	Normality, Newton
OFB	:	Oryzanol Fortified Biscuits
OSP	:	Olive Stone Powder
PGI	:	Post Graduate Institute
PDA	:	Potato Dextrose Agar
ppm	:	parts per million
PSC	:	Plain Shortened Cake
PUFA	:	Poly Unsaturated Fatty Acids
RBO	:	Rice Bran Oil
RMO	:	Raw *Moringa Oleifera*
RPC	:	Rapeseed Pressed Cake
RWF	:	Refined Wheat Flour
S.E.	:	Standard error
SMP	:	Skim Milk Powder
TEAA	:	Total Essential Amino Acids
TMSP	:	Treated *Moringa* Seed Powder
TPA	:	Texture Profile Analysis
TPC	:	Total Plate Count
TSF	:	Tomato Seed Flour
VCO	:	Virgin Coconut Oil
viz.	:	Namely
w/w	:	Weight by weight basis
WGO	:	Wheat Germ Oil
WPC	:	Whey Protein Concentrate
WVTR	:	Water Vapour Transmission Rate

ABSTRACT

STUDIES ON CHARACTERIZATION AND VALUE ADDITION OF *MORINGA* SEED OIL AND DEFATTED FLOUR IN DIFFERENT BAKERY PRODUCTS

by

Miss. Musale Shubhada Vijaykumar

A candidate for the degree
of
DOCTOR OF PHILOSOPHY
in
FOOD TECHNOLOGY
2021

Research Guide	**:**	**Dr. U.D. Chavan**
Department	**:**	**Food Science and Technology**

The present research work on "Studies on characterization and value addition of *Moringa* seed oil and defatted flour in different bakery products" was undertaken to investigate the possibility of utilization of this highly nutrient dense *Moringa* seed in bakery products. The defatted *Moringa* seed flour and oil was extracted from seed and characterized. The defatted seed flour as a rich source of protein, crude fiber, minerals and its oil as rich source of oleic acid was utilized in bakery products such as biscuits and cupcake. The products were prepared by using two different varieties of wheat *Trimbak* (NIAW 301) and *Phule Samadhan* (NIAW 1994). The prepared products were analysed for nutritional composition and their shelf life.

The chemical composition of raw *Moringa* seed flour and defatted *Moringa* seed flour had the moisture content 4.80 and 5.10 per cent, respectively. Raw *Moringa* seed flour recorded carbohydrate 21.41 per cent, protein 28.62 per cent, fat 34.36 per cent, crude fiber 6.75 per cent and ash 4.06 per cent. The defatted *Moringa* seed flour recorded carbohydrates 29.18 per cent, protein 45.08 per cent, fat 2.02 per cent, crude fiber 10.02 per cent and ash 8.42 per cent. The mineral content such as calcium, phosphorus, iron and zinc of *Moringa* seed flour were 358.75, 602.08, 8.75 and 5.31 mg/100g respectively whereas in defatted *Moringa* seed flour these were 416.39, 270.31, 17.5 and 8.24 mg/100 g, respectively.

The physical properties of *Moringa* seed oil has colour values such as L* value (44.535), a* value (0.633) and b* value (32.642). The oil has 44.838 (mPa.s) viscosity at 25^{0}C. Specific gravity of oil was 0.908 g/ml. Chemical properties of oil showed saponification value (180.13), iodine value (68.20), acid value (4.64), ester value (175.49) and peroxide value (1.61). The fatty acid profile analysis of *Moringa* seed oil showed the presence of major fatty acids such as oleic acid (75.15 %), linoleic acid (0.498%), linolenic acid (0.112 %), palmitic acid (5.79 %), arachidic acid (3.33 %), behenic acid (5.32 %), methyl cis,11-eicosenaoate (1.949 %), cis-13,16- docosadienoic acid (0.868 %) and myristic acid (0.114 %). The overview of fatty acid composition of *Moringa* seed oil showed 16.89 per cent of total saturated fatty acid and 83.11 per cent of total unsaturated fatty acids. The unsaturated fatty acids had 78.197 per cent monounsaturated fatty acids and 4.913 per cent polyunsaturated fatty acids. The ratio of total saturated fatty acids to total unsaturated fatty acids was 0.2032 per cent.

Rheological study of defatted *Moringa* seed flour incorporated dough showed that can be replaced up to 10 per cent to get acceptable bakery products. The biscuits and cupcake incorporated with *Moringa* seed oil 40% and 100% respectively and defatted *Moringa* seed flour 10% and 5% respectively were found nutritionally superior than the control samples with special reference to protein, crude fiber, minerals and oleic acid content. Storage study of biscuits showed that the biscuits incorporated with *Moringa* seed oil and defatted *Moringa* seed flour can be stored up to three months in laminated pouch with minimum losses in sensory, nutritional and textural characteristics. Storage study of cupcake showed that the cupcake incorporated with *Moringa* seed oil and defatted *Moringa* seed flour can be stored up to 6 days in laminated pouch with minimum losses in sensory, nutritional and textural characteristics.

The total cost of production for 1 kg of control (whole wheat flour) biscuit was Rs. 137.01 and production cost of *Moringa* seed oil biscuit (T_2) was Rs. 184.05 and production cost of defatted *Moringa* seed flour biscuit (T_2) was Rs. 192.61. The total cost of production for 1 kg of control (whole wheat flour) cupcake was Rs.146.14 and production cost of *Moringa* seed oil cupcake (T_5) was Rs. 269.04 and production cost of defatted *Moringa* seed flour cupcake (T_1) was Rs. 171.01. Whereas the cost of one cupcake of control (whole wheat flour) was Rs. 2.35 and cost of one cupcake of *Moringa* seed oil cupcake was Rs. 4.56 and cost of one cupcake of defatted *Moringa* seed flour cupcake was Rs. 2.55. Biscuits and cupcake prepared from *Trimbak* (NIAW-301) and *Samadhan* (NIAW-1994) had very good organoleptic score and both were suitable for biscuits and cupcake making.

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1. INTRODUCTION

Nutrition does begin with food, but it's quite food. It's not only the food but is the process that happens from the time, food is digested and its nutrients are absorbed and at last distributed to the all parts of the body where they are utilized for various metabolic activities (Martin *et al.,* 2001). Nutrients and other components in food are required for maintenance, growth, reproduction, good health and to prevent disease of an organism. Food also contains various phytochemicals including tannins, phenolic acids, anthocyanins, phytosterols antioxidant, glycosides are recommended as treatments for cancer or chronic conditions like high cholesterol, atherosclerosis and diabetes. There are number of plant sources which are nutrient dense and have potential to act as functional food ingredient. Beside their good nutritional quality and health promoting activities these are remained as neglected or underutilized crops, some of them are chia seed, flax seed, cress seed and *Moringa oleifera* seed.

Moringa oleifera belonging to the family *Moringaceae*, native of sub-Himalayan region of northwest India and now grown worldwide within the tropics and sub-tropics. Its fast growing, drought resistant, perennial tree and its cultivation is spread over in arid, semiarid and warm areas, with temperatures varying between 25 and 35^{0}C, having the ability to tolerate upto 48°C and in weak frost conditions in subtropical areas (HRDA, 2002). *Moringa oleifera* is the fast growing, soft wood, aesthetically pleasing tree. The tree can be established in slightly alkaline soils up to pH 9 additionally acidic soils as low as pH 4.5 (Shindano and Chitundu, 2008). There are 14 known species of *Moringa oleifera* from tropical and subtropical climates that vary in size from tiny herbs to massive trees. It is exploited both in irrigated and in dry conditions. The tree is quite slender, with drooping branches and tree ranges in height from 5-12 m.

Moringa oleifera a small native tree of the sub-Himalayan regions which is now indigenous to several regions in Africa, Arabia, South East Asia, the Pacific and Caribbean Islands and South America for various culinary and medicinal uses. Seeds, leaves, pods and roots of *Moringa oleifera* are of economic importance; however the crop is principally cultivated for seeds. Hence, countries like Ethiopia, the Philippines, Sudan, tropical Asia, East, West and South Africa, the Caribbean, geographic region, the Pacific Islands and Florida are the big producers of *Moringa oleifera* across the globe. In some regions *Moringa oleifera* is known as drumstick or horse radish tree. *Moringa oleifera* is additionally called as 'Shevga' in Marathi, 'Saguna' in Hindi, 'Shobhanjana' in Sanskrit, 'Murungai' in Tamil, 'Munaga' in Telegu, 'Sainjna' in Punjabi languages and it's a very important medicinal crop in India (Jed, 2005). *Moringa* may be a style of local medicinal Indian herb which is familiar within the tropical and subtropical countries. *Moringa oleifera* is employed a crucial food commodity which has enormous attention because the 'natural nutrition of the tropics' (Anwar and Bhanger, 2003). It is well known to the traditional world, but currently, its been rediscovered as a multiple use of tree with an amazing kind of potential benefits (Chen *et al.,* 2011). In India Andhra Pradesh leads in area and production followed by Karnataka, Tamil Nadu and Maharashtra.

In developing countries, *Moringa* has potential to enhance nutrition, boost food security, foster rural development, and support sustainable land care. It is used as fodder for livestock, a micronutrient liquid, a natural anthelmintic. Plant parts including leaves, stem, roots, seeds and flowers are reported as source of various biochemical compounds with anti-carcinogenic, anti-inflammatory, anti-diabetic, antioxidant, and antimicrobial effects (Anwar and Bhanger, 2003). In addition, due to its high nutritional value and several medicinal properties, this tree act as a nutritional and medical alternative for socially neglected populations. *Moringa* seeds are rich in proteins and oil, and are traditionally used for beauty care. Seeds are used for water purification. Medicinal qualities offer to treat diabetes, to staunch an skin infection, to be an antibiotic, to compliment anemic blood, to worry eyes and to heal gastric ulcers. Thus, this tree offers very interesting opportunities as food supplement, nutrition, vegetable, oil, water treatment, manure, natural fertilizer, livestock feed, foliar spray, fodder, medicine, cosmetic and care products.

India is the prime producer of *Moringa* (Drumstick) with an annual production of 2.2 million tonnes of tender fruits from a section of 43,600 ha resulting to the productivity of around 51 tonnes per ha. Among the various states, Andhra Pradesh leads both in area and production (15,665 ha) followed by Tamil Nadu (13042 ha) and Karnataka (10,280 ha). In other states, it occupies a vicinity of 4,613 ha. Tamil Nadu is the pioneering state because it has varied genotypes from diversified geographical areas, moreover as introductions from land. Tamil Nadu is one of the most important producers of *Moringa* with an annual production of 6.71 lakh tonnes of tender fruits from a section of 13042 ha. Among the districts, Theni leads in both area and production (3424 ha) followed by Dindigul (2645 ha), Karur (2070 ha), Thoothukkudi (1465 ha), Tiruppur (1191 ha), Ariyalur (813 ha) and Madurai (536 ha) (Shekhar *et al.,* 2018).

Moringa tree is additionally referred to as 'the tree of life' because all parts – leaves, flowers, immature pods, seeds and roots are edible, and additionally have a high nutritional value (Freiberger *et al.,* 1998). Parts of the tree for the employment for medicinal and therapeutic purposes. The roasted seeds are utilized in snacks, like peanuts (Sidhuraj and Becker, 2003). *Moringa oleifera* has several traditional uses, the majority parts of this tree (root, bark, leaves, fruits, flowers, seeds) and seed oil are utilized for several ailments within the indigenous medicine in South Asia (Anwar and Rashid, 2007). Additionally, for human consumption, the young fresh pods, kernels and roots as pickles, sauces, juices and vegetables are used for traditional medicine purpose (Anwar *et al.,* 2005).

Associated with high nutritional value of its edible portions pave some way in making this plant is more popular as a very important food source to combat protein energy malnutrition problem prevailed in most of the under developed and developing countries of the world. Presence of antioxidant compounds make this plant leaves a valuable source of natural antioxidants (Anwar *et al.,* 2007) and a decent source of nutraceuticals and functional components as well (Makkar and Becker, 1996).

The *Moringa* plant has been consumed by humans throughout the century in diverse culinary ways (Iqbal and Bhanger, 2006). The majority parts of the plant are used culturally for its nutritional value, purported medicinal properties and for taste and flavour as a vegetable and seed. The leaves of *M. oleifera* are often eaten fresh, cooked, or stored as a dried powder for several months without major loss of its nutritional value (Arabshahi-D *et al.*, 2007; Fahey, 2005).

The leaves, seeds, flowers, pods (fruit), bark and roots are all seen as a vegetable and every part is uniquely harvested and utilized. As an example, fresh leaves are picked, shade dried, ground to a powder, and stored for later use as a food flavouring or additive. Dried or fresh leaves are also incorporated in foods such as soups and porridges (Lockett *et al.,* 2000), curry gravy and in noodles, rice or wheat (Abilgos and Barba,1999). The leaves being rich in nutrients, pregnant women and lactating mothers use the powdered leaves to boost their child's or children's nourishment, especially in under developed countries for overcoming by malnutrition (Lockett *et al.,* 2000; McBurney *et al.,* 2004).

The seeds of *Moringa* contain 38-42 per cent oil, which is edible vegetable oil. This oil possesses physico-chemical properties similar to those of other vegetable oil and contains high level of tocopherols like olive oil (Tsaknis *et al.,* 1999). The oil extracted from *Moringa* is also called as Ben oil or Behen oil and reportedly contains 70% monounsaturated fatty acid as oleic acid, an 18-Carbon long monounsaturated fatty acid (MUFA) which makes it suitable for edible purpose because of clear, odorless and good oxidative stability because it allows for extended storage and maximum frying temperature processing (Jessica *et al.*, 2012). The seed oil may be used as a natural source of behenic acid, which has been used as an oil structuring and solidifying agent in margarine, shortening, and foods containing semisolid and solid fats, eliminating the necessity to hydrogenate the oil (Foidl *et al.,* 2001). Ben oil is used for household cooking, because its colourless, odourless and resist once to rancidity which enhances the development and retention of taste and natural flavour. This oil also contains fatty acids, vitamin A and C, which is required for human nutrition (Fuglie, 1999).

Increased interest in high oleic oil has been spurred by dietary recommendation favouring high monounsaturated oil. Monounsaturated oils have a cardiovascular benefit which lower plasma total cholesterol level to further lowering the chance of heart disease. With a high amount of monounsaturated (oleic acid) and low polyunsaturated (linoleic acid) carboxylic acid, *Moringa oleifera* seed oil represent an another source of superior oil with high stability and good characteristics towards prevention of cholesterol and cardiopathy. *Moringa* seed oil is taken into account akin to olive oil (vegetable oil), and is used for human consumption. The oil from *Moringa* seeds has also shown the strongest anti-fungal activity against a zoophilic dermatophyte causing marked inflammatory reactions in humans (Mani *et al.,* 2007).

The seeds contain much of the plant's edible oil which is employed as a vegetable oil for frying and as a salad oil for dressing. Other prominent fatty acids in *Moringa* seed oil include palmitic (7.8 and 6.8 %), stearic (7.6 and 6.5 %) and behenic (6.2 and 5.8 %) acids for the solvent and enzyme-extracted oils, respectively (Abdulkarim *et al.*, 2005). Because of the high monounsaturated to saturated fatty acid ratio, *Moringa* seed oil will considered a suitable substitute for highly monounsaturated oils such as vegetable oil like olive oil (Lalas, and Tsaknis, 2002). *Moringa* is rich in Omega 3, Omega 6, and Omega 9 oils. *Moringa* seed oil utilized as a frying oil will be a healthy alternative to other commonly used oils like as palm, canola and soybean oil when comparing carboxylic acid composition. Oils with high amounts of monounsaturated (oleic type) fatty acids are desirable because of an association with decreased risk of coronary heart disease (Mensink and Katan, 1990; Aldulkarim *et al.,* 2007).

The composition of the sterols of *Moringa* seed oil mainly consists of campesterol, stigmasterol, β-sitosterol, Δ5-avenasterol and clerosterol accompanied by minute amounts of 24-methyl enecholesterol, Δ7-campestanol, stigmastanol and 28-isoavenasterol (Tsaknis *et al.*, 1999; Anwar and Bhanger, 2003; Anwar *et al.*, 2005). The sterol composition of the foremost fractions of *Moringa* seed oil differs greatly from those of most of the standard edible oils (Rossell, 1991).

The plant seeds contain hypotensive activity, strong antioxidant activity and chelating property against arsenic toxicity (Arabshahi *et al.,* 2007; Ghasi *et al.,* 2000; Mehta *et al.,* 2003; Santos *et al.,* 2009). In India, seed oil is applied externally to alleviate pain and swelling just in case of gout or rheumatism, and to treat skin diseases. Oil is employed to treat hysteria and scurvy. Oil is applied to treat prostrate and bladder troubles.

Moringa oleifera oil an oil with peanut flavor and a fatty acid composition resembling vegetable oil such as olive oil, has been used extensively as a general culinary, a superb vegetable salad oil and for cooking purposes. However, because its high iodine value and low melting point, *Moringa oleifera* oil encountered limiting application in food products like margarine and shortenings (Dollah *et al.,* 2014).

Moringa seed oil is taken into account such vegetable oil in terms of its chemical properties and contains lots of abundance of tocopherol. Because of high content of tocopherol it is used for rheumatism and gout, purification of blood and enhancing cardiac function as medicine and also for edible purpose (Lalas and Tsaknis, 2002). *Moringa oleifera* seeds oil appear to be an acceptable good source for oil rich in oleic acid which is equal to olive oil quality, that can be consumed in Malaysia where the olive oil is imported with high prices. At the same time cultivation of *Moringa oleifera* tree is considered to be a new source of income for the country and give more rural employment opportunities (Eman and Muhamad, 2016).

The whole seeds also can be eaten green, roasted or powdered, and steamed in tea and curries (Fahey, 2005). The pods and seeds, often cited as *Moringa* kernels, have a taste that ranges from sweet to bitter and are most popularly consumed after frying to pick up a peanut-like taste (Makkar and Becker, 1997). *Moringa* seed has high nutritional value as reflected within appreciable amount of nutrients thus it may be included in diets to supplement human's daily nutritional needs of foods lacking protein, carbohydrate and lipid. The seed cake remaining after oil extraction is also used as a fertilizer (Rashid *et al.,* 2008). *Moringa* seed has been known to combat malnutrition in infant and nursing mothers.

Seed flour from *Moringa oleifera* is widely used as a natural coagulant for water treatment in developing countries (Santos *et al.,* 2005). It has a powerful range of medicinal uses with high nutritional value. *Moringa* seed content crude protein, crude fat, ash, crude fiber and carbohydrate were 28.04, 45.84, 4.10, 7.73 and 10.59 per cent respectively. Mineral content calcium, iron and zinc were 203.85, 31.03 and 8.08 respectively (Abiodun *et al*., 2012) where as defatted cake contain crude protein, crude fat, ash, crude fiber and carbohydrate were 50.80, 3.06, 10.00, 12.96 and 18.15 respectively. Mineral content of defatted cake calcium, iron and zinc were 249.85, 37.32 and 12.09 respectively.

Periyakulam 1 (PKM 1) is new early variety released from the Horticultural Research Station of the Tamil Nadu Agricultural University (TNAU) in India. It's a variety of local types and is propagated only by seed. Seedling were observed to grow to 4m tall within 12 months of field planting and to own flowered and fruited after 6 months from sowing and would yield for 3-4 years. After two years the trees matured to 6m tall productive specimens. The seed pods are left to mature and dry naturally on the tree before harvesting. The seeds are easily shelled, crushed and sieved using traditional methods.

Wheat (*Triticum* spp.) is that the second most important winter cereal in India after rice. Bread wheat contributes approximately 95% to total production while another 4 per cent comes from hard wheat and dicoccum share in wheat production remains only 1 per cent. Wheat crop contributes substantially to the national food security by providing 50 per cent of the calories to the people that mainly rely on it. India has witnessed a big increase in total food grain production to the tune of 291.95 million tonnes with a significant contribution of wheat with 106.21 million tonnes (45.11 %) during 2019-20. Wheat is consumed in various forms by quite 1000 million human beings. Its used for various food purposes after grinding wheat kernel into flour. The flour is major ingredient in chapatti, bread and bakery products like cakes, cookies, crackers, doughnuts, sweet rolls, biscuits etc. Flour from wheat is basic ingredient in bakery products because of their inherited property to make dough and retain gases. Wheat (*Triticum aestivum*) is staple food crop which occupies important place next to rice in India (Singh, 2010).

Usually the full grain is milled to get the endosperm for white flour, while the by-products of bran and germ are discarded. It’s been shown that the whole grain should be concentrated source of essential nutritional components like vitamins, minerals, protein, fat and fibre while the refined grain is usually starch (Potter and Hotchkiss, 2006; Bakke and Vickers, 2007).

Today consumers demand are convenience, quality and innovative food products. Consumers expect the food producers to deliver prime quality products for an affordable price. Additionally, consumer's tastes and preferences are changing. Health is taken in to account important, but not at the expense of flavor. Consumers want variety, information and new eating experiences. Consumers want to experience novel and interesting foods, which are fresh and convenient. Increased attention to health together with the unavailability of unique foods plus a powerful consumer demands for convenience creates the requirement for convenience foods. Consumers demand for information about preparation, serving, and nutrition. Technology is additionally a challenge to the food industry. The advances in technology helps to develop a brand new food product within the market (Fuller, 2011).

Baked products have popularities within the populace thanks to their availability, eating convenience and having good time period. Due to their low moisture content this ensures less chance of microbial spoilage, therefore large scale production and distribution is possible. Common bakery products include biscuits, cookies, pastries, muffins, cake, bread etc. Among all the bakery products biscuits are more popular since they are vastly used as snacks by children and adult. Attempts are being made in recent days to enhance nutritional qualities and functionalities of biscuits, due to competition within the market place for healthier, natural functional products, in cost effective manner. It is produced by mixing various ingredients like flour, fat, sweeteners and water to make dough. Cakes are the foremost consumed bakery product owing to unique products and are always utilized in festivals in addition as in joyous celebrations. It is increasing worldwide by about 1.5 per cent each year (Khalifa *et al.,* 2015). Cakes are flour confections that are mostly prepared from flour and other essential ingredients.

Cookies belong to the group of food products that are very popular in daily diet of just about all profiles of consumers, having not only the nutritive purpose but influencing also on emotional status of consumers with the results even on the positive mood enhancement. Cookies are characterized with quite long period of time, which ends up in their availability almost everywhere at any time. Therefore, the alteration of composition of cookies directed to enhancement their nutritive and functional properties or to enabling of their consumption to the groups of consumers with special needs and demands has been the topic of interest of the many researchers. The essential composition of cookies enables a range of various possibilities for achievement of dietary properties of the products with regard to type, share and performance of three main components for cookie dough production: flour, fat and sugar. There are different possibilities for development and production of dietary cookies, from sugar replacement or reduction, over alteration of fat shares, composition and properties to enrichment of cookies with different functional components (Popov-Raljic *et al.,* 2013).

The consumption of cakes prepared from wheat flour has become very famous in most developing countries of the tropics especially among children and adolescent. Formulation and development of nutritious cakes from local and readily available stuff have received a lot of attention in many developing countries because of malnutrition which has been called a serious problem especially to infants as a result of lack of several essential nutrients within the food product (Offia *et al.,* 2014).

The value addition by utilization of iron, protein and energy rich foods within the diet is most dependable strategy to beat the nutritional gap and to assist person to stop from ravages of nutrient deficiencies. To fulfil this purpose exploitation of accessible foods with high density of nutrient is required. There are the food stuffs which are good source of protein, fat and also in addition as iron.

Studies have shown that there is a high correlation between the surplus of fat in diets and therefore the risk of cardiovascular diseases. Saturated fat is the main alimentary explanation for plasmatic cholesterol levels increase (Lourencetti *et al.,* 2013).

It is well recognized that a diet high in fat ends up in health problems such as obesity, high blood pressure, and heart diseases. Recently, consumers have shown a priority for the amount of fat in foods and an interest in lower fat, heart-healthy products. With these trends as a actuation, food scientists have a market-driven impetus to develop low-fat or fat-free foods with acceptable taste and texture (Lee *et al.,* 2005).

One reason to switch to oil is that there is an excessive amount of consumption of fat specifically saturated fat, which isn't good for health. Therefore, current public concern for the fat present in foods has contributed to the introduction of desirable fat or oil sources (Lee *et al.,* 2004). To fulfil the consumer demand for low-fat or fat-free food products, various sources are being developed and used as a fat substitute in foods (Lee *et al.,* 2005).

Keeping in view all the above facts the present research was designed to cut down the amount of fat in bakery products by reducing saturated fats with the *Moringa* seed oil and enrich in protein content by using defatted *Moringa* seed flour with following objectives.

1. To study physico-chemical properties of *Moringa oleifera* seed oil.
2. To study MUFA and fatty acid profile of oil.
3. To study effect of addition of defatted *Moringa* seed flour on rheological properties of dough.
4. To assess the physico-chemical and organoleptic quality of bakery products using *Moringa* seed oil and defatted seed flour.
5. To study the shelf life of bakery products.

2. REVIEW OF LITERATURE

A number of reviews have appeared in recent years covering various aspects of exploration, characterization, value addition and quality evaluation of different parts of (seed, oil, defatted seed flour) *Moringa oleifera* seed in health food. The research conducted in past and aspect relevant to present investigation are referred and reviewed under suitable headings in this chapter.

2.1 *Moringa Oleifera* Seeds

2.1.1 Physical Properties of *Moringa* Seeds

Adesina *et al.* (2013) investigated some physical properties of *Moringa oleifera* seeds at moisture content of 8.33 per cent dry wet basis. The average length, width, thickness, mass, geometric and arithmetic mean diameters were: 9.223 mm, 8.423 mm, 7.424 mm, 0.258 g 9.144 mm and 8.320 mm respectively. The surface area, volume, sphericity and aspect ratio are 0.297 mm^2, 1.39 cm^3, 90.37 per cent and 0.914 per cent, respectively. The solid density, bulk density, porosity and specific gravity were: 4.77 g/cm^3, 8.42 g/cm^3, 7.420 per cent and 0.28, respectively. These properties are necessary for the design of equipment for harvesting, processing, transporting, separating, packaging and storage processes.

Ajav and Fakayode (2013) reported the physical properties are very important in the design and manufacturing of processing machines. The average moisture content was found to be 7.31 per cent wet basis. The average seed length, width, thickness, arithmetic and geometric mean diameters were found to be 8.45, 7.82, 6.41, 7.560 and 7.490 mm respectively. The average surface area was 177.19 mm^2; while the mean sphericity and aspect ratio were 0.889 and 0.9257 respectively. The average true and bulk densities were 971 and 662 kg m^{-3} respectively and the porosity was 68.18 per cent. The mean angle of repose was 21.44. The average static coefficient of friction on six different surfaces viz glass, stainless steel, mild steel, galvanized steel, rubber and plywood was found to be 1.027, 1.111, 1.376, 1.234, 2.199 and 1.607, respectively.

Ajav and Fakayode (2013) studied the mechanical properties of *Moringa* were as design parameters for the development of an oil expeller for the crop. The average force at peak, deformation at peak, stress at peak and energy to peak were found to be 58.535 N, 5.0990 mm, 49.26 $N/mm^2$and 0.1344 m respectively. The average force at break, deformation at break, stress at break and energy to break were found to be 58.420 N, 5.1241 mm, 49.12 N/mm^2 and 0.1357 Nm respectively. The force at yield, stress at yield and energy to yield were found to be 39.000 N, 33.66 N/mm^2 and 0.0224 Nm respectively. The Young's modulus was found to be 195.32 N/mm^2.

Abubakar and Benjamin (2019) studied the engineering properties of agricultural products as the dimensional, gravimetric and frictional properties of *Moringa oleifera* seeds. The moisture content of seeds was 7.82 per cent dry basis. The mean seed length of 9.217 mm, width of 8.012 mm and thickness of 5.443 mm, respectively. The mean arithmetic diameter, geometric mean diameter, sphericity and surface area were 7.557 mm, 7.366 mm, 0.7964 mm, 176.185 mm^2 respectively. The mean true density, bulk density, average porosity, unit mass and thousand seed mass were found to be 0.5100 g cm^{-3}, 0.247 g cm^3; 58.86 per cent, 0.339 g and 272.051 g, respectively. The mean angle of repose, average static coefficient of friction on three different surfaces that include: glass, galvanized steel, and plywood were found to be 17.834, 0.437, 0.481, and 0.569, respectively.

Abubakar and Benjamin (2019) studied that moisture content of moringa seeds were 15.82 per cent dry basis (db). The mean seed length of 11.460 mm, width of 10.079 mm and thickness of 7.377 mm respectively. The mean arithmetic diameter, geometric mean diameter, sphericity and surface area were 9.639 mm, 9.475 mm, 0.826 mm, 285.476 mm^2 respectively. Also, the average true density, bulk density, average porosity, unit mass and thousand seed mass were 0.610 gcm^{-3}, 0.253 gcm^{-3}, 58.52 per cent, 0.350 g and 273.396 g, respectively. Also, the mean angle of repose, average static coefficient of friction on three different surfaces that include: glass, galvanized steel, and plywood were found to be 19.345, 0.471, 0.570, and 0.612 respectively.

2.1.2 Chemical Properties of *Moringa* Seeds

Anwar and Rashid (2007) investigate the physico-chemical characteristics of *Moringa oleifera* seeds exhibited an oil yield of 34.80 per cent. Protein, fiber, moisture and ash contents were 31.65, 7.54, 8.90 and 6.53 per cent, respectively.

Abiodun *et al.* (2012) investigated the chemical and physico-chemical properties of *Moringa oleifera* seed. The *Moringa* seed were divided into two portions, first portion was milled into flour and second portion was defatted using soxhlet extraction method. The moisture content of the *Moringa oleifera* seed cake was slightly lower than that of raw *Moringa* flour that is ranged from 4.70-5.03 per cent. The *Moringa oleifera* seed cake also had higher values in the ash, crude fibre, protein, carbohydrate, all the mineral contents. The undefatted *Moringa oleifera* seed flour had higher fat content of 45.84 per cent. The phytate, oxalate and tannin contents of the defatted *Moringa oleifera* seed flour were higher than the undefatted flour. The defatted cake could be used in fortification of other food materials.

Oluwole *et al.* (2013) reported that the proximate, minerals, amino acids, fatty acids, phytochemicals/antinutrients, and functional properties of raw *Moringa oleifera* (RMO). Protein content 18.86 g/100 g, energy value of RMO (409.04 kcal) respectively. Total essential amino acids (TEAAs) in RMO (23.56 mg/g crude protein).

Campas *et al.* (2014) studied that the chemical composition of the seed. Moisture, ash, protein and lipid contents in the seed were found to be 4.7, 5.8, 26 and 39%, respectively.

Peter and Philip (2014) studied that the proximate, mineral analyses and anti-nutrient compositions of *Moringa oleifera* which are commonly used as nutritional and medicinal plant on both raw and defatted seeds. The result showed that defatting *Moringa oleifera* seeds increased the fibre, carbohydrate, vitamins B and C, iron and zinc content and significantly reduced the calcium, potassium and phosphate contents. The result also showed that defatting *Moringa oleifera* significantly decreased the tannin, alkaloids, saponin, phytate, oxalate levels but increased the cyanogenic glycosides level to a level lower than what is considered toxic to human beings and livestock. Hence, the defatted cake could be used in fortification of other food materials.

Fowoyo and Oladoja (2015) reported that the seed had higher percentage of lipid (41.79 %), protein (8.31 %) and carbohydrate (39.41 %).

Hassan and Galal (2016) reported the physicochemical properties of *Moringa* seeds that the range of protein 34.51 - 36.5 per cent, lipid 28.62 - 30.06 per cent, ash 4.22 - 5.06 per cent, fiber 10.92 - 12.16 per cent and total carbohydrate 19.00 - 20.29 per cent, respectively. Consequently, caloric value was around 450.36 - 451.32 kcal 100 g^{-1} for dried *Moringa* seeds. Dried *Moringa* seeds are considered as a rich source of dietary minerals. TPCs content of *Moringa* seed were ranged from 16.9 -18.5 mg GAE g^{-1} dw. The antioxidants activity was in a range of 0.17 - 0.28 µmol TE g^{-1} dw (DPPH scavenging activity) and was in a range of 4.19 - 6.29 µmol TE g^{-1} dw (DPPH scavenging activity). The chlorophyll a, chlorophyll b, carotenoids, flavonoids and flavonols contents were ranged from 0.93 to 1.78, 4.89 to 8.41, 13.53 to 19.56 mg g^{-1} dw, 3.30 to 5.40 and 2.30 to 4.10 mg QE g^{-1} dw, respectively.

Munirat *et al.* (2016) studied that the use of *Moringa oleifera* seeds extract and its application in the environment. It is a source of protein, calcium, iron, carotenoids and phytochemicals utilized for several usages in developing countries. The plant parts have been used in various applications such as medicine, cosmetics, food supplements and water purification. The various application of *Moringa oleifera* seed extract as an adsorbent, coagulant, dewatering agent and as a disinfectant also highlight the various methods used in processing the seed extracts.

Adegbe *et al.* (2016) the result showed that the proximate composition of the seed contains 10.50 per cent moisture, 39.57 per cent crude protein, 5.00 per cent ash, 5.00 per cent crude fiber, 32.50 per cent fat and 7.44 per cent carbohydrate.

Alessandro *et al.* (2016) studied that *Moringa oleifera* seeds are a promising resource for food and non-food applications, due to their content of monounsaturated fatty acids with a high monounsaturated/saturated fatty acid (MUFA/SFA) ratio, sterols and tocopherols, as well as proteins rich in sulfated amino acids. Despite the relatively diffuse use of *Moringa* seeds and their oil in traditional medicine.

Manju *et al.* (2018) evaluated the chemical composition of *Moringa* seed meal the full fat seeds contained on proximate basis, reasonable concentration of 93.57 dry matter, 6.43 per cent moisture, 95.55 per cent organic matter, 43.26 per cent crude protein, 12.08 per cent crude fibre, 21.36 per cent ether extract, 4.45 per cent ash and 12.42 per cent nitrogen free extract. Calcium and phosphorous value in *Moringa* seeds were 357.78 mg/100 g and 127.6 0 mg/100 g, respectively. The Ca/P ratio was high in *Moringa* seed meal. The ME value of seed meal was 3859.92 kcal/kg. The obtained data of proximate analysis of *Moringa* seed meal revealed that the seeds are good sources for protein, fat, ash and also crude fiber.

Lesten and Emmanuel (2018) reported that the nutritive composition of *Moringa* seeds. *Moringa* seeds contained 50.70 g kernels and 19.03 g hulls per 100 seeds representing 72.71 and 27.29 per cent as a fraction of the whole seed, respectively. The 100 seeds contained 28.48 and 20.71 per cent oil as a fraction of kernels and seeds, respectively. The seeds revealed 28.56 per cent crude protein, 5.37 per cent ash, 34.92 per cent crude fat, 7.90 per cent crude fiber and 23.27 per cent carbohydrates. Raw kernel recorded 37.86 ± 0.38 per cent crude protein, 4.60 ± 0.13 per cent ash, 41.18 ± 0.06 per cent crude fat, 4.80 ± 0.23 per cent crude fiber and 11.55 ± 0.37 per cent carbohydrate.

2.1.3 Nutraceuticals content of *Moringa* Seeds

Aja *et al.* (2014) reported that the *Moringa oleifera* is a medicinal plant widely used for the treatment of various infections, diseases. The chemical constituents of the methanolic extract of *Moringa oleifera* seeds were investigated using Gas chromatography-mass spectrometry. Five chemical constituents were identified in methanolic seed extract and they are oleic acid (84 %), L-(+) - ascorbic acid- 2, 6-dihexadecanoate (9.80 %), 9-octadecenoic acid (1.88 %), methyl ester-hexadecanoic acid (1.31 %) and 9- octadecenamide (0.78 %).

Fowoyo and Oladoja (2015) studied that the phytochemical content and nutritional composition of *Moringa oleifera* seed. The antagonistic activity of the aqueous and ethanol extract of the leaf and seed of *Moringa oleifera* was tested against selected gastrointestinal pathogens (*Escherichia coli, Proteus mirabilis, Staphylococcus aureus, Enterobacter aerogenes* and *Bacillus cereus*) using the agar well diffusion assay. Both aqueous and ethanol seed extract showed the presence of terpenoids, cardiac glycosides, steroids and saponin. *Moringa oleifera* may be used in treating gastrointestinal infections.

Munirat *et al.* (2016) studied that the *Moringa oleifera* seed extract is a source of carotenoids and phytochemicals.

Saini *et al.* (2016) reported that the *Moringa oleifera* as a source of phytochemicals, having potential applications in medicines, functional food preparations, water purification, and biodiesel production. As well as folk medicinal uses of *Moringa oleifera* are attributed to the presence of functional bioactive compounds, such as phenolic acids, flavonoids, alkaloids, phytosterols, natural sugars, vitamins, minerals, and organic acids. The low molecular weight of *Moringa oleifera* cationic proteins (MOCP) extracted from the seeds is very useful and is used in water purification, because of its potent antimicrobial and coagulant properties

Ogundele *et al.* (2017) studied that the phytochemical constituents of aqueous and ethanolic and seed extracts of *Moringa oleifera*. The qualitative phytochemical constituents showed the presence of tannins, flavonoid, alkaloids, saponins, steroids, terpenoids and cardiac glycoside in both aqueous and ethanolic extracts. Results showed the presence of iron, calcium, potassium and zinc and proved extensively the use of the plant in ethnomedicine and its potential for diet formulation.

Birendra *et al.* (2017) reported that the phytochemical composition, medicinal uses and pharmacological activity of *Moringa oleifera* plant is widely used as nutritional herb and contains valuable pharmacological action like anti-asthmatic, anti-diabetic, hepatoprotective, anti-inflammatory, anti- fertility, anti-cancer, antimicrobial, anti-oxidant, cardiovascular, anti-ulcer, CNS activity, anti-allergic, wound healing, analgesic, and antipyretic activity. Different types of active phytoconstituents like alkaloids, protein, quinine, saponins, flavonoids, tannin, steroids, glycosides, fixed oil and fats are present. Some other constituents are niazinin A, niazinin B and niazimicin A, niaziminin B present in the *Moringa* oil.

2.1.4 Health Promoting and Nutritional Properties of *Moringa* Seeds

Verma *et al.* (1976) reported that *M. oleifera* has a variety of potential purposes containing antioxidants like vitamin C, vitamin E, carotenes, polyphenols, and many other compounds reduce the diseases. Leaves, flowers and pods containing protein, vitamins (A, B and C), and some mineral like iron calcium and potassium.

Anhwange *et al.* (2004) amino acids are considered the building blocks of proteins, as they are important elements of a healthful diet. The different parts of *M. oleifera* are as source of essential amino acids; especially the leaves and seeds provide high amounts of amino acids.

Roloff *et al.* (2009) stated that *Moringa oleifera* seeds contain ben oil (40 %) that produced from this tree contains very nutritious and is non-drying resists rancidity, have been utilized for cooking, lubrication, perfume industry and cosmetic products *Moringa* seed oil is a high antiinflammation and antibacterial due to its high antioxidant potential.

Srikanth *et al.* (2014) reported that *Moringa* tree is considered as one of the important trees with reference to nutritional security of rural communities; therefore, *Moringa* to improve human health used and assist in combating malnutrition especially for developing countries.

Aja *et al.* (2014) reported that the *Moringa oleifera* is a medicinal plant widely used in folkloric medicine of Africa and Asia for the treatment of ailments such as ulcer, wound, inflammation, heart problem, cancer, stroke, obesity, anaemia and liver damage.

Jikasmita *et al.* (2016) studied that *Moringa* are being grown for differential purposes like supplement, medicine, plant growth enhancer, green manure, biopesticides, biomass production and domestic livestock fodder. The present review focuses on the nutritional and pharmacological potencies of *Moringa* like antidiabetic (hyperglycemic), anti-microbial, anti-fertility, anti-inflammatory, anti-cancer, anti-arthritis, hepatoprotective, etc.

Saini *et al.* (2016) reported that the *Moringa oleifera* as a vibrant and affordable source of phytochemicals, having potential applications in health benefits. The multiple biological activities including antiproliferation, hepatoprotective, anti-inflammatory, antinociceptive, antiatherosclerotic, oxidative DNA damage protective, antiperoxidative, cardioprotective.

Mahmud *et al.* (2017) reported that the presence of beta-sitosterol (β-sitosterol) one of the important and which play an important role in the metabolism within the body and is an important and active ingredient for patients with high cholesterol and triglycerides and diseases of atherosclerosis and heart disease, obesity, food Sterols.

Lalita *et al.* (2018) reported that the *Moringa oleifera* Lam., historically, is regarded as nutrient rich food supplement with immense medicinal and therapeutic values. In various medicinal applications, it works as antioxidant, anticancer, anti-inflammatory, antiulcer, antihyperglycemic, antidiabetic and antimicrobial agent.

2.2 *Moringa* Seed Oil

2.2.1 Extraction of *Moringa* Seed Oil

Tsaknis *et al.* (1999) reported oil from *Moringa oleifera* variety Mbololo seeds from Kenya was extracted using three different procedures including cold press (CP), extraction with *n*-hexane (H), and extraction with a mixture of chloroform/methanol (50:50) (CM).

Tsaknis and Lalas (2002) reported that the oil from *Moringa oleifera* seeds variety Periyakulam 1 (PKM 1) from India was extracted using three different procedures including cold press (CP), extraction with nhexane (H) and extraction with an mixture of chloroform:methanol (1:1) (CM).

Lalas and Tsaknis (2002) studied oil from the dried seeds of the *Moringa oleifera* tree (Variety of Malawi) was extracted with a mixture of chloroform/methanol (50:50).

Rahman *et al.* (2009) reported that the *Moringa oleifera* Lam. seed oil of the indigenous-cultivar of Bangladesh was extracted using n-hexane (H), light petroleum ether (b.p. 40–60C) (LPE) and chloroform/methanol (50:50, v/v) mixture (CM). The oil content ranged from 37.50 per cent (H) to 40.20 per cent (CM).

Adejumo *et al.* (2013 A) their investigation showed that effect of heat treatment on the characteristics and oil yield of *Moringa oleifera* seeds. The *Moringa oleifera* seed samples was divided into four portions A, B, C and D. Samples A, B and C were heated at 100, 130 and 150^{0}C respectively for 30 minutes, while sample D served as the control. The percentage of oil yield of 33.7, 32.2, 30.9 and 28.6 per cent for samples A, B, C and D, respectively.

Adejumo *et al.* (2013 B) studied that the effect of moisture content variation on the yield and characteristics of oil from *Moringa oleifera* seeds. The oil was extracted using the soxhlet method at 7.28, 10, 15 and 20 per cent moisture content for sample A, B, C and D, respectively. The percentage oil yield of 38.01, 38.48, 32.56 and 27.53 per cent for samples A, B, C and D, respectively.

Orhevba *et al.* (2013) studied that the seed oil was extracted using the solvent extraction method. The physicochemical properties of the oil were also determined.

Babatunde *et al.* (2014) evaluated the cold pressed and hexane extracted *Moringa* seed oils for their physico-chemical and stability characteristics.

Bale *et al.* (2015) reported that the oil from *Moringa oleifera* seeds was extracted using n-hexane. The oil yield determined experimentally was 26.2 per cent.

Francisco *et al.* (2016) studied that extraction of *Moringa* oil using the techniques: mechanical pressing (11.36 %) and by with hexane extraction (35.48 %).

Eman and Muhamad (2016) investigated the effect of seeds particle size on oil extraction using chemical method (solvent extraction). Also, to compare *Moringa oleifera* seeds oil properties which are produced chemically (solvent extraction) and mechanically (mechanical press). The *Moringa oleifera* seeds were grinded, sieved, and the oil was extracted using soxhlet extraction technique with n-Hexane using three different size of sample (2 mm, 1 mm and 500 µm). The average oil yield was 36.1, 40.80 and 41.5 per cent for 2mm, 1mm, and 500µm particle size, respectively. Both methods can produce oil with high quality.

2.2.2 Physico-chemical Properties of *Moringa* Seed Oil

Tsaknis and Lalas (2002) reported that oil was found to contain high levels of unsaturated fatty acids, especially oleic (up to 71.60 %). The dominant saturated acids were palmitic and behenic (both up to 6.4 %). The oil was also found to contain high levels of b-sitosterol (up to 45.58 %), stigmasterol (up to 23.10 %) and campesterol (up to 15.81 %). α-, β- and γ-tocopherols were detected up to levels of 15.38, 25.40 and 15.51 mg/kg of oil, respectively.

Anwar and Rashid (2007) investigated the physico-chemical characteristics of seed oil an iodine value of 68.63; refractive index (40^0C), 1.4571; density (24^0C), 0.9032 g cm^{-3}; saponification value, 181.4; unsaponifiable matter, 0.74 per cent; acidity (as oleic acid) 0.81 per cent and colour (1-in. cell) 1.28 R + 31.00 Y. Tocopherols (α, γ and δ) contents of the oil amounted to 140.5, 63.18 and 61.70 mg kg^{-1}, respectively and were reduced considerably after degumming. The major sterol components of the oil were β-sitosterol (46.16 %), campesterol (17.59 %), stigmasterol (18.80 %) and Δ5, avenasterol (9.26 %). The wild *M. oleifera* seed oil was found to contain oleic acid up to 73.22 per cent followed by palmitic, stearic, behenic and arachidic acids 6.45, 5.50, 6.16 and 4.08 per cent, respectively and fell in the category of high-oleic oils.

Rahman *et al.* (2009) reported that the *Moringa* seed oil extracted using n-hexane (H), light petroleum ether and chloroform/methanol (50:50, v/v) mixture (CM). Oil content ranged from 37.50 per cent (H) to 40.20 per cent (CM). The moisture, protein, ash and crude fiber contents of seed residues, and the density, refractive index, color, acidity, saponification value, iodine value, unsaponifiable matter content, oxidative state, sterols, tocopherols and fatty acid composition of the extracted oil were determined. The oil contained a high amount of oleic acid (C18:1) of up to 74.41 per cent and a high ratio of monounsaturated to saturated fatty acids with moderate oxidative stability

Graziela *et al.* (2011) reported that oil extracted from *Moringa oleifera* seeds from the nutritional standpoint. Nutritional evaluation of crude or degummed *Moringa* oil or soybean oil (as a control) involved the determination of the Food Efficiency (FE) and the fatty acid composition of the *Moringa* oil. The FE was slightly increased by the crude *Moringa* oil while no differences were found between the soybean and degummed *Moringa* oil regarding this parameter. Renal or hepatic injures as well as major alterations in serum proteins were not induced by the tested oils. These results suggested that degummed *M. oleifera* oil possessed adequate biological quality as compared to the crude oil.

Ghazali and Abdulkarim (2011) reported the mature seed of *Moringa oleifera* is rich in oil containing between 22-40 per cent crude fat. An examination of the oil composition indicates that the oil has a high proportion of monounsaturated fatty acid, namely oleic acid, which comprising between 65-75 per cent of the total fatty acid composition. It has been demonstrated that a higher dietary intake of monounsaturated fatty acid (mainly oleic acid) is associated with decreased risk in coronary heart disease. Like other high oleic oils, *M. oleifera* seed oil has been found to have excellent deep-fat frying performance, being less prone to oxidative and high-temperature degradation into by-products that may be toxic to the body following consumption of the fried food.

Ogbunugafor *et al.* (2011) studied that oil was extracted from *Moringa oleifera* seeds and evaluate its physico-chemical properties. *M. oleifera* seeds gave oil yield of 41.47 per cent. Refractive index, melting point (^{0}C) and acid value (mg KOH g^{-1}) of *M. oleifera* oil were 1.471, 28, 3.80. Similarly, iodine (I_2 100 g^{-1}), saponification (mg KOH g^{-1}) and peroxide (m Mol kg^{-1}) values obtained for *M. oleifera* oil were 85.30, 171.90 and 8.10.

Abiodun *et al.* (2012) studied that the physicochemical properties of *Moringa Oleifera* seed oil. The acid, peroxide and saponification values were 7.09 mg/g, 5.96 Meq/kg and 80.31 mg/g respectively. The lower iodine value signifies low degree of unsaturation and the lesser the liability of the oil to become rancid by oxidation.

Ojiako and Okeke (2013) reported that the percentage of oil yield of 26.9 per cent, specific gravity of 1.1827, Saponification value 187.5, Acid value 5.038620 mg/KOH/g, free fatty acid 2.51 mg/KOH/g, peroxide value not observed. The oil was found to be good commercially, and its production and consumption is highly recommended.

Adejumo *et al.* (2013 B) studied that the extracted oil had viscosity (kg/m^3) of 43.50, 43.69, 44.00 and 44.30 with specific gravity of 0.90, 0.93, 0.94 and 0.97 at 7.28, 10, 15 and 20 per cent moisture content for sample A, B, C and D respectively. The saponification (mg/KOH/mol) and iodine (g/100g) values of 117.12, 93.97, 96.77, 91.16 and 68.58, 68.50, 68.41, 68.42 for sample A, B, C and D respectively. The acid values (mg/KOH/mol) are 3.23, 3.16, 2.81 and 2.81 for sample A, B, C and D respectively. The peroxide value (mg/KOH/mol) and free fatty acid (mg/KOH/mol) ranged between 0.95-

1.15 and 5.61-6.45 for the extracted oil at moisture content of 7.28-20 per cent. The high free fatty acid value indicates its edibility while the iodine value is a measure of the unsaturation of the oil. The oil can be use as lubricant, cooking as substitute for other vegetable oil.

Orhevba *et al.* (2013) studied that the physicochemical properties of the oil were values of moisture content, ash, crude protein, crude fat and carbohydrate were 0.60, 1.50, 2.19, 39.3 and 56.42 per cent, respectively. While the values obtained for pH, saponification value, iodine value, free fatty acid and specific gravity were 5.96, 164.09 mg/g, 68.23 g/mol, 8.27 mgKOH/g and 0.86, respectively.

Adejumo *et al.* (2013 A) studied the effect of heating on physicochemical properties of oil. The samples were heated at 100, 130 and 150^{0}C respectively for 30 minutes. The oil yield, saponification value, free fatty acid, acid value, peroxide value and iodine value decreases with increase in heating temperature, while heating temperature has no significant effect on the specific gravity of the oil. The properties evaluated indicate the long shelf life, resistance to rancidity and edibility of *Moringa* seed oil.

Ojiako and Okeke (2013) reported that the percentage of oil yield of 26.9 per cent, specific gravity of 1.1827, Saponification value 187.5, Acid value 5.0386 mg/KOH/g, free fatty acid 2.51 mg/KOH/g, peroxide value not observed. The oil was found to be good commercially, and its production and consumption is highly recommended.

Premi and Sharma (2013) reported that the *Moringa* seed (PKM 1) was examined for extracted oil recovery under the different designed conditions using Central composite face centered design of Response surface methodology. The maximum extraction was found to be 33.30 per cent. The characterization revealed that the oil had Iodine value 67.23, saponification value 184.65, density 0.907 and refractive index 1.436, respectively.

Babatunde *et al.* (2014) evaluated the iodine value, saponification value and unsaponifiable matter of CPMSO and HEMSO were found to be 67.8 and 68.5g I_2/100 g oil, 190.4 and 191.2 mg KOH/g oil and 0.59 and 0.65 per cent, respectively. The total tocopherols of CPMSO and HEMSO were found to be 95.5 and 90.2 mg/kg. The fatty acid composition of CPMSO and HEMSO showed oleic acid as the major fatty acid (78–79 %). The CPMSO was of adequate thermal stability and better oxidative stability. The frying stability of CPMSO was better as it showed lower increase in free fatty acid (28 %), peroxide value (10 meq O2/kg) and colour (25 %) after frying.

Campas *et al.* (2014) studied that the physicochemical characterization, polyphenol content, DPPH radical scavenging capacity and fatty acid profile of *Moringa* seed oil. The oil showed a refractive index of 1.4642. The saponification number was 183 mg KOH/g oil, iodine value: 75 g I/100 g of oil, acid value: 0.49 (% oleic acid). The polyphenol content was 0.137 mg of gallic acid equivalent/g and DPPH radical scavenging capacity was 87.39 per cent. The *Moringa* seed oil was rich (68 %) in the major fatty acid, oleic acid (C18:1n9).

Bale *et al.* (2015) reported that some physicochemical properties of *Moringa* seed oil like the density, specific gravity, refractive index, pH, viscosity, acid value, peroxide value, saponification value, iodine value and FFA were determined.

Khanitta and Angelika (2015) studied that the physico-chemical properties, fatty acid compositions and oxidative stability of cold pressed *Moringa* seed oil in comparison with those of extra virgin olive (*EVO*) oil were also evaluated and the results indicated that *Moringa* seed oil residue had the highest antioxidant activity followed by oil and seed, respectively. *Moringa* seed oil contained a high level of oleic acid (71.87 %) to that of *EVO* oil (78.10 %). *Moringa* seed oil was much more stable against oxidation than *EVO* oil based on the oxidative stability index results.

Vibhute *et al.* (2015) reported *Moringa* seed oil impregnated anti-inflammatory topical micro-dispersion. The ternary phase diagrams for micro emulsion regions were constructed using *Moringa* seed oil as oil phase. The percentage transmittance and refractive index (RI) of formulation was found to be 99.60 and 1.469 respectively; whereas pH and average globule size was 7.1 and 167nm respectively. The permeability of *Moringa* seed oil microemulsion was 76.86 per cent as compared to 54.06 per cent of pure oil. The prepared microemulsion was found to be non-irritant and showed significant ($P<0.05$) anti-inflammatory effect. The *Moringa* seed oil can be used to develop stable micro-dispersion system with better skin permeation and promising anti-inflammatory activity without any skin irritation.

Khanitta and Angelika (2015) reported that *Moringa* seed contains highly valuable substances with an impressive range of medicinal, cosmetic and food uses.

Moringa seed oil contained a high level of oleic acid (71.87 %) to that of *EVO* oil (78.10 %).

Francisco *et al.* (2016) studied that purification and characterization of *Moringa* oil extracted by pressing was analysed for gas chromatography, revealing a profile of 21.5 per cent of saturated fatty acids and 78.5 per cent of unsaturated fatty acids, having the oleic acid as the major component.

Adegbe *et al.* (2016) reported that the oil from *Moringa* seed oil was analyzed by a combination of GC and GCMS. The major constituents were oleic acid (22.51 %), palmitic acid (10.64 %), 9-octadecenol (12.76 %) and phenylbut-3-yne (5.79 %). The fixed oil of *Moringa* seed is rich in fatty acids (44.93 %) followed by hydrocarbons (32.95 %), others are aldehyde (12.76 %) esters (3.55 %) and oxygenated hydrocarbon (2.62 %). The oil was found to contain moderate level of unsaturated fatty acids, mainly oleic acid (22.51 %) and erucic acid (1.98 %). The dominant saturated acids were Palmitic (10.64 %), stearic acid (6.07 %), arachidic acid (2.21 %) and Docosanoic (Behenic acid) (1.03 %).

Adegbe *et al.* (2016) studied physicochemical properties of *Moringa* seed oil the specific gravity and refractive index were 0.9050 and 1.456. The acid value, iodine value, Saponification number, free fatty acids and peroxide values were in the order 6.73 mg KOH g^{-1}, 68.65 g 100 g^{-1}, 180.92 mg KOH g^{-1}, 4.21 mg KOH g^{-1}, 2.60 meq kg^{-1}. The percentage yield of the oil was 38.0% and the colour of the oil was cream yellow. The seed oil of *Moringa* showed good physio-chemical properties and could be utilized successfully as a source of edible oil for human consumption and for industrial applications.

Amany and Maliha (2016) reported that the physico-chemical properties, fatty acids composition, unsaponifiable matter, tocopherols and phenolic content of *Moringa oleifera* seed oil. *Moringa* oil showed a better overall quality, its acid, peroxide, iodine, saponification values. Sterol fraction was found rich in β-sitosterol (45.11), stigmasterol (19.20 %), campesterol (16.90 %) and 5-avenasterol (10.00 %). The major fatty acids were identified as oleic acid (65.00 %).

Eman and Muhamad (2016) reported that the average oil yield was 36.1, 40.80 and 41.5 per cent for 2 mm, 1 mm, and 500 μm particle size, respectively. Also, to compare *Moringa* seeds oil properties which are produced chemically (solvent extraction) and mechanically (mechanical press). The properties of *Moringa* seeds oil were: density of 873 kg/m^3, and 880 kg/m^3, kinematic viscosity of 42.2 and 9.12 mm^2/s for the mechanical and chemical method, respectively. pH, cloud point and pour point were same for oil produced with both methods which is 6, 18 and 12°C, respectively. For the fatty acids, the oleic acid is present with high percentage of 75.39 and 73.60 per cent from chemical and mechanical method, respectively. Other fatty acids are present as well in both samples which are (Gadoleic acid, Behenic acid, Palmitic acid) which are with lower percentage of 2.54, 5.83 and 5.73 per cent, respectively in chemical extraction method of oil, while they present as 2.40, 6.73 and 6.04 per cent, respectively in mechanical extraction method of oil.

Omosuli *et al.* (2017) investigated that the effect of drying methods on physicochemical properties and fatty acid composition of oils extracted from *moringa* seeds. Drying increased the yield from 30.30-33.11 per cent. The oil samples were less dense than water with specific gravities of 0.9032, 0.9075 and 0.9030, respectively. Drying increased the yield from 30.30-33.11 per cent. The oil samples were less dense than water with specific gravities of 0.9032, 0.9075 and 0.9030, respectively. A significant difference exists in the moisture contents (0.11-0.21 %); smoke point (202-225 ^{0}C), flash point (310-317 ^{0}C) and fire point (360- 369 ^{0}C). Sun-drying and cabinet oven drying brought about a decrease in the acid value (1.80-1.08 mgKOH/g), saponification value (174.87-105 mg KOH/g), iodine value (16.10-13.90 wijs) and peroxide value (11.24-2.3 Meq/kg). The decrease is an indication of quality improvement of the oils.

Mahmud *et al.* (2017) reported that the tocopherol values (α- γ-δ-) and the image of high values, was tocopherol - α (126.1- 127) milligrams, so it has a greater vitamin (E) well compared to other oils such as coconut 17 mg, sunflower 7 mg. The fatty acids (FA) in *Moringa* seed oils containing oleic acid (C18: 1) up to 74.4 per cent and is considered the best by comparing other.

Tripathi *et al.* (2018) evaluated that the oil properties of a commercially modified and common edible seed species, *Moringa oleifera* (PKM-1). The experiments were conducted from oil obtained from seeds with pods removed and seeds with pods. The (PKM -1) seed variety gave an oil yield of (45.36 % ± 2.05), while the acid value was found to be (178.3 % ± 2.8). Deviation in the polarity of the pure seed oil and the seed with pod oil were observed, Laevorotatory and Dextrorotatory respectively.

2.2.3 Oxidative Properties of *Moringa* Seed Oil

Tsaksins and Lalas (2002) reported that the oil from *Moringa* seeds variety Periyakulam 1 (PKM 1) showed high stability to oxidative rancidity. Among the methods used for extraction, the mixture of chloroform:methanol (1:1) showed the higher resistance to oxidation.

Anwar and Rashid (2007) reported that the oxidation parameters like induction period (Rancimat 20 L/h, 120^0C), specific extinctions at 232 and 270 nm, peroxide- and *p*-anisidine values demonstrated a good oxidative stability of the *Moringa* seed oil.

Abdulkarim *et al.* (2007 B) reported greater stability of solvent-extracted *Moringa* seed oil than that of conventional frying oils i.e., canola oil, soybean oil, and palm olein after frying of potato chips.

Rahman *et al.* (2009) reported on the effect of different extraction methods on the quality characteristics of *Moringa* seed oil. The *Moringa* seed oil contains high amounts of tocopherols and oleic acid, which contribute to the oil's oxidative stability and lower the risk of developing coronary heart disease. Solvent-extracted *Moringa oleifera* oil underwent greater oxidative deterioration as compared to cold-pressed oil upon frying of potatoes and cods.

Khanitta and Angelika (2015) investigated that the *Moringa* seed oil was much more stable against oxidation than *EVO* oil based on the oxidative stability index results.

Mahmud *et al.* (2017) reported that the contain of *Moringa* seed to 40.2 per cent by weight in favor of oils for human use next to contain nutrients granted retain vitality and viability of storage for a long time. The values free fatty acids (FFA), show good resistance to oil degradation compared to the values of olive oil, corn oil, cotton oil, peanut oil. The values of peroxide with low values indicating a resistance to oil, *Moringa* from oxidation during storage, making it the important nutritional oils to store and persistence chemically.

2.2.4 Antioxidant Property of *Moringa* Seed Oil

Fang *et al.* (2002) reported that the antioxidant activities play great an important role in preventing stress, inhibiting and scavenging free radicals that may cause several diseases such as cancer, heart disease, hypertension and stroke.

Veena *et al.* (2010) investigated the phytochemical profile and antioxidant activities of pods of *Moringa oleifera* against free radicals. The antioxidant activity of the Hydro-ethanolic extract of pods of *Moringa oleifera* was evaluated by free radical scavenging activity using 1, 1-diphenyl-2-picryl-hydrazil (DPPH), FRAP assay, reducing power assay, FTC, TBA and Non-specific assay. The extract of the pods of *Moringa* is a good source of compounds with antioxidant properties while the extract also exhibited significant free radical scavenging activity, reducing power activity and Total antioxidant activity.

Ogbunugafor *et al.* (2011) studied that oil was extracted from *Moringa oleifera* seeds and evaluate its antioxidant properties. Total phenol (mg Gallic Acid Equivalent g^{-1}), total flavonoids (mg Rutin Equivalent g^{-1}) and total antioxidant capacity (mg Ascorbic Acid Equivalent g^{-1}) were 40.17 ± 0.01, 18.24 ± 0.01, 37.94 ± 0.02 for *M. oleifera* oil respectively. *Moringa* seed oil showed a concentration dependent DPPH free radical scavenging and reducing power capabilities.

Ojiako and Okeke (2013) reported that the use of *Moringa oleifera* as a medicinal plant for curing many diseases. Oil was extracted from *Moringa oleifera* seed using Soxhlet extraction. The antioxidant inhibition results of the free radical showed inhibition above average which was an indication of high antioxidant advantage.

Khanitta and Angelika (2015) investigated that the *Moringa* seed contains highly valuable substances with an impressive range of medicinal, cosmetic and food uses. *Moringa* seed, seed oil and its residue for antioxidant and antimicrobial activities against selected foodborne microorganisms using disc diffusion and minimum inhibitory concentration. *Moringa* seed oil residue had the highest antioxidant activity followed by oil and seed, respectively.

Tripathi *et al.* (2018) reported that the high value of radical scavenging activity was found with oil extracted with the seed pods (58.330 % ± 0.05).

2.2.5 *Moringa* Seed Oil Used in Different Products

Tsaknis and Lalas (2002) reported that the frying performance of the *Moringa* seed oil variety Periyakulam 1 (PKM 1) from India extracted using cold press (CP). The oils were used for intermittent frying of potato slices and cod filets. The analytical and sensory results showed that the lowest deterioration occurred in cold pressure produced oil. Therefore, cold pressure oil appears to be the most appropriate for frying.

Abdulkarim *et al.* (2005) reported that the seed of *Moringa* contains high quality edible oil (up to 40 % by weight). The oil has been used as general culinary and salad oil. It resembles olive oil in its fatty acid composition. The characteristics of *Moringa* seed oil are especially desirable, because of the current trends of replacing polyunsaturated vegetable oils with monounsaturated fatty acids.

Manal and Mahdi (2012) studied that quality of *Moringa* oil and his suitability for frying, the results showed that there were significant difference (P 0.05) in density and refractive index for *Moringa* oil, groundnut oil and their blend before frying. There was significant difference in free fatty acids for *Moringa* oil compared with groundnut oil and their blend before frying and after frying, while there was no significant difference of F. F. A for *Moringa* oil, groundnut oil and their blend before frying compared to after frying. The results obtained showed that there was significant difference in the taste, colour and acceptability for potato chips fried in *Moringa* oil, groundnut oil and their blend, also no significant difference in odour and texture for potato chips fried in *Moringa* oil compared with groundnut oil, while a significant difference in odour and texture for potato chips fried in *Moringa* oil compared with the blend.

Warra (2014) reported that *Moringa* seed oil found application in skin preparations and ointments. The clear yellow oil has a pleasant taste, and has been compared, in terms of quality with other seed oils. The oil of excellent quality similar to the olive oil, the *Moringa* seed oil finds wide application in cosmetic industry.

Muhammad *et al.* (2015) evaluated that the suitability of *Moringa* oil and palm olein blends as Vanaspati substitutes on the basis of physico-chemical and sensory characteristics. The addition of *Moringa* seed oil improved the induction period of the blends strongly inhibited the formation of primary and secondary oxidation products. Blend containing 50 per cent palm olein and 50 per cent *Moringa* oil can be used in the formulation of a functional shelf stable fat that can be used as a Vanaspati substitute.

Aida *et al.* (2015) studied that to improve the quality of sour cream and prolonged the shelf life. *Moringa* seed oil was added to sour cream at concentration 600, 800, and 1000 ppm. The acidity content decreased with increasing level of *Moringa* oil. Peroxide value of sour cream samples as affected by addition of *Moringa* oil at different levels. Sour cream fortified with *Moringa* oil exhibited lowest PV. The results indicated that total count decreased with advanced storage period in sour cream fortified with *Moringa* seed oil than control. Lipolytic and proteolytic bacteria, yeast and mould were not detected in sour cream fortified *Moringa* seed oil.

Lucia *et al.* (2017) reported the *Moringa* oil comes from the seed of the *Moringa* plant which has been used in the preparation of varieties of product such as food, cosmetics, medicine and others. The main aim of the study was to use *Moringa* oil in the preparation of some dishes and to create awareness on the usage of *Moringa* oil in cooking. It was therefore recommended that *Moringa oil* should be introduced to the public because of its nutritional value.

Boukandoul *et al.* (2018) reported that there was increasingly demand for alternative vegetable oils sources. In *Moringa* particularly due to its high seed oil yield (30-40 %), composition of *Moringa* oil, rich in oleic acid and highly resistant to oxidation, for industrial purposes. *Moringa* seed oil can be extracted by conventional methods or using physical methods (Pressing), creating diverse products from a compositional perspective, able to serve both the biodiesel and food industries.

2.3 Utilization of Seed Flour and Defatted Cake in Food Stuff

2.3.1 Effect on Sensory Properties

Atef *et al.* (2011) reported that with increase in the level of legumes (raw and germinated) in the formulation, the sensory scores for highest, crust colour, texture and odor of cakes slightly decreased. Replacement of flour with 25, 50 and 75 per cent legumes flour (raw and germinated) impaired the taste of cakes (control samples had 29.5 score), which slightly decreased from 28.5 to 27.8 in raw bean, while exhibited a significantly decreased in case of 50 per cent replacement level in germinated cowpea to be 26.6 and at 25 per cent raw cowpea was 25.9. Cake contained lower than 50 per cent raw and germinated cowpea flour were slightly decreased in overall acceptance compared to that in control sample. At all levels of substitution by raw or germinated bean flour the crust colours were insignificant differences among samples and control (at $P < 0.05$). But above more than 50 per cent substitution levels of raw and germinated cowpea the colour of cake had lower scores and significantly differed than the control sample.

Yadav *et al.* (2012) evaluated that the partially de-oiled peanut meal flour (DPMF) was blended with wheat flour for making biscuits. DPMF at 5, 10, 15 and 20% was used to partially replace wheat flour in biscuits formulation and biscuits thus made were evaluated for nutri- tional composition, physical characteristics and sensory quality.

Yadav *et al.* (2013) reported that the sensory evaluation of the sample containing 15 per cent DPMF scored highest in most of the attributes including overall acceptability. Incorporation of DPMF had significant ($P \leq 0.05$) effect on colour values of bread. As the level of DPMF was increased, L values decreased from 75.2 to 65.2 for crumb and 71.8 to 63.3 for crust.

Shameena *et al.* (2016) studied that to develop muffins by substituting refined wheat flour (RWF) with virgin coconut oil (VCO) cake (0-50 g/100 g flour blend). Sensory scores of the parameters such as appearance and colour, odour, texture, flavour and taste and the overall acceptability of the muffin formulations as affected by the level of VCO cake. Muffins containing 40 g VCO cake/100 g flour blend obtained the maximum score for odour (7.85). The lowest score for odour was obtained for the control (7.25) and the muffins with 50 g VCO cake-based formulation (7.25). Regarding texture, as the VCO concentration increased, the product became softer because of the enriched fat presents in the VCO cake (39.2 g/100 g). Texture of 40 and 50 g VCO cake-based formulations was significantly different from other formulations including control with a mean score of 8.55 and 8.83, respectively. The control sample obtained the lowest score for flavour and taste. The order of preference of muffins with VCO cake (in terms of flavour and taste) was40 > 50 > 30 > 20 > 10 g > 0 g/100 g flour blend with mean score of 8.46, 7.95, 7.65, 7.50, 7.20 and 7.15, respectively.

Azza *et al.* (2016) evaluated that the biscuits containing 25 per cent defatted flaxseed flour showed maximum sensory scores compared to other samples and non-significantly difference with control biscuit. However, above 50 per cent substitution, the product becomes less acceptable to the consumer. The overall quality of the biscuits was significantly reduced by addition of flaxseed flour compared with wheat biscuit except for 25 per cent DFF which insignificantly decreased. Significant difference was observed between different supplementation with 25 per cent DFF in textural scores.

Kripa and Anita (2018) studied that the cupcakes were prepared by incorporating partially defatted peanut flour at different levels (10-20 %). The highest scores for appearance, colour, texture, flavour and taste of coconut muffins with 15 per cent (S3 treatment) partially defatted peanut flour supplementation have scores 7.4, 7.5, 7.4, 8, 8 respectively, which was liked very much with overall acceptability of 7.66. The scores of S3 (15 %) were found to be comparatively higher than control sample i.e., 8 and 8 for flavour and taste respectively, showing significant difference and non significant difference for appearance, colour and texture.

Raziyeh and Sara (2020) studied that olive stone powder (OSP) was used to substitute 0, 15, 25, and 35 per cent of wheat flour in sponge cake recipe. Cakes had colors that were darker than expected when treated with OSP ($P < 0.05$). According to sensory evaluations, no significant differences were observed between OSP cakes and the control sample in terms of taste, after taste, color, and odor. The samples containing OSP scored significantly less in terms of chewing ability, texture, and appearance parameters, although there was no significant difference between samples containing different levels of OSP in this regard ($P > 0.05$). Moreover, among the OSP cakes, the sample with 15% and 35 per cent OSP received the highest and the lowest scores, respectively. Results revealed that, for the 35 per cent OSP sample, the flavor and odor of the cake were less acceptable.

Aleksandra *et al.* (2021) studied that biscuit samples containing 0, 20 and 40 g of RPC flour, respectively. The baked biscuits with the highest amount of RPC flour (40 g) had the lowest sensory score values for overall acceptance. With increasing RPC content in the dough, the fortified biscuits color changed gradually from light (biscuits without RPC) to dark for biscuits with the highest amount of RPC flour (40 g). Therefore, these samples scored the lowest for color (4.45-4.62), odor (3.45-3.93), flavor (3.03-3.52), and overall acceptability (2.89-3.44). The biscuits with the highest RPC level were characterized by a typical intensity of bitter and grassy flavor due to the high concentration of phenolic compounds present in RPC.

2.3.2 Effect on Physical Properties

Aleem zaker *et al.* (2012) reported that the defatted soy flour was incorporated in the traditional recipe to replace wheat flour at levels defatted soy flour by 0, 10, 20, and 30 per cent in preparation of biscuits. The results revealed that increase in level of DSF incorporation results in linear decrease of total weight, diameter, spread ratio and hardness. While, thickness of biscuits increased with increase in concentration, reduction of spread ration of biscuits may be attributed to better binding strength of soy protein, also resulting in increase of thickness. The DSF incorporated biscuits reported to having lower hardness. This could be attributed to high water binding capacity of defatted soy flour.

Azza *et al.* (2016) studied that biscuit was prepared by substituting 25, 50 and 75 per cent of wheat flour with full fat (FFF) or defatted flaxseed flour (DFF). The results indicated that diameter and thickness of biscuit (FFF and DFF) were slightly increased with increasing substitution percentage of flaxseed flour compared with control biscuit. The results of spread ratio of biscuit revealed a reduction in spread ratio from 6.58 to 6.13 mm and from 6.14 to 6.02 mm for DFF and FFF, respectively.

Simona *et al.* (2019) investigated physical properties of biscuits made replacing wheat flour with 18 and 36 per cent of DSSF. When compared to control biscuits, the diameter of DSSF biscuits at both inclusion levels was significantly lower. Thickness also decreased at the 36 per cent DSSF inclusion level, while there was no significant difference in thickness between the control and the 18 per cent DSSF biscuits. The decrease in thickness and diameter in biscuits with DSSF inclusion might be due to the dilution of gluten or increase in fibre content. There was no significant difference in spread ratio between the control and the 18 per cent DSSF biscuits, while the 36 per cent DSSF biscuits had a significantly higher spread ratio.

Aleksandra *et al.* (2021) indicated that increase in RPC flour incorporation significantly decreased the diameter, thickness, and weight of the studied biscuits. Insignificant differences in the mean spread ratio were found between samples without RPC containing coconut oil and biscuits prepared with 40 g of RPC and rapeseed oil. The insignificant increase in spread ratio and the significant contraction of diameter after addition of RPC flour can be attributed to the reduction of total gluten content as well as the increase in protein amount.

2.3.3 Effect on Proximate Composition

Foidl *et al.* (2001) evaluated that after oil extraction of *Moringa* seeds, the left press cake contains water soluble proteins that act as effective coagulants for water purification. Seed powders are mixed with water, after hours, the water is filtered to get purified water. The charged protein molecules can serve as nontoxic natural polypeptide to settle mineral particles and organics in the purification of drinking water, vegetable oil, depositing juice (sugarcane) and beer.

Chinma *et al.* (2014) investigated the effects of substituting germinated *Moringa* seed flour for wheat flour on the cake quality. Substitution of the germinated *Moringa* seed flours for wheat flour increased protein, crude fiber, iron, calcium and zinc contents of cakes from 13.14 to 23.10 per cent, 0.71 to 2.52 per cent, 2.95 to 7.88 mg/100 g, 48.29 to 54.56 mg/100 g and 0.86 to 1.44 mg/100 g, respectively, while carbohydrate content decreased from 65.40 to 51.08 per cent. Physical properties of cakes were influenced by substitution of germinated *Moringa* seed flour for wheat. The taste and overall acceptability of composite cakes up to 30 per cent germinated *Moringa* seed flour substitution were not significantly different from the whole wheat flour cake.

Muhammad *et al.* (2016) studied that effect of level of defatted sesame meal on mineral composition of bread. concentration of minerals enhanced significantly due to the supplementation of sesame meal in wheat flour as 0, 4, 8, 12, 16 per cent, respectively. The highest contents of sodium (10.45 mg/100 g), potassium (355.85 mg/100 g), calcium (91.72 mg/100 g) and magnesium (185.84 mg/100 g) were found in 16 % sesame meal supplemented composite flour. The iron and zinc contents improved significantly due to the supplementation of sesame meal in wheat flour.

Ogunsina *et al.* (2011) investigated that the effects of replacing wheat flour with 0-15 per cent debittered *moringa* seed (DBMS) flour on the physical, sensory and chemical properties of bread and cookies. The bread with 10 per cent DBMS had a typical *Moringa* seed taste and was acceptable. Cookies with 20 per cent DBMS grits had the nutty taste of *moringa* seeds and were acceptable. Bread with 10 per cent DBMS flour and cookies with 20 per cent DBMS grits had more protein, iron and calcium. Incorporating *Moringa* seeds in baked foods may be exploited as a means of boosting nutrition.

Ayo *et al.* (2018) studied the proximate composition, physical and sensory quality of the biscuits prepared from acha-*Moringa* seed flour blends. The values of moisture, ash, fats, protein, fibre and carbohydrate content of the acha-*Moringa* seed flour blend biscuits range from;- 8.79 - 8.60, 4.85 - 5.96, 18.46 - 20.31, 12.25 -14.19, 2.56 - 4.15 and 52.86 - 46.80 per cent, respectively. The spread ratio and break strength of the acha *Moringa* flour blend biscuits decreased from 4.81 to 3.46 and 1572.50 to 1125.00 g, respectively, with an increase in the added *Moringa* seed flour. The flour blend biscuits were most acceptable at 10 per cent and below of added *Moringa* seed flour.

Mahmoud *et al.* (2018) studied that the nutritional value, physical properties, and sensory evaluation of cakes containing three different concentrations of treated *Moringa* seed powder (TMSP) (10, 20, and 30 %) as partial replacement for wheat flour. The results of nutritional analyses showed significant increase ($P<0.05$) in crude protein (7.6-17.65 %), crude fiber (0.68-1.65 %), total ash (1.06-1.97 %), calcium (30.06-65.63 mg/100 g) and iron (7.6-17.65 mg/100 g) value with the increase of treated *Moringa* seed powder addition. Cake samples substituted with 20-30 per cent TMSP and equivalent to 80 gm considered nutritious in iron and protein.

Adewumi and Samson (2018) reported that *Moringa oleifera* tree is referred to as a miracle tree due to its rich source of certain macro and micro nutrients of great importance in human nutrition. *Moringa* leaf, seed and flower have found numerous applications in food. In this review we firstly summarized the present knowledge on the use of *Moringa* as a food fortificant in amala (stiff dough), ogi (maize gruel), bread, biscuits, yoghurt, cheese and in making soup.

Lalita *et al.* (2018) reported that the *Moringa Moringa* had potential as nutrient rich food supplement with multipurpose applications of different parts of *Moringa* such as leaves, flowers, pods, seeds and roots. Fruits of *Moringa* are a major source of vitamin C, i.e., 120 mg per 100 g fresh sliced pods. It is used in functional and traditional foods, *e.g*., in making soups, weaning foods, *amala*, biscuits, bread, cake and yoghurt as well as cheese and has the ability to preserve foods.

Zarka and Neelash (2018) investigated that the moisture content of the biscuits increased from 2.30 to 2.64 per cent with the increase in soybean flour from 0 to 30 per cent. The control sample made of 100 per cent of wheat flour had lowest moisture content while the sample made of 30 per cent of defatted soy flour had highest moisture content. The higher moisture content in the cookie samples were due to the large amount of water required in optimum dough preparation and less baking time then the control cookie. Increase in protein content could be due to the soya fraction of the blended flour as the soya flour has higher protein (40.2 %) as compare to wheat flour (12.1 %). The protein content of the biscuits increased from 6.98 to 18.61 per cent with the increase in soybean flour from 0 to 30 per cent. Addition of defatted soy flour improve the quantity and quality of protein content of the food product, thereby has the great potential in combating with protein energy malnutrition. There was slight reduction in fat content with increase in defatted soy flour incorporation. The fat content of the biscuits decreased from 25.44 to 20.91 per cent with the increase in soybean flour from 0 to 30 per cent. The ash content increased from 1.52 to 2.35 per cent with increase in the percentage of soy flour from 0 to 30 per cent.

Islamiyat *et al.* (2019) reported that the proximate, mineral, vitamin A content and sensory attributes of the *Moringa* fortified bread samples improved at varying proportions (0–20 %). Results showed that *Moringa* seed powder addition significantly increased the protein (8.55–13.46 %), ash (0.63–1.76 %), fat (7.31–15.75 %) and fibre content (0.08–0.62 %) of the bread samples, while the moisture (22.90–20.01 %) and carbohydrates content (57.68–46.73 %) of the bread decreases. The mineral contents (Phosphorus, potassium, calcium and Iron) of the *moringa* fortified bread also increased significantly. Vitamin A contents of the bread samples increased by 50-74 per cent, as the proportion of *Moringa* seed powder increases in the flour blends. Result showed that the *Moringa* fortified bread was acceptable to consumers at 5 per cent fortification level.

2.3.4 Effect on Textural Properties

Shameena *et al.* (2016) studied that with increasing the level of virgin coconut oil (VCO) cake increased softness in the prepared muffins. One reason is the richness of fat in VCO cake which led to a significant change in the textural properties of the prepared muffins. Another reason being the richness of sugar exists in the VCO cake decreased gluten development and thus resulted in an increase in softness. The significant ($P < 0.05$) decrease in hardness, springiness, resilience and chewiness of muffins with increasing levels of VCO cake. Hardness values of the muffin formulations containing VCO cake were significantly lower ($P < 0.05$) than control. It decreased significantly from 80.97 N (control) to 25.49 N (50 g VCO cake/100 g flour blend). Springiness of the muffins was also adversely affected by the addition of VCO cake (from 0.88 to 0.43 in the control and 50 g VCO-based formulation, respectively), which was evident from the lower springiness values obtained for VCO cake-based formulations (0.82, 0.77, 0.72, 0.59 and 0.43 in 10, 20, 30, 40 and 50 g VCO cake-based formulations, respectively) in comparison with the control (0.88).

Azza *et al.* (2016) reported that the hardness of defatted flaxseed flour (DFF) biscuits was increased with increasing flaxseed percentages.

Muhammad *et al.* (2016) reported that the effect of defatted sesame meal on textural properties of bread. Texture has significant influence on consumer’s perception of a good bread quality. The most important attribute of bread include hardness. Hardness is defined as the force required for biting of bread. The mean values showed that bread hardness ranged from 1732.2 to 2811.3 g among the various treatments. The highest bread hardness (2811.3 g) was recorded for the bread prepared from control, while the lowest hardness (1732.2 g) was recorded with the bread produced by 16 per cent sesame meal supplementation.

Bharti *et al.* (2017) reported that various types of natural fibre-rich ingredients are added into bakery-based products to improve their fibre content for health promotional purposes. The prepared dietary fiber rich muffins by using cauliflower stem and potato peel powder are investigated. The texture of the muffins was found good in all aspects of texture analysis. Hardness 693.3 g, chewiness 284.8, gumminess 397.26, adhesiveness is nill.

Raziyeh and Sara (2020) evaluated significant decrease in hardness as the amount of olive stone powder (OSP) increased in formulation. Springiness values of sponge cakes with OSP were in the range of 7.74 to 7.83 mm. TPA values showed an increase in cake chewiness and gumminess parallel to increased levels of OSP. Values of chewiness ranged from 732.21 to 837.25 g mm, whereas those of gumminess ranged from 93.75 to 106.28 g. Generally, higher levels of OSP meant lower values of hardness and springiness but enhanced values of cohesiveness, gumminess, and chewiness.

2.4 Replacement of Shortening in Bakery Products

Zoulias *et al.* (2002) used carbohydrate or protein-based fat mimetics to replace up to 50 per cent of fat in cookies. The effect of the type of fat mimetic and of the percentage of fat replacement on textural behaviour of the products was studied by compression tests. Hardness and brittleness of the cookies generally increased with fat replacement.

Wiese and Duffrin (2003) investigated the sensory properties of plain shortened cake (PSC) using pawpaw fruit puree as a partial replacement for fat in the food formulation. The cakes were prepared by replacing about 25, 50 and 75 per cent of the fat with pawpaw fruit puree and were compared to a control using 100 per cent vegetable shortening. Panelists indicated that 25 per cent fat replacement with pawpaw fruit puree is acceptable in a PSC formula. The notable differences in colour, texture, tenderness and overall acceptability attributes may be overcome with further research and product development. Higher levels of fat replacement may prove to be acceptable in other types of cake formulations and further testing of the various varieties of pawpaw fruit as a fat - replacement in baked goods is warranted.

Sharif *et al.* (2005) applied rice bran oil (RBO) into baked products such as cookies at various levels i.e., 0, 25, 50, 75 and 100 per cent by gradually replacing normal shortening to improve the quality of cookies in term of shelf life due to natural antioxidants present in RBO. Five treatments of RBO and normal shortening (NS) were used to prepare cookies. T_3 (50 % RBO + 50 % NS) can produce superior quality cookies to prove effectiveness of RBO as bakery shortening.

Lee *et al.* (2005) evaluated oatrim (oat -glucan amylodextrins) as a fat substitute in a cake system. The physical and rheological properties of cakes containing shortening replaced with 20, 40, and 60 per cent by weight of oatrim were characterized. The increase in the specific gravity of the cakes and the decrease in the viscosity as more shortening was replaced with oatrim were correlated with the change in the cake volume. The cakes containing more oatrim displayed a higher starch gelatinization temperature due to the amylodextrins in the oatrim. The dynamic rheological properties of the cakes were investigated during baking and correlated with the differential scanning calorimetry results. The cakes prepared with up to 20 per cent by weight of oatrim did not evidence significant changes in softness and generally exhibited similar physical properties to the control cake.

Zbikowska and Rutkowska (2008) studied effects of inulin used as partial fat replacement in cookies containing three different fats. Shortenings used for preparation of cookies differed greatly in saturated fatty acids (SFA) (29.9–57.5 %), trans fatty acids (TFA) (0.9–23.1 %) and solid fat content (SFC) at 25°C (13.6–31.6 %). Replacement of 50 per cent fat with inulin in the formulations enabled obtaining samples with higher instrumental values of texture and resulted in cookies which were harder and less crispy. Also the intensity of sweet taste was sharply reduced by decreasing the fat content of cookie recipes.

Arshad *et al.* (2008) prepared cookies from wheat germ oil (WGO) with the objective of providing higher antioxidant content in the diet. Normal shortening was replaced with WGO at the levels of 0, 25, 50, 75 and 100 per cent in the cookies formulation. Sensory attributes of the cookies containing WGO up to 50 per cent were as acceptable as control cookies.

Nasir *et al.* (2009) extracted oil from maize germ, refined and used in cake recipe for value-addition. Cakes were successfully prepared with all levels of MGO fortification with high acceptability.

Abdul *et al.* (2010) found favourable cookies close to the standard cookies have been made by using interesterified palm and cottonseed oil blends at the ratio of 50:50 (wt %) without any significantly adverse change in sensorial properties.

Kaur *et al.* (2014) carried out study to replace bakery shortening with refined rice bran oil in the preparation of muffins. Muffin samples were prepared by replacing bakery shortening with rice bran oil at 0, 25, 50, 75 and 100 per cent levels. Statistical analysis revealed that muffin making and organoleptic quality of muffins prepared after replacing rice bran oil at the 50 % level or greater varied significantly which is desirable from that of control.

Rangrej *et al.* (2015) reported that flaxseed oil, being the richest vegetarian source of alpha linolenic acid, was incorporated in cookies by replacing shortening at level of 5, 10, 20, 30, 40 and 50 per cent. Effect of shortening replacement with flaxseed oil on physical, textural and sensory attributes were investigated. Spread ratio and breaking strength of cookies increased as flaxseed oil level increased. Sensory score was not significantly affected up to 30 per cent shortening replacement with flaxseed oil as compared with the control cookies.

Amita and Khatkar (2016) studied that effects of some major fats and oils such as butter, bakery fat, hydrogenated fat, lard, margarine, palm oil, sunflower oil, coconut oil, and soybean oil on the physical and sensory characteristics of cookies.

Khaled *et al.* (2017) reported that the effect of using jojoba and *Moringa* protein concentrate as a fat mimetic on physical and sensory properties of cupcake using level of 25, 50, 75 per cent, respectively. The moisture content found increased in the cupcake with jojoba and *Moringa* protein concentrate with a significant difference at $p < 0.05$. Therefore, that absorption of water by the protein concentrates generally increased with temperature increased. Water absorption increased with the increasing levels of protein concentrate. The amount of protein found in the samples enriched with jojoba and *Moringa* protein had higher protein content. The values obtained in the analysis of lipids were 2.8 and 2.3 per cent for the samples with 75 per cent of jojoba and *Moringa* protein concentrate respectively and (5.3, 4.5 % respectively) for samples with 50 per cent jojoba protein and *Moringa* protein with significant difference at $P < 0.05$ when compared with those of control sample (10.2 %). Thus it can be indicate that the products have relatively low lipid.

2.4.1 Effect on Sensory Properties

Muhammad *et al.* (2008) evaluated the cookies were prepared from wheat germ oil (WGO). Normal shortening was replaced with WGO at the levels of 0, 25, 50, 75 and 100 per cent in the cookies formulation. The sensory properties of cookies prepared with different concentrations of WGO. Analysis of variance explicit that cookies differed significantly ($P \leq 0.05$) regarding various sensory attributes like taste, texture and overall acceptability but crispness, color and flavor found to be nonsignificant ($P > 0.05$) in this case. The cookies prepared with more than 50 per cent WGO had lower rating scores than the control for all attributes except crispness, which was similar ($P \leq 0.05$) to the control. Cookies prepared with WGO replacement levels upto 50 % had similar ($P \leq 0.05$) sensory scores as the control for all attributes except appearance and color in cookies prepared with WGO replacement levels upto 50 per cent which had higher scores than the control.

Arnab and Proshanta (2015) reported that sensory properties of cupcakes developed with incorporation of different amount of essential oil of betel leaf, i.e., 0.01, 0.005 and 0.001 per cent (v/w) of the flour. The results show that novel cupcake developed with 0.005 per cent oil occupied first place for colour and taste but second and forth places respectively, for aroma and mouth feel, while the control cakes occupied fourth place for taste and aroma and first and second places for mouth feel and colour respectively. A fair comparison therefore, clearly indicates that the developed cupcake (0.005 % oil) was the best and control cupcakes were the least preferred cakes while the other two cakes (0.01 and 0.001 % oil) occupied intermediate positions, which was also confirmed by overall scores.

Radhika *et al.* (2020) studied that cupcakes made from red palm olein received higher score (mean=3.29) in sensory evaluation as compared to cupcakes containing palm olein (mean=3.07). No statistical difference was found between the two oils of which most of the samples showed average score of likeliness. The attributes that were evaluated in this study were taste, colour, crust, inner texture, oiliness, waxiness, stickiness, mouth feel, odour, flavour and overall acceptance. Cupcakes baked with red palm olein showed equal acceptance average value 3.25 as compared to cupcakes containing palm olein average value 3.06.

2.4.2 Effect on Physical Properties

Jissy and Leelavathi (2006) reported that the physical characteristics of cookies made using different fats. The result showed that cookies containing sunflower oil had relatively higher spread value. Cookie dough containing the hydrogenated fat ('dalda') had significantly less spread.

Muhammad *et al.* (2008) investigated that the physical characteristics as diameter, thickness and spread ratio of cookies prepared from replacing wheat germ oil. Normal shortening was replaced with WGO at the levels of 0, 25, 50, 75 and 100 per cent in the cookies formulation. There were no significant ($P \leq 0.05$) differences between the values obtained for physical parameters of cookies prepared from WGO and the control (100 % Normal shortening) cookies.

Rangrej *et al.* (2015) reported that the physical characteristics of cookies made using flaxseed oil at different proportions. Significant increase in the weight of cookies was observed at 30 per cent shortening replacement with flaxseed oil and above. As the flaxseed oil content increased, significant increase in cookies diameter and thickness were observed. The lowest diameter of 48.13 ± 0.14 and thickness of 12.0 ± 0.18 were observed in control while the highest diameter of 54.23 ± 0.18 and thickness of 12.60 ± 0.11 were found in 50 % flaxseed oil cookies. Consequently, lowest spread ratio of 4.00 ± 0.05 in control cookies while the highest spread ratio of 4.30 ± 0.05 were observed at 50 per cent shortening replacement with flaxseed oil.

Khaled *et al.* (2017) reported that the effect of jojoba and *Moringa* protein concentrate on cupcake physical properties. Increasing of jojoba and *Moringa* protein substitution level increased weight property. Accordingly, increasing either jojoba and *Moringa* protein concentrate levels could bind more water led to increasing weight. The volume of cupcakes indicated that the maximum value for volume was observed in control sample (107.35 cm^3) followed by jojoba 25 and *Moringa* 25 while the minimum value was observed in jojoba 75 and *Moringa* 75. Increasing protein concentrate levels could led to decreased the volume and specific volume thinks to influence on gluten net with low strength and gas retention.

2.4.3 Effect on Textural Properties

Arnab and Proshanta (2015) studied that the hardness of betel leaf oil cake was highest among all the cupcakes Such hardness leads the new product towards a greater gumminess, which is much higher than all the other cakes but it did not impart any undesirability as would be evident from the overall values of organoleptic quality of the developed product. The value of gumminess is more as it is a product of hardness and cohesiveness. The value of springiness in the novel developed product was 1.44, whereas it was 0.55 for the control cake.

Jissy and Leelavathi (2006) reported that the force required to compress the cookie dough containing four different types of fats respectively. The cookie dough containing the non-emulsified hydrogenated fat ('dalda') was the hardest requiring more strength to compress it to the required extent. Cookie dough containing 'margarine' was the softest requiring the least force to compress it. Dough samples containing the bakery fat and sunflower oil respectively had almost similar textural properties that were marginally harder than that containing margarine. It is possible that dough made with oil is generally more cohesive and viscous and hence softer. Breaking strength showed that cookies containing the oil were the hardest. Cookies made using sunflower oil were the hardest while those containing the bakery fat were the least hard.

Rangrej *et al.* (2015) evaluated that the breaking strength of cookies showed that cookies containing more flaxseed oil were the hardest. Cookies containing shortening had the lowest breaking strength of 3.4 kgf while cookies containing 50 % flaxseed oil replaced with shortening had the highest breaking strength of 6.5 kgf.

2.5 Rheological Properties of Dough and Products

Rheology is the study of flow of materials, or more precisely, the mode of response by materials to specific deformation strains or stresses (Steffe, 1996). When a deformation is applied, individual polymers will produce distinct responses to stress or strain, and measuring the differences can provide valuable information about the makeup and structure of that material. Steffe (1996) outlines several areas in the food industries where rheological characterization is useful. These include calculations in process engineering for pipelines, pumps, extruders, mixer, heat exchangers and other equipment, ingredient functionality evaluation for product development of quality control relation of food texture data to sensory data and rheological constative equations since rheometry can reveal so many integral characteristics of material it has great potential for the study of wheat flour dough and regulation of dough processing performance. Effect of flour cultivar, ingredient and dough additives can be study through testing. A significant amount of research has been conducted on cultivar and ingredient effects in wheat flour dough rheology (Faubion and Hoseney, 1990).

Morteza *et al.* (2008) determined that the effects of soy-fortified bread on the sensory and rheological properties. Ground defatted soy flour was blended with wheat flour at 3, 7 and 12 per cent. The effect of this fortification on the rheological properties of the resulting dough was investigated using farinograph and extensograph for quality assessment of the final product.

Hasmadi and Sandra (2014) studied that fat is an important ingredient to providing desirable textural properties of baking products, particularly biscuit. The effect of fat types on dough rheological properties and quality of semi-sweet biscuit were investigated using various techniques. Texture profile and extensibility analysis were used to study the dough rheology.

Adriana *et al.* (2017) investigated that the effect of defatted rapeseed flour addition from which proteins were extracted (DRF) on quality characteristics of bread as a finished product by baking test, rheological and microstructural examination. The dough rheological properties were determined by using the Alveograph device and its microstructure was analyzed by using the epifluorescence light microscopy (EFLM).

Olugbenga *et al.* (2018) reported that farinograph analysis had acceptable mixing profile at 25 per cent defatted mango kernel flour incorporation, after which the mixing profile was adversely affected. The pasting temperature was between 65.8 and 75.6^{0}C; peak viscosity ranged between 448 and 521 BU while the final viscosity ranged between 594 and 709 BU.

Silvia and Georgiana (2019) reported that the replacing wheat flour with TSF (Tomato seed flour) increased dough development time, stability, and viscosity during the initial heating-cooling cycle and decreased alpha amylase activity. With the increase of TSF addition level in wheat flour the dough samples presented higher viscoelastic solid properties.

2.5.1 Amylograph

Leon *et al.* (2006) analyzed the effect of damaged starch levels in two different flours (wheat and triticale) on flour-thermal behavior of dough. They reported that the damaged starch content changed the thermal behavior of flour-water mixtures: the higher the levels of damaged starch the lower the starch-gelatinization enthalpy and the higher the melting enthalpy of amylase-lipid complexes. The flour viscosity during pasting decreased as their damaged starch content increased.

Chinma *et al.* (2014) reported that the effects of substituting germinated *Moringa* seed flour for wheat flour on the rheological properties of flour blends. Wheat and germinated *Moringa* seed flour were blended at different proportions. Pasting properties of wheat flour were influenced by germinated *Moringa* seed flour substitution.

Haroon and Sekhon (2014) studied that effect of soya flour addition to 70 per cent extraction bread wheat flour (PBW-343) at (0, 5, 10, 20 and 30 %) was investigated for physico-chemical, dough handling and pretzel making properties. Amylogram characteristics gelatinization temperature, peak viscosity, peak temperature and viscosity at 95°C decreased with extended rate of DSF addition.

Hassan *et al.* (2015) studied that ratios of starch used in wheat flour were 5, 10 and 15 per cent with 5 per cent lentil flour. Pasting temperature increased in the blends, while gelatinization temperature and gelatinization maximum decreased.

Zanwar (2020) showed that beginning of gelatinization temperature decreased, gelatinization temperature increased and gelatinization maximum decreased with addition of whole linseed flour.

Ana-Maria *et al.* (2020) studied that the dough rheological characteristics were analyzed for composite flours obtained through different blends between refined wheat flour and defatted flaxseed one. The flaxseed flour was incorporated in wheat flour to a substitution level of 0, 5, 10, 15 and 20 per cent. From the pasting point of view, compared to the control sample, the samples in which flaxseed were incorporated in wheat flour presented a lower falling number value and a higher peak viscosity one.

2.5.2 Farinograph

Sudha *et al.* (2010) reported that the defatted soy flour (DSF) and whey protein concentrate (WPC) having protein content of 54.1 and 61.9 per cent, respectively, were blended with wheat flour at 0–15 per cent. Incorporation of DSF increased the farinograph water absorption from 59.3 to 63.8 per cent, whereas addition of WPC decreased the water absorption to 53.5 per cent. The dough stability increased from 4.5 to 8.5 min with DSF. The increase in maximum pressure value was greater on addition of DSF. The peak viscosity value decreased from 818 to 657 and 587 BU on addition of DSF and WPC, respectively.

Ogunsina *et al.* (2011) studied the effects of replacing wheat flour with 0–15 per cent debittered *Moringa* seed (DBMS) flour on the dough rheology of wheat flour. Incorporation of an increasing amount of DBMS from 0 to 15 per cent decreased farinograph water absorption, dough stability, amylograph peak viscosity.

Atef *et al.* (2011) reported that the raw and germinated of either beans (GB) or cowpea (GC) flours, as a substitute for wheat (W) flour in cake production. The results should that the water absorption, dough development time (DDT) and dough weakening increments, mixing tolerance index (MTI) and dough stability decrements in the case of raw and germinated legumes flours, were observed. On the other hand, the mixing tolerance index values (MTI) was increased in the case of germinated legumes flour.

Haroon and Sekhon (2014) studied that effect of soya flour addition to 70 per cent extraction bread wheat flour (PBW-343) at (0, 5, 10, 20 and 30 %) was investigated for physico-chemical, dough handling and pretzel making properties. Results revealed that with increasing DSF addition, farinogram characteristics, water absorption, arrival time, dough development time and dough stability increased while mixing tolerance index and degree of softening decreased.

Hassan *et al.* (2015) studied that ratios of starch used in wheat flour were 5, 10 and 15 per cent with 5 per cent lentil flour. Addition of 5 and 10 per cent millet starch blends resulted in increase in gluten index to 94.00 and 96.33 respectively. Water absorption decreased to the value ranged between 57.50 to 59.50 per cent for 5 per cent wheat, sorghum and cassava starches blends. Addition of high percentage of starch results in low values of dough development time.

Muhammad *et al.* (2016) studied that the defatted sesame flour incorporated at the level of 0, 4, 8, 12, 16 per cent to the wheat flour. Increase in water absorption with increase in level of defatted sesame seed flour. Water absorption ranged from 60.40 to 64.40 per cent in different composite flours. The maximum softening of dough was observed in the 16 per cent sesame meal supplemented flour (90 BU). The highest dough development time was observed in the 16 per cent sesame meal supplemented flour (7.5 min) while the minimum (4.5 min) was observed in the 100 per cent wheat flour (control). The maximum dough stability was observed in the 16 per cent sesame meal supplemented flour (15 min), while the lowest dough stability (12 min) was observed in the 100 per cent wheat flour (control). It is reported that farinographic characteristics increased with the increase in protein content as well as improvement in gluten quality.

Mahmoud *et al.* (2018) evaluated the effect of FFF and DFF at different addition levels (5, 10 and 15 %) on the flour characteristics, dough rheological properties were investigated. The results of Mixolab analysis showed that flour water absorption and dough stability were decreased as FFF or DFF addition levels increased.

Mostafa *et al.* (2019) reported that the rheological properties of the dough's were found to be affected with flaxseed meal addition. The results showed that replacement 5 per cent of wheat flour by flaxseed meal flour increases the water absorption and development time of the dough.

Zanwar (2020) reported that present investigation was undertaken to study its rheological study by addition of deoiled linseed at different level. Increasing addition of deoiled linseed flour from 5 to 20 per cent, caused increase in water absorption (at 500 FU and 14 % moisture content), dough development time, time to breakdown and farinograph quality number whereas reduction was observed in dough stability and mixing tolerance index.

Ana-Maria *et al.* (2020) studied that the dough rheological characteristics were analyzed for composite flours obtained through different blends of flaxseed flour was incorporated in wheat flour to a substitution level of 0, 5, 10, 15 and 20 per cent. According to the obtained data it may be noticed that in general, flaxseed addition increased Farinograph values such as water absorption, dough stability, dough development time and decreased the degree of softening at 10 min.

2.5.3 Extensograph

Extensograph measures the stretching properties of the dough in a particular the resistance to extension and extensibility, to make reliable statement about the baking behavior of dough. Extensograph shows the influence of flour additives on rheological properties of dough.

The extensograph is designed to measure the balance of the elastic and viscous properties of dough extension and extensibility of the dough. The curve gives a measure of the resistance to extension and extensibility of the dough. Dough is mixed in farinograph, rounded and molded into cylinder. The cylinder dough is placed in the extensograph cradle and allowed to rest. At the end of the rest period the cradle containing the dough is placed in the instrument and the dough is stretched at a constant rate with a hook. The height of the resulting curve is related to the dough's resistance to extension. The distance the dough is stretched before it fails is the extensibility of the dough. Generally, for bread making a balance a these two factors are desirable. The procedure calls for stretching the dough after and before rest time of 30, 60 and 90 min. Extensibility tests are typically conducted on wheat dough to evaluate its tensile strength and extensibility characteristics which are heavily dependent on the protein quality (Dobraszczyk and Morgenstern, 2003).

The extensograph provided information about the viscoelastic property of dough. This equipment measures dough extensibility for its resistance to extension. A combination of the properties of good resistance and good extensibility indicate desirable dough (Walker and Hazetton, 1996).

Hassan *et al.* (2015) studied that ratios of starch used in wheat flour were 5, 10 and 15 per cent with 5 per cent lentil flour. The energy and the extensibility of the dough of wheat flour decreased with addition of different starches percentages and the dough resistance to extension increased.

Zanwar (2020) reported that the increasing addition of deoiled linseed flour from 5 to 20 per cent, the extensograph parameters revealed reduction in the energy, resistance to extension, extensibility, maximum (BU), whereas ratio number and ratio number (max) increased.

Ana-Maria *et al.* (2020) studied that the dough rheological characteristics the flaxseed flour was incorporated in wheat flour to a substitution level of 0, 5, 10, 15 and 20 per cent. During extension, flaxseed flour decreased dough strength and extensibility.

2.6 Storage Studies of Bakery Products

2.6.1 Effect on Proximate Composition

Cookies absorbed moisture from surrounding atmosphere due to hygroscopic behaviour of wheat flour. An increase in moisture contents of cookie samples during storage has also been changes on nutrient quality reported by Leelavathi and Rao (1993).

Sharoon *et al.* (2014) investigated that the moisture content showed considerable increment in all cookies fortified with linseed oil with increasing storage duration. This increase was primarily due to packaging material (Polythene bags). The packaging was not airtight and lack of temperature control resulted in an increase in moisture contents of cookies. Moreover, cookies absorbed moisture from surrounding atmosphere due to hygroscopic behavior of wheat flour. Reduction in protein content of cookies throughout storage might be due to increasing level of moisture which enhances proteolytic activity. This decline in fat content throughout storage might be due to moisture uptake by cookies from the surrounding air and break down of fats to different compounds. Decrease in crude fiber during storage might be due to increase in moisture content which was engrossed from air.

Sujitha and Thirumani (2014) reported that the value addition of developed breakfast biscuits are highly nutritious and it consists of whole grains like, whole wheat flour, buckwheat flour, black flour and flax seed flour, these are relatively rich in protein, fat, fiber, vitamins and minerals. The moisture content was increased in value added flour and breakfast biscuits in storage period. The nutrients were decreased at the end of the study period (60^{th} day).

Prasanth Kumar *et al.* (2014) studied that the biscuits were prepared with commercially available fat (CF) and oryzanol fortified fat (OFF). The control biscuits (CB) and oryzanol fortified biscuits (OFB) were packed in 200 gauge polypropylene pouches, stored at 27^0C with different relative humidity and analysed for its stability during storage of 120 days. Biscuits are moisture sensitive products and are able to develop oxidative rancidity and hydrolytic rancidity at very low moisture content. The moisture content of the stored biscuits mainly depends on the water vapour transmission rate (WVTR) of the packaging material and the storage conditions.

Biradar *et al.* (2020) investigated that the optimum level of little millet flour with wheat flour for the preparation of quality cookies. The quality cookies were prepared from 20 per cent wheat flour and 80 per cent little millet flour (WLF80). The selected treatments were packed in LDPE and PP and stored at ambient (30 ± 4^{0}C) for 90 days to study their storage feasibility. Protein, fat, crude fiber, carbohydrate, and iron decreased in ambient temperature during storage period of 3 month. The decrease in protein, fat, carbohydrate, crude fiber and iron and increase in moisture was more rapid in the samples stored in PP than LDPE during the storage period.

2.6.2 Effect on Fatty Acid Composition

Inkpen and Quackenbush (1989) opined that in soft wheat crackers, the per cent oleic acid was highest followed by palmitic, linoleic and stearic acids respectively.

Chen *et al.* (1994) stated that ground flaxseed does not lose significant amount of α-linolenic acid during baking in muffin mixes and the ground flaxseed readily absorbs oxygen under typical baking conditions but this did not markedly affect its fatty acid composition.

Singh *et al.* (2000) studied that free fatty acid content of soy-fortified biscuits and reported its increase with storage period. The increase in FFA content of soy biscuits was due to greater increase in their moisture content which promoted fat hydrolysis during storage

Vicario and Viviana (2003) reported a higher content of saturated fatty acid i.e. palmitic, stearic and oleic acids in butter cookies. Also, palmitic and oleic acid content were dominating than the stearic acid and among the polyunsaturated fatty acids, linoleic acid content was higher and linolenic acid content of cookies was very negligible.

Kaur *et al.* (2005) reported that formation of free fatty acids was higher in case of cookies stored in LDPE as compared to these stored in aluminium laminates and this could have been because of the fact that aluminium laminates protect biscuits against light, as light acts as catalyst for oxidation.

Nagi *et al.* (2012) studied that the packaging material and storage period tangibly affected free fatty acid content of biscuits containing full fat cereal brans. The free fatty acid value (2.70 %) was found to be significantly higher for rice bran fortified biscuits, whereas lowest values were obtained for oat bran biscuits (0.41 %). Significant variations were observed in free fatty acid contents of different cereal bran added biscuits. Packaging also manifested a conspicuous effect on the free fatty acid content of biscuits.

The free fatty acid content was higher in the product packed in HDPE pouches, than the laminate pouches.

Prasanth Kumar *et al.* (2014) studied that the free fatty acids formation is responsible for the undesirable aroma, flavor and bitterness in oryzanol fortified biscuits. The high free fatty acid content of the stored biscuits is mainly contributed by the partial hydrolysis of fats. The increase in FFA content of CB (0.36–0.49 %) and OFB (0.6–0.85 %) were significant during the storage period. The variance analysis showed significant increases in their FFA content (P<0.001). All the biscuits stored at different RH exhibited similar increasing trend in FFA.

2.6.3 Effect on Peroxide Value

Cunnane and Thompson (1995) reported that flaxseed either whole or coarsely ground, appears stable to long-term storage at room temperature. Even after 308 days at 22^0C there was essentially no change in peroxide value as a measure of oxidation by–products or in the percentage of α-linolenic acid in fat extracted from the stored flaxseed samples.

Jyotsna *et al.* (2012) reported that the there was some increase in the peroxide value of the control and flaxseed cookies.

Prasanth Kumar *et al.* (2014) reported that the large surface area of oryzanol fortified biscuits increases the exposure of oxygen and light and this may increase the possibility of oxidation. Although, PV is conventionally used for measuring the oxidative deterioration in fats and oils, accurate assessment of oxidative deterioration in biscuits cannot be made, because the peroxide formed during the early stages of oxidation may have been converted in to stable aldehydes, ketones, acids and alcohols. The CB were stable at 22 % RH and at 11 % RH have shown significant increase in PV (P<0.001) after 90 days of storage. The significant variation among the peroxide value of CB and OFB during the storage is mainly due to the oxidation of unsaturated fatty acids (MUFA: PUFA035:12) present in the OFB than the CB (MUFA: PUFA034:9).

Divyashree *et al.* (2016) investigated that the buckwheat-chia seeds fortified biscuits were stored in poly propylene pouches at room temperature and stored for 60 days. Peroxide value, the indicator of rate of auto oxidation, was increased significantly during storage from 7.09 to 22.18 meq O2/kg fat at the end of 60 days. In packed products, the rate of auto-oxidation is mainly governed by the oxygen retention in the pack, which in turn is related to the headspace and oxygen permeability of the packaging material.

2.6.4 Effect on Sensory Properties

Sathe and Salunkhe (1981) reported development of rancid flavour in crackers prepared from soy flour and groundnut flour after 60 days of storage.

Jood *et al.* (2001) reported gradual decrease in the organoleptic characteristics of β-carotene and iron rich biscuits and *shankarpara*. The colour changes during storage might be due to acceleration of Maillard reaction, absorption of moisture contents during storage stimulates Maillard reaction in cookies (Bender, 1996).

Kamran *et al.* (2003) studied that the storage had significant effect on colour of rice bran oil fortified cookies. The maximum score 7.30 was obtained at 0 day by all the cookies which was significantly decreased as the storage increased. The deterioration in colour of cookies might be due to the absorption of moisture from the atmosphere and oxidation of fats. The loss in flavor might be attributed to absorption of water that resulted in fat oxidation. As regarding taste of cookies, maximum score was obtained by fresh cookies (0 day) which was gradually decreased with storage days.

Kaur *et al.* (2005) reported that flavour changes were higher in case of cookies stored in LDPE as compared to those stored in laminate package because of the fact that aluminiun laminates protects the cookies from light which acts as catalyst for oxidation.

Prashant and Shere (2017) studied that the decrease in colour and appearance score in fiber rich cookies was less in PET jar as compared to LDPE pouch. The migration or absorption of moisture results in loss of colour during storage. There is also natural tendency of colour fading with progressive storage which ultimately affects the appearance. LDPE is having low moisture, light and oxygen barrier property which contributed to more colour changes during 90 days of storage studies. Storage period had pronounced effect on the flavour of the cookies and greatly affected the sensory quality of the cookies. Flavour score for all cookies was found to be progressively decreasing in LDPE. More pronounced effect was observed in oat cookies followed by control cookies which might be due to oxidation of fats.

Kulthe *et al.* (2018) investigated that the storage stability of cookies as influenced by different packaging materials, *viz.* low density polyethylene (LDPE-25µ), high density polyethylene (HDPE-25µ) and aluminium laminated pouches (20µ) was evaluated at ambient conditions. A gradual decrease in mean score for colour and appearance from 8.18 to 6.56 was observed for 180 days of storage. It is clear from the data that a gradual decrease in score for flavour from 7.85 to 6.37 was observed. The flavour retention was higher in case of laminated package (P_3) as compared to LDPE (P_1) and HDPE (P_2) packages. The flavouring compounds might be lost at higher rate during storage that lowered the flavour score. This might be due to high GTR of LDPE compared to other packaging materials. The texture score was found to be decreased from 8.00 to 6.40 during the storage of cookies for 6 months. The gradual decrease in texture score was due to softening effect resulting from gain of moisture during storage was observed. Cookies packed in LDPE (P_1) showed more moisture gain during storage and became soft compared to HDPE (P_2) and Laminate (P_3). This might be due to high water vapour transmission rate (WVTR) of LDPE as compared to HDPE and laminated packages.

2.6.5 Effect on Textural Properties

Sathe and Salunkhe (1981) reported softening of crackers packed in PP bags and stored at ambient conditions. This might be due to high water vapour transmission rate (WVTR).

Balloli (2011) reported that the barnyard millet flour cookies by the addition of garden cress seed and studied textural changes during storge and studied that the cookies lost their hardness.

Kulthe *et al.* (2014) reported higher reduction in crispiness of high protein low calorie cookies packed in LDPE and PP pouches than those packed in HDPE pouches during storage for 90 days.

Santina *et al.* (2014) reported that the change in hardness due to hygroscopic nature of ingredient. Increase in moisture during storage, affected also biscuit texture characteristics in term of hardness and crispiness loss.

Divyashree *et al.* (2016) studied that the breaking strength of the buckwheat- chia seeds fortified biscuits decreased from 17.42 to 14.18 N at the end of 60 days of storage affecting the crispiness. The moisture and water activity plays an important role in dry foods hardness. The decrease in hardness of biscuits might be due to moisture migration and redistribution as well physical changes of main biscuits components and their interaction.

Seema and Charanjit (2020) evaluated that the texture changes during storage at room temperature, in terms of hardness of cookies samples of raw and germinated millets. Hardness decreased with increase in storage time of cookies packed in both METPPE and LDPE, whereas, decrease was more in cookies packed in LDPE laminate as compared to cookies packed in METPPE laminated.

2.6.6 Effect on Microbial Quality

Nagi *et al.* (2012) stated that the packaging material had non-significant effect on the microbial quality of biscuits, however, growth was observed more in cereal bran biscuits packed in HDPE than the laminate packed biscuits.

Berwal *et al.* (2013) investigated that the yeast and mould growth was only detected after 60^{th} day of storage and had very less growth 3 to 9 cfu/g in chicken meat mince incorporated cookies throughout the storage period.

Deshmukh (2017) studied that the yeast and mould count gradually increased in garden cress seed oil biscuits during storage period. The sample packed in LDPE showed higher yeast and mould count than the HDPE and aluminium foil packages on the 180 days of the storage. This might be due to higher WVTR and GTR of LDPE than HDPE but it was negligible in aluminium foil.

3. MATERIALS AND METHODS

The present investigation entitled "Studies on characterization and value addition of *Moringa* seed oil and defatted flour in different bakery products" was carried out in Department of Food Science and Technology, Post Graduate Institute, Mahatma Krishi Vidyapeeth and Dr. Annasaheb Shinde College of Agricultural Engineering and Technology, Mahatma Phule Krishi Vidyapeeth, Rahuri, during academic year 2017-2020. The details of materials used and methodologies adopted during the course of investigation are described in this chapter. The methodologies on extraction and characterization of oil and defatted seed flour from *Moringa* seed, preparation of biscuits and cupcake and quality evaluation of dough, biscuits and cupcake are reported under following heads.

3.1 Materials

3.1.1 Raw Materials

The raw materials such as wheat varieties *Trimbak* (NIAW 301) and Phule *Samadhan* (NIAW 1994) were obtained from Wheat Research Station Niphad, Dist.- Nashik. *Moringa* seeds variety PKM-1 procured from S. K. International, Vadodara, Gujrat.

3.1.2 Ingredients For Bakery Product

Other ingredients sugar, vanaspti (dalda), sodium bicarbonate, ammonium bicarbonate, baking powder, egg and vanilla essence were procured from local market were used for the preparation of biscuits and cupcake.

3.1.3 Chemicals and Glasswares

Most of the chemicals used in this investigation were obtained from M/s British drug house Mumbai, M/s Dodal Enterprises Aurangabad, E-Merk (India) Limited, Mumbai - 400 018, Qualigen Fine Chemicals, Galaxo Smith Kline Pharmaceuticals Limited, Mumbai 400 025, Thermo Fisher Scientific India Pvt. Ltd., 403 404, B-Wing Delphi, Hiranadani Business Park Powai, Mumbai 400 076, Fine Chemicals Limited Ahmedabad – 380 006 (India).

3.1.4 Equipments and Instruments

The different equipments used in this investigation like flour mill, mixer or grinder, sieve, hand molder, baking oven, weighing balance were available from the Department of Food Science and Technology, Mahatma Phule Krishi Vidyapeeth, Rahuri. The instruments like Brabender Amylograph, Farinograph, Extensiograph, available in Department of Agricultural Process Engineering, Dr. Annasaheb Shinde College of Agricultural Engineering and Technology, Mahatma Phule Krishi Vidyapeeth, Rahuri, were used for the study of rheological properties of dough.

Instron texture analyzer, colour analyser, viscometer available in Department of Agricultural Process Engineering, Dr. Annasaheb Shinde College of Agricultural Engineering and Technology, Mahatma Phule Krishi Vidyapeeth, Rahuri were used.

The machinery available in pilot bakery unit of the Department of Food Science and Technology were used for making biscuits and cupcake.

3.1.5 Packaging Material

Packaging materials such as low density polyethylene, butter paper and Laminated pouch purchased from local market of Rahuri and Ahmednagar.

3.2 Methods

3.2.1 Cleaning of *Moringa* Seeds and Wheat Grains

The *Moringa* seed kernel and wheat grains were thoroughly cleaned and made free from dust and other foreign materials and used for the preparation of flour and extraction of oil.

3.2.2 Separation of Shell from *Moringa* Seeds

Separation of shell from seed by using mortal pastel by manually.

3.2.3 Extraction of Oil from *Moringa* Seed Kernel

The oil from *Moringa* seed powder was extracted by using Soxhlet solvent extraction method (A.O.A.C., 2000). The oil was collected in clean PET bottle and stored for further analysis.

3.2.4 Physical Properties of Wheat Grains and *Moringa* Seed Kernel

The knowledge of physical properties such as thousand grains and *Moringa* seeds weights, bulk density, true density, porosity, conveying, drying, aeration of grains is necessary for the effective and proper design of various separating, handling, storing and drying systems (Sahay and Singh, 1994; Tabatabaeefar, 2000). Therefore, in designing the proper equipment for the processing, transportation, separation and storing of the grains and seeds it is necessary to have reliable results about the physical properties of grains and *Moringa* seeds.

3.2.4.1 Colour

Colour of *Moringa* seeds kernel was determined by visual observation.

3.2.4.2 Average Size

The average size (Length, Width and Thickness) was determined based on 4 randomly selected seeds. The length, width and the thickness were measured at tapering point. All the dimensions were measured using a digital caliper with an accuracy of 0.01 mm.

3.2.4.3 Thousand kernel weight

Thousand kernel weight was determined by taking 1000 kernels of *Moringa* seeds and wheat seed and taking its weight.

3.2.4.4 Bulk density

The bulk density was measured by pouring seeds into a stainless steel cylinder of known volume and removing excess seeds by rolling a cylindrical glass rod on the rim of the container without compacting the seeds (Carman, 1996; Konak *et al.,* 2002).

3.2.4.5 True density

True density was determined as the ratio of sample mass to the true volume of the seeds using the toluene displacement method (Nimkar and Chattopadhyay, 2001; Aydin, 2003; Konak *et al.,* 2002).

3.2.4.6 Porosity

The porosity of the sample seeds were computed from the values of true density and bulk density of the seeds, ε was calculated using following equation (Mohsenin, 1986).

$$\varepsilon = \left(1 \; \frac{pb}{pt} \right)$$

Where,

pb and pt are the bulk and true density, respectively in kg m^{-3}.

3.2.5 Physicochemical Characterization of *Moringa* Seed Oil

3.2.5.1 Colour

Colour of *Moringa* seed oil was measured by colour scanning machine (Plate 3.4). It works on principle of focusing the light and measures energy reflected from the sample across the entire visible spectrum. It provides reading in terms of L*, a* and b*. Where, luminance (L*) forms the vertical axis, which indicates whiteness (+) to darkness (-). In the same way a* indicates redness (+) to greenness (-) and b* indicates yellowness (+) to blueness (-).

The instrument was standardized before placing the sample by placing black tile and white tile provided with the instrument. It can also be cross checked by placing the white tile which was provided by the L*, a* and b* values. The sample was filled in the sample cup. The deviation of the colour of the sample to standard was observed and recorded in the computer interface.

3.2.5.2 Viscosity

Viscosity was measured by Brookfield viscometer (Plate 3.5) according to method of A.O.A.C. (1990) and represented in millipascal second (mPas).

3.2.5.3 Specific gravity

Preparation of sample

The oil sample was filtered through a filter paper to remove any impurities and the last traces of moisture. It was confirmed that the sample was completely dry. The sample was cooled at 30^0C.

Procedure

The dry specific gravity bottle was filled with prepared sample in such a manner to prevent entrapment of air bubble after removing the cap of the side arm. The stopper was inserted and it was immersed in water bath at 30 ºC and hold for 30 minutes. Carefully wiped off any oil that had come out of the capillary opening. The bottle was removed from the bath, it was cleaned and dried thoroughly. The cap of the side arm was removed and quickly weighed (A.O.A.C., 2000).

$$\text{Specific gravity at } 30^0\text{C} = \frac{A - B}{C - B}$$

Where,

A is weight in g of specific gravity bottle with oil at 30^0C

B is weight in g of specific gravity bottle at 30^0C

C is weight in g of specific gravity bottle with water at 30^0C

3.2.5.4 Saponification value

Saponification value is a measure of molecular weight of fatty acids present in the oil and amount of alkali required to saponify fatty acid in given weight of oil. A known quantity of oil was refluxed with an excess amount of alcoholic KOH after saponification, remaining KOH was estimated by titrating it against standard acid. Saponification values of *Moringa* seed oil and prepared products were determined by titration method (A.O.A.C., 2000).

Reagents

Hydrochloric acid 0.5N

Alcoholic potassium hydroxide solution

Phenolphthalein indicator

Procedure

Weigh 1 g of fat melt the fat sample if it is not in liquid form. Then add 50 ml alcoholic potassium hydroxide solution. Connect the condensers to the flask and boil gently for 30 minutes on steam bath under reflux. After cooling to room temperature and 1 ml of phenolphthalein indicator. Pink colour will appear. Then titrate with the 0.5N HCl until pink colour disappear. Noted the volume of 0.5 N HCl used for titration.

3.2.5.5 Iodine value

The iodine value is a measure of the degree of unsaturation of fatty acids and is used to characterize oils and fats. Halogens add across the double bonds of unsaturated fatty acids to form additional compounds. Iodine monochloride (ICL) is allowed to react with the fat in the dark. Iodine gets incorporated into fatty the fatty acids chain wherever the double bonds exists. The amount of iodine consumed is then determined by titrating the iodine released (after adding KI) with standard thiosulphate and comparing with blank in which the fat is omitted. Hence, the measure of iodine absorbed by an oil or fat gives the degree of unsaturation. Iodine value of *Moringa* seed oil and prepared product was determined by titration method (A.O.A.C., 2000).

Reagents

Potassium iodide solution

Potassium dichromate 0.1 N

Starch indicator

Sodium thiosulphate 0.1 N

Wij's solution

Carbon tetrachloride

Procedure

Taken 20 ml of carbon tetrachloride in to a flask and added 0.5-1 g of oil or fat and 25 ml of wij's solution. Stirred the flask, stopper it and kept in a dark place for 30 minutes at room temperature. Then added 20 ml potassium iodide and 10 ml water. Titrate it with 0.1 N sodium thiosulphate till yellow colour disappears. Add 1-2 ml starch indicator solution and continued titration until the blue colour disappear. Noted the volume of sodium thiosulphate used.

$$\text{Iodine value} = \frac{(B - S) \times N \times 0.1269}{W}$$

Where,

B = Blank reading

S = Sample reading

N = Normality of Sodium thiosulphate

W = Weight of sample

3.2.5.6 Acid value

The fatty acid in oil was estimated by titrating it against NaOH in presence of phenolphthalein indicator. The acid number is defined as mg of NaOH required to neutralize the free fatty acids present in 1 g of sample. However, the free fatty acid content was expressed as oleic acid equivalent. Acid values of *Moringa* seed oil and prepared product were determined by titration method (A.O.A.C., 2000).

Reagents

Sodium hydroxide 0.25 N

Neutralized alcohol 99 per cent

Phenolphthalein indicator

Procedure

Weighed 10 g of oil in a flask then added 50 ml of neutralized alcohol to dissolve the oil. Added phenolphthalein indicator and titrated with 0.25 N NaOH. Shaked vigorously while titrating, till pink colour persists for 30 seconds. Noted the volume of 0.25 N NaOH used.

$$\text{Acid value} = \frac{V \times N \times 56.1}{W}$$

Where,

V = Volume of NaOH required for titration

N = Normality of NaOH

W = Weight of sample

3.2.5.7 Peroxide value

Peroxide value is a measure of the peroxides contained oil and oxidative rancidity of the oil and it is one of the most important chemical characteristics for assessing the degree of deterioration of fats and oils. The peroxides present were determined by titration against sodium thiosulphate in the presence of KI. Starch is used as an indicator. The fatty acid peroxide is thought to liberate iodine. Peroxide value of *Moringa* seed oil and prepared bakery products was determined by titration method (A.O.A.C., 2000).

Reagents

1. Saturated potassium iodide (KI)- dissolve excess amount of KI in fresh boiled water. Excess solid should be remaining. Kept in dark.
2. Standard 0.01N $Na_2S_2O_3$-$5H_2O$ (Standard against 0.01N $K_2Cr_2O_7$)
3. 1 % Starch- 1g of starch in 10ml water. Pour the suspension into 90ml of boiling water for 2 minutes.

Procedure

Five g of oil sample was dissolved in CH_3COOH:$CHCl_3$. Mixed and dissolved the oil completely. 0.5ml of saturated KI was added in the above mixture. Mixed well and allowed to stand for 1 minute. Added 430ml water in the mixture and added 3-4 drops of starch and mixed well. Then the mixture was titrated against standard 0.01N $Na_2S_2O_3$ $5H_2O$ until the blue colour disappears. If less than 0.5 ml of 0.1 N $Na_2S_2O_3$ is used repeat using 0.01 N $Na_2S_2O_3$. Conducted blank determination (must be less than 0.1 ml 0.1 N $Na_2S_2O_3$).

$$\text{Peroxide value} = \frac{(B - S) \times N \times 100}{W}$$

Where,

B = Blank reading

S = Sample reading

N = Normality of $Na_2S_2O_3$ $5H_2O$

W = Weight of sample

3.2.5.8 Ester value

The ester value is the number of milligrams of potassium hydroxide required to saponify the ester present in 1 g of the substance. The acid value and saponification value of *Moringa* seed oil was determined (as mentioned above). Ester value of *Moringa* seed oil was calculated by subtracting acid value from saponification value (A.O.A.C 2000).

Ester value = Saponification value – Acid value

3.2.5.9 Fatty acid profile of *Moringa* seed oil

Fatty acid analysis of *Moringa* seed oil was carried out by gas liquid chromatography method. Fatty acid methyl esters (FAME) were prepared according to the method of Morrison and Smith (1964). An MSO sample (10-20 mg) was saponified for 1 h with 1 ml of methanolic KOH (0.7 N) at 60^0C, followed by neutralisation with 1 ml of methanolic HCL (0.7 N). The resulting free fatty acids were extracted in hexane and evaporated to dryness. The fatty acids were methylated using boron trifluoride (14% in methanol) and 0.2 ml benzene. The FAME were extracted in hexane, washed with water and evaporated to dryness. Fatty acid analysis was performed using a gas-liquid chromatograph (Shimadzu, GC-14B, Shimadzu Corporation, Japan) fitted with a fused silica capillary column (BP 21:30 m length, 0.30 mm i.d., 0.50 µm film thickness). The GC was equipped with a flame ionization detector and Clarity Lite 420 integrator. The above-mentioned analysis was carried out using isothermal conditions. The column temperature was set at 220^0C, the injector temperature at 230^0C and the detector temperature at 240^0C. nitrogen was used as the carrier gas with a flow rate of 1 ml/min. Individual fatty acids in the sample were identified by comparison with the retention times of standard fatty acid methyl esters.

3.2.6 Rheological Properties of Different Wheat Flour Variety *Trimbak* (NIAW-301) and *Samadhan* (NIAW-1994) Blended with Defatted *Moringa* Seed Flour

Rheological properties of dough incorporated with defatted *Moringa* seed flour were evaluated using farinograph, extensograph and amylograph. Farinograms, extensogram and amylogram were determined according to AACC approved methods No. 54-21[(1)], 54-10[(2)] and 22-10[(3)] respectively (A.A.C.C., 1983).

3.2.6.1 Amylograph

In amylograph rotating a suspension of flour and distilled water was heated with a constant heating rate of 1.5^{0}C/min within a rotating bowl. Depending on the viscosity of the suspension, a measuring sensor reaching into the bowl was deflected. This deflection was measured as viscosity over time vs temperature and recorded on-line.

Method

1. A sample of 80 g of flour was combined with 450 ml of distilled water and mixed to make slurry.
2. The slurry was stirred while being heated in the amylograph, beginning at 30^{0}C and increasing at constant rate of 1.5^{0}C per minute until the slurry reaches 95^{0}C.
3. The amylograph recorded the resistance to stirring as a viscosity curve on graph paper.

Amylograph evaluation result

The parameters like beginning of the gelatinization, gelatinization temperature and gelatinization maximum obtained from the amylograph were evaluated.

Amylograph technical specification

Option	Language	English	
Setting			
1)	General	Interface	COM2
		Demo speed	x10
		Basic moisture	14%
		Printing	
		Print Graphics with border	X
		Print logo	X
		Print logo right	•
		Accoustic alarm by end test	X
Toolbar	Test	Test Parameters	
		Method	Flour
		Operator	Musale S. V.
		Sample	DMSF
		Moisture	14%
		Sample weight	80 g
		Water	450 ml
		Starting temperature	30 ºC
		Heating rate	1.5 ºC/min

3.2.6.2 Farinograph

The farinograph consists of a drive unit with continuous speed control and an attached measuring mixer for mixing the dough to be tested. Flour/water suspension is into the heated measuring mixer where it is subjected to a defined mechanical stress by the rotating mixer blades. The resistance of the dough against the blades, which depends on the dough viscosity, is measured as torque, recorded and plotted online as a function of time in a clear color diagram recording values of water absorption, dough development time, dough stability, degree of softening, consistency and farinograph quality number.

Method

1. A flour samples of 50 or 300 g on 14 per cent moisture basis were weighed and placed into the corresponding farinograph mixing bowl.
2. Water from a burette was added to the flour and mixed to form a dough.
3. As the dough was mixed, the farinograph recorded a curve on graph paper.
4. The amount of water added (absorption) which affected the position of the curve on the graph paper. Less water increased dough consistency and moved the curve upward.
5. The curve was centred on the 500-brabender unit (BU) line ± 20 BU by adding the appropriate amount of water and it was ran until the curve leaves the 500-BU line.

Farinograph evaluation

The parameters like water absorption, dough development time, dough stability, mixing tolerance index, time to breakdown and farinograph quality number obtained from the farinograph were evaluated.

Farinograph technical specifications

Option	**Language**	**English**	
Setting			
1.	Graphics	Time scale	20 min
		For long measurement	Expand
		Line width curve	3
		Line width evaluation	4
2.	Basic setting	Convert old files to test	Database (MS access)
		Reference test	Database (MS access)
		Demo speed	X 12
		Mixer speed	200/min
		Basic moisture content	14%
		Interface	Farinograph E USB
		Serial port torque	COM 3
		Serial port speed	COM 7
		Acoustic alarm by end test	√
		Stop motor by end test	√

Option	Language	English	
3.	Printing	Print graphics with border	√
		Logo-print logo	√
		Logo-right	√
		Foot note	Brabender OHG Kulturstr
			51-55, 47055, Duisburg
Toolbar	Test	Test parameters	
		Date	
		Operator name	Musale S. V.
		Mixer	300 g
		Evaluation	BRABENDER/ICC/BIPEA
		Consistency	500 FU
		Comparison with reference test	No
		Sample	Defatted *Moringa* seed flour
		Moisture content	14%
		Sample weight	300 g
		Time of test	20 min
		Water absorption	See table
		Speed	63
		Remarks	Addition defatted *Moringa* seed flour

3.2.6.3 Extensograph

The extensograms shown by extensograph recorded online and represented as a color diagram on the monitor, shows the exerted force as a function of the stretching length (time). The shape of the measuring curve and its variation during the individual proving times, the area below the curve as well as the numerical values of the different evaluation points, permit to make reliable and reproducible statements as to the flour quality and the suitability of the flour for baking. Furthermore, the influence of flour additives on the flour characteristics can be made evident.

Method

Preparation

1. A 300 g flour sample on a 14 per cent moisture basis was combined with a salt solution and mixed in the farinograph to form dough.
2. After the dough was rested for 5 min, it is mixed to maximum consistency (Peak time).

Analysis

1. A 150 g sample of prepared dough was placed on the extensograph rounder and shaped in to a ball.
2. The ball of dough was removed from the rounder and shaped into a cylinder.
3. The dough cylinder was placed into the extensograph dough cradle, secured with pins, and rested for 45 min in a controlled environment.
4. A hook was drawn through the dough, stretching it downwards until it breaks.
5. The extensograph recorded a curve on graph paper as the test was run.
6. The same dough was shaped and stretched at 90 min.

Extensograph evaluation

The parameters like energy required for extension, resistance to extension, extensibility, maximum, ratio number and ratio number (max) obtained from the extensograph were evaluated.

Extensograph technical specification

Option	**Language**	**English**	
Setting			
1)	Graphics	Line width curve	2
		Printing	
		Print graphics with border	X
		Logo print logo	X
		Logo print right	•
2)	Adjustage	Schnittstelle	COM2
		Show test info In the sample list	X
Toolbar	Test	Test parameters	
		Operator name	Musale S.V.
		Duplication	Yes
		Test	3
			30, 60 and 90
		Times after	Minutes
		Sample	DMSF
		Water absorption	See table

3.2.7 Experimental Design

3.2.7.1 Preparation of biscuits and cupcake

Based on review of literature and preliminary trials, the experimental work plan was prepared and experimental parameters were identified. The detailed work plan, sample variables and experimental designs are given below. Biscuits and cupcake prepared by value addition of appropriate amount of *Moringa* seed oil (MSO). Biscuits and cupcake were prepared using following proportion as shown in Table 3.1.

Biscuits and cupcake prepared by value addition of appropriate amount defatted *Moringa* seed flour (DMSF). Biscuits and cupcake were prepared using following proportion as shown in Table 3.2.

Table 3.1 Different formulation of *Moringa* seed oil used for the preparation of bakery products (Biscuits and cupcake)

Variety	Treatment	Vanaspati: *Moringa* seed oil
Trimbak (NIAW-301)	T_0	100:00
	T_1	80:20
	T_2	60:40
	T_3	40:60
	T_4	20:80
	T_5	00:100
Samadhan (NIAW-1994)	T_0	100:00
	T_1	80:20
	T_2	60:40
	T_3	40:60
	T_4	20:80
	T_5	00:100

Table 3.2 Different formulation of defatted *Moringa* seed flour used for the preparation of bakery products (Biscuits and cupcake)

Variety	Treatment	Wheat flour: Defatted *Moringa* seed flour
Trimbak (NIAW-301)	T_0	100:00
	T_1	95:05
	T_2	90:10
	T_3	85:15
	T_4	80:20
	T_5	75:25
Samadhan (NIAW-1994)	T_0	100:00
	T_1	95:05
	T_2	90:10
	T_3	85:15
	T_4	80:20
	T_5	75:25

Table 3.3 Recipe for the preparation of biscuits

Ingredients	**Quantity (g)**
Flour (g)	100
Sugar (g)	50
Vanaspati fat (g)	50
Sodium bicarbonate (g)	0.5
Ammonium bicarbonate (g)	0.5
Water	As per req.

Flour

Dried Mixed
(Flour, sodium bicarbonate, ammonium bicarbonate)

Sugar + Hydrogenated fat

Mixed thoroughly
↓
Pasted

↓
Mixed thoroughly the dried mix and pasted
↓
Dough was formed
↓
Rolled into proper shape and size
↓
Cut with impression cutter
↓
Baking was done at 180 ^{0}C for 12 min
↓
Biscuits
↓
Cooled to room temperature
↓
Packed
↓
Storage

Fig. 3.1 Flow sheet for preparation of biscuits

Table 3.4 Recipe for preparation of cupcake

Ingredients	Quantity (g)
Flour (g)	100
Sugar (g)	85.00
Vanaspati fat (g)	68.00
Sodium bicarbonate (g)	2.00
Eggs (no.)	1.00
Baking Powder	2.00
Essence (ml)	2.00
Water	As per req.

Flour
↓
Dried Mixed
(Flour, sodium bicarbonate, baking powder)

Mixed sugar and shortening to foam cream
↓
Beaten the eggs to foam form
↓
Mixed beaten egg and foam cream

↓
Added dried mixture in egg foam and cream to form batter
↓
Mixed batter in one direction
↓
Placed batter in cups
↓
Baking was done at 190 ^{0}C for 15-25 min in electric baking oven
↓
Cooled to ambient temperature
↓
Cupcakes
↓
Packed
↓
Storage

Fig. 3.2 Flow sheet for preparation of cupcake

3.2.8 Physical Analysis of Biscuits and Cupcake

3.2.8.1 Physical parameter of biscuits

Weight, diameter and thickness

The weight, diameter and thickness of biscuits were calculated as per A.A.C.C. (2000) methods. Weight in terms of grams (g) was measured using electronic weighing balance. Diameter and thickness of biscuits in terms of millimeter (mm) were measured with the help of Vernier caliper having least count 0.01.

Spread ratio

Spread ratio of biscuits was calculated by A.A.C.C. (2000) method. It was estimated as ratio of diameter to thickness of biscuits.

Spread factor (%)

As per A.A.C.C. (2000) method the spread factor of control sample was considered to be standard (100 %) and spread factor of another samples of biscuits was determined in comparison with the standard value. It was expressed in terms of percentage.

3.2.8.2 Physical parameter of cupcake

Cupcakes were analyzed for physical quality attributes. Weight (g), volume (cm^3), bulk density (g/cm^3), specific volume (cm^3/g) and height (cm) were determined by methods given in A.A.C.C. (2000).

Weight

Weight of cupcakes was determined by using electronic weighing balance.

Volume

Volume of cupcakes were measured by rapeseed displacement method in which 100 ml measuring cylinder was taken, filled half with rapeseeds and put the cake sample and filled the remaining space with rapeseeds. The cake samples were removed. The cylinder was again filled with rapeseeds and the volume was measured.

Bulk density

Bulk density of cupcakes was measured by using weight / volume. The cake sample was taken in 100 ml measuring cylinder and its weight and volume were measured and bulk density was determined.

Specific volume

Specific volume of cupcakes was determined by volume / weight formula.

Height

Height of cupcake was determined by using scale expressed in "cm".

3.2.8.3 Textural analysis of biscuits

Textural analysis of biscuits was performed for cutting force, crushing force and penetration force by using Instron Universal Texturometer in the instrumentation laboratory, Department of Agriculture Process Engineering, Dr. Annasaheb Shinde college of Agriculture Engineering and Technology, MPKV, Rahuri. Each biscuit and cupcake were placed on the loading cell and compressed.

Cutting force of biscuits

Cutting force of biscuits was measured using HDP/BS blade of texture analyzer. The individual samples of cookies were placed on the platform and the blade was attached to the crosshead of the instrument. The TA setting was kept at: pre-test speed of 2 mm/s, test speed of 3 mm/s; post- test speed 10 mm/s. the absolute peak force of the resulting curve was considered as cutting strength of the cookies (Singh *et al.* 1993).

Crushing force of biscuits

Crushing force of biscuits was measured using HDP/BS blade of texture analyzer. The individual sample of cookies were placed on the platform and the blade was attached to the crosshead of the instrument. The TA setting was kept at: pre-test speed of 2 mm/s, test speed of 3 mm/s; post- test speed 10 mm/s. the absolute peak force of the resulting curve was considered as cutting strength of the cookies (Bourne, 2002; Singh *et al.* 1993).

Penetration force of biscuits

Penetration force of biscuits was measured using cylindrical prob of texture analyzer. The individual sample of cookies were placed on the platform and the blade was attached to the crosshead of the instrument. The TA setting was kept at: pre-test speed of 2 mm/s, test speed of 0.5 mm/s; post- test speed 10 mm/s. the absolute peak force of the resulting curve was considered as cutting strength of the cookies (Bourne, 2002; Singh *et al.,* 1993).

3.2.8.4 Textural analysis of cupcake

Stable Micro System TA_XT plus Texture Analyzer was used for texture profile analysis (TPA) of cupcakes. Instrumental analysis of textural properties of cupcake was performed to record springiness. Each cupcake was cut into 2.5 cm sided cube, where the upper and lower crusts were eliminated. A 75 mm diameter aluminium plate (P/75) was used for compression. Cupcake cube was compressed twice to obtain the texture parameters (springiness). The test was performed under the following states:

Test speed : 1 mm/s

Strain : 50 %

Trigger force : 5 g.

$$\text{Springiness (mm)} = \frac{\text{Length 2}}{\text{Length 1}}$$

3.2.9 Chemical Analysis of Wheat Flour (*Trimbak* and *Samadhan*), Raw *Moringa* Seed Flour, Defatted *Moringa* Seed Flour, Biscuits and Cupcake

Chemical analysis was carried out for wheat flour, *Moringa* seed oil and defatted *Moringa* seed flour as well as for finished food products biscuits and cupcake by following methods.

3.2.9.1 Moisture

A weighed sample 5 g was taken in a tare moisture box and was weighed accurately using a single pan digital balance of 0.0001 g sensitivity to get the exact weight of the sample. It was kept in hot air electric oven maintained at temperature of 105 ± 1^0C for 4 hours. The sample was taken out of oven, cooled in desiccators and weighed. The procedure was repeated until a constant weight was obtained (A.O.A.C., 2000).

$$\text{Moisture (\%)} = \frac{W_1 - W_2}{W_1 - W} \times 100$$

Where,

W_1 = Weight (g) of the dish with the material before drying

W_2 = Weight (g) of the dish with the material after drying

W = Weight (g) of the empty dish

3.2.9.2 Fat

The fat content was determined by the ether extraction using soxhlets apparatus.

Reagent

Petroleum ether having a boiling point of 40-60^0C.

Procedure

About 5 g sample was taken on filter paper and made a suitable size packet. The packet was placed in extraction flask of Soxhlets unit and attached it to collecting flask. One and half siphonful of solvent was poured through extraction flask into pre weighed collecting flask. Assembly condenser was connected to tap water and the flask was heated at 60^0C. Sample with 6-8 siphoning was extracted and most of the solvent was distilled off to extraction flask. The collecting flask was dried on water bath and then at 100^0C for 1 hr in oven. The flask was cooled and weighed. Increase in weight of flask represented crude fat content. Per cent fat content in the sample was calculated using formula.

$$\text{Crude fat (\%)} = \frac{A - B}{\text{Weight of sample (g)}} \times 100$$

A = Weight of flask containing fat residue after evaporation of solvent (g)

B = Weight of dry empty flask (g)

3.2.9.3 Protein

The protein content was determined by Micro- Kjeldahl's apparatus.

Reagents

1. N- free sulphuric acid
2. Catalyst mixture Potassium sulphate (9.9 g), mercuric oxide (0.41 g), Copper sulphate (0.8 g) were weight, mixed and ground into a fine powder.
3. Sodium hydroxide (50 %, w/v): 50 g Sodium hydroxide and 5 g sodium thio-sulphate were dissolved in distilled water separately, mixed and the volume was made up to 100 ml with distilled water.
4. Hydrogen peroxide (30 %, v/v) commercially available in the market.
5. Boric acid (4 %) 4 g of boric acid was dissolved in distilled water and the volume was made up to 100 ml with distilled water.
6. Mixed indicator (Dissolved separately 0.2per cent each of bromo-cresol green and methyl red indicators in 95% ethyl alcohol and mixed together in 5 : 1, respectively and transferred to bottle provided with stopper)
7. Standard hydrochloric acid (Diluted 0.17 ml conc. HCL to 100 ml with water and checked the concentration against 0.02 N sodium hydroxide).

Procedure

About 0.2 g defatted sample was taken and transferred to the digestion flask. The catalyst mixture 1g and 5 ml each of H_2O_2 and conc. H_2SO_4 were added carefully. The sample was digested until it became colorless by frequent rotating flask. The flask was cooled and 5 ml portion of water was slowly added with mixing. After cooling, the content was transferred to 50 ml volumetric flask with 2-3 rising and the volume was made up with distilled water and mixed thoroughly. Blank digestion was carried out simultaneously. The distillation unit was cleaned by starting and sucking back the water. The beaker of 100 ml capacity containing 10 ml boric acid, 4 drops of indicator was taken and placed under condenser with its tip dipped in solution. The digest (5 ml) with rinsing was transferred to distillation flask, 5 ml NaOH was added and closed with stop cork. The digest was allowed to boil and about 50 ml distillate of ammonia liberated in boric acid was collected. The distillate was titrated with standard hydrochloric acid until blue color disappeared and finally to pink red at the end of titration. Blank titration was carried out simultaneously. Protein content was calculated using following formula.

$$N (\%) = \frac{(S-B) \times N \times 0.014 \times \text{Volume taken (ml)}}{\text{Weight of sample (g)}} \times 100$$

Where,

S = ml of HCL required for sample titration

B = ml of HCL required for blank titration

N = Normality of HCL (0.01N)

Protein (%) = Nitrogen (%) × 6.25

3.2.9.4 Crude fibre

Reagents

Sulphuric acid (0.255 N)

Sodium Hydroxide (0.313N)

Potassium Sulphate (10% solution)

Procedure

About 2 g fat free residue was taken and then transferred to the digestion flask. 200 ml boiling sulphuric acid was added and immediately the flask was connected to condenser. The flask was heated, boiled by frequently rotating for 30 min and volume was maintained with hot water.

Then filtered through filter cloth in a fluted funnel. The residue was washed on cloth with hot water or potassium sulphate solution. The residue was returned to digestion flask by washing with hot water, 200 ml boiling sodium hydroxide was added and boiled for 30 min. The volume was adjusted with boiling water, filtered it through the muslin cloth and the residue free alkali was washed. The residue was transferred into crucible and washed with 15 ml alcohol and the crucible was dried at 110^0C for 2 hrs. The crucible was cooled in desiccators and weighed. The crucible was ignited in the furnace at 550^0C for 30 min. then cooled and weighed. The loss in weight represented the fiber.

$$\text{Crude fibre (\%)} = \frac{(W_1 - W_2)}{\text{Weight of sample (g)}} \times 100$$

Where,

W_1 = Weight of material before ashing (g)

W_2 = Weight of material after ashing (g)

3.2.9.5 Ash

About 5 g of the powder sample was accurately weighed into a pre-weighed silica crucible. It was then carbonized in silica crucible on burner fallowed by heating at about 550^0C for 6 hrs in the muffle furnace. Then the crucible was transferred to desiccators and weighed as possible to prevent moisture absorption. The ash was calculated using following formula.

$$\text{Ash (\%)} = \frac{\text{Weight of ash (g)}}{\text{Weight of sample (g)}} \times 100$$

3.2.9.6 Carbohydrate

Carbohydrate content of sample was calculated by difference method as follows (A.O.A.C., 2000).

Carbohydrate (%) = 100 % (Moisture + Fat + Protein + Ash + Crude Fiber)

Estimation of Minerals

The analysis for calcium, phosphorus and iron was determined by using titration and spectrophotometric method respectively.

Mineral solution preparation

The ash obtained by above procedure was moisture with glass distilled water (0.5-1ml) and concentrated HCl was added and evaporated to dryness on a boiling water bath. Again, 5 ml concentrated HCl was added and evaporated to dryness as before. Lastly 4ml of HCl and 5ml of distilled water were added. This solution was warmed over a boiling water bath and filtered into the 100 ml of volumetric flask using Whatman No.4 filter paper. After cooling the volume was made to 100 ml using distilled water and suitable aliquot was used for the estimation of Calcium, Phosphorus and Iron.

3.2.9.7 Calcium

Calcium content of selected samples was estimated titrimetrically by standard method of A.O.A.C. (1990).

Reagents

1. Sodium acetate (20 %)
2. Oxalic acid (3 %)
3. Ammonium hydroxide (1:5 solutions with water)
4. Potassium permanganate (0.05 N- Dissolve 0.79 g $KMnO_4$ in water to make 500 ml)
5. Sulphuric acid
6. Bromocresol green indicator
7. Dilute HCl

Procedure

Five g sample was ignited and prepared 250 ml acid extract (5 g sample burnt to ash and transferred in 150 ml beaker, added 30 ml dil. HCl digestion, cooled and filtered through filter paper, made volume 250ml with distilled water). Pipetted 20 ml extract in 250 ml beaker added 8-10 drops of indicator and acetate until colour changed from green to blue. The beaker was covered with watch glass and heated to boiling. Precipitated the calcium by adding oxalic acid slowly to change colour from blue to green. The precipitate was allowed to settle for some time, filtered through Whatman No. 40 and washed with 50 ml ammonium hydroxide.

The filter paper was punctured and washed out precipitate in beaker with mixture of 125 ml water and 5 ml conc. H_2SO_4 at 80 to 90^0C. The filtrate was titrated against 0.05 N $KMnO_4$ at 70 to 90^0C till permanent pink colour obtained. Filter paper was added to beaker and titration was continued (2-3 drops of $KMnO_4$) and the volume of $KMnO_4$ required was noted. Calcium content was calculated by following formula.

$$\text{Calcium (mg/100 g)} = \frac{\text{Titer x N of } KMnO_4 \text{ x 0.02 x Total volume of ash solution}}{\text{ml of ash solution taken x weight of sample}} \text{ x 100}$$

3.2.9.8 Phosphorus

Phosphorus content was estimated by colorimetric method as described by Chapman and Pratt (1961).

Reagents

1. Ammonium molybdo-vanadate reagent: Ammonium molybdate weighing 22.5 g was dissolved in about 400 ml distilled water. Ammonium metavanadate 1.25 g was dissolved separately in about 300 ml boiling water and added to ammonium molybdate solution. After cooling to room temperature, 250 ml concentrated nitric acid was added and volume made to 1 liter with distilled water.
2. Standard phosphate solution: potassium dihydrogen phosphate weighing 0.2194 g was dissolved in distilled water and diluted to one liter. This solution contained 50 μg phosphorus per ml.
3. Catalyst mixture: Potassium sulphate, mercuric oxide and copper sulphate were weighed 99, 4.1 and 0.8 g respectively and mixed thoroughly.
4. Hydrogen peroxide (30 %).

Procedure

Two hundred mg of powdered sample was weighed accurately and transferred to digestion flask. One gram catalyst mixture was mixed thoroughly with sample. Five ml each of concentrated sulphuric acid and 30 per cent hydrogen peroxide were added carefully. The sample was digested until a clear colourless solution obtained. After cooling, the content of flask was transferred to 100 ml volumetric flask and volume was made with distilled water.

Ten ml aliquot was taken in 50 ml volumetric flask to which 10 ml the ammonium molybdovanadate reagent added. The content were diluted to 50 ml with distilled water and mixed well. The absorbance was read after 30 min at 470 nm on Spectronic-20. Phosphorus content was calculated from standard curve prepared in the same way by using 0, 1, 5, 10, 15, 20 ml of standard phosphate solution instead of the sample. Following formula was used for estimation of phosphorus.

$$\text{Phosphorus (mg/100 g)} = \frac{\text{mg of P in aliquot of as solution taken for} \times \text{Total volume of ash solution}}{\text{ml of ash solution taken for estimation} \times \text{Weight of sample taken for ashing}} \times 100$$

3.2.9.9 Iron and zinc

The iron and zinc content of samples and developed products were estimated by (A.O.A.C., 1990). One gram of sample was digested with 10 ml of nitric acid: perchloric acid (7:3) mixtures at temperature up to 180-200 °C till transparent contents were obtained. The contents were diluted to a volume of 100 ml with double distilled water. Concentration of mineral contents was determined by running the diluted samples through Atomic Absorption Spectrophotometer (Varian, AA240, Victoria, Australia), using air acetylene flame.

3.2.10 Sensory Evaluation of Biscuits and Cupcake

Sensory evaluation is usually performed towards the end of the product development or during storage and is carried out to assess the reaction of judges towards the product and they rate their liking on a scale. The biscuits and cupcake were evaluated for sensory attributes by a panel of 10 semi-trained judges, using 9-point Hedonic scale system (Amerine *et al.,* 1965) for different parameters like colour, flavour, texture, taste and overall acceptability for biscuits and cupcake. Their judgements were recorded and mean values of 10 semi-trained judges were considered for evaluating the quality. The appropriate analysis was carried out to determine the significance of variations of average score and the contribution of individual parameter. Samples were served to the panellists and they were asked to rate acceptability to the product on 1-9 points hedonic scale, ranging from extreme like (9) to dislike extremely (1). The format of sensory score card is presented in Appendix- I and II.

3.2.11 Microbial Evaluation of Prepared Biscuits and Cupcake

The microbial evaluation of prepared biscuits (fresh) and during storage (After 90 days) of biscuits was performed for Total plate count and Yeast and Mould count. The microbial evaluation of prepared cupcake (fresh) and during storage (After 6 days) of cupcake was performed for Total plate count and Yeast and Mould count.

3.2.11.1 Total plate count

Samples were prepared by mashing and mixing in peptone water. Subsamples were diluted decimally and 0.1 mL aliquots were spread plated on nutrient agar (NA) for the enumeration of total plate count. The NA plates were incubated at 37^0C for 24-48 h. The colonies were then counted and expressed as colony forming units per gram (cfu/g) of samples. All counts were done in duplicate using the Stuart scientific colony counter (APSHA, 2001).

3.2.11.2 Yeast and mould count

Samples were prepared by mashing and mixing in peptone water. Subsamples were diluted decimally and 0.1 mL aliquots were spread plated on potato dextrose agar (PDA) for the enumeration of yeast and mould. PDA plates were incubated at room temperature (28±2^0C) for 3-5 days. The colonies were then counted and expressed as colony forming units per gram (cfu/g) of samples. All counts were done in duplicate using the Stuart scientific colony counter (APSHA, 2001).

3.2.12 Storage Study of Biscuits

The selected best treatment of biscuits was packed in LDPE and laminated pouches are stored at ambient room temperature (27 $\pm$ 5^0C) temperature for 90 days and samples were drawn at an interval of 30 days for the period of 3 months and evaluated for nutritional and sensory qualities attributes.

3.2.13 Storage Study of Cupcake

The selected best treatment of cupcake was packed in LDPE and laminated pouches are stored at ambient room temperature (27 $\pm$ 5^0C) temperature for 6 days and samples were drawn at an interval 0, 3, 6 days for the period of 6 days and evaluated for the nutritional, sensory, textural analysis and microbial quality of the optimized product.

3.2.14 Production Cost of Biscuits and Cupcake

The cost of production of whole wheat flour and defatted *Moringa* seed flour biscuits and cupcake and whole wheat flour and *Moringa* seed oil biscuits and cupcake was calculated after consideration of the cost of raw material required, labour, processing cost and miscellaneous charges at prevailing rates during experimental period. The cost was worked out by using procedure as described by (Lal *et al.,* 1980). The review of literature related to present investigation and findings of experiments are presented in subsequent chapter.

3.2.15 Statistical Analysis

The results obtained in the present investigation were statistically analyzed by using factorial completely randomized design (Rangaswamy, 2009; Bradley and Douglas, 2020).

4. RESULTS AND DISCUSSION

The investigation was carried out for utilization of *Moringa* seed oil and defatted seed flour as highly nutritional ingredients in bakery products such as biscuits and cupcake. The results obtained in this investigation on physicochemical characterization of extracted oil and defatted seed flour from *Moringa* seed are reported in this chapter. The effect of wheat variety flour with the addition of defatted *Moringa* seed flour on dough rheology, quality evaluation of prepared biscuits and cupcake and also quality changes during storage of biscuits and cupcake are discussed here under following heading in this chapter.

4.1 Proximate Composition of Wheat Flour (*Trimbak* and *Samadhan*), Raw *Moringa* Seed Flour and Defatted *Moringa* Seed Flour

The proximate composition of raw material plays an important role for deciding and evaluating nutritional and functional qualities of end products.

4.1.1 Proximate Composition of Wheat Flour

The proximate composition of wheat flour and *Moringa* seed flours is presented in Table 4.1.

Moisture

The moisture content of wheat varieties *Trimbak* and *Samadhan* flours was 14 and 13.82 per cent, respectively. Kulkarni *et al*. (2012) reported the moisture content of wheat flour was 12.67 per cent. Kent Jones and Amos (1967) reported the values for moisture content of wheat flour ranged from 9 to 18 per cent. Supekar *et al*. (2005) observed the moisture content in different wheat flour in the range of 10.71 to 13.80 per cent. Butt (1997) and Qamar (2002) determined the moisture content of wheat flour in the range of 7.8 to 14.8 per cent. The present results obtained are similar to the literature values.

Fat

The wheat varieties *Trimbak* and *Samadhan* flours contained 1.82 and 2.2 per cent fat respectively (Table 4.1). The values for fat content are in good agreement with Khan *et al*. (1987) who reported crude fat from 0.88 to 2.93 per cent in different wheat varieties. Lande (2016) reported the fat content of different varieties of wheat flour in range of 0.82 to 0.94 per cent.

Protein

Protein is an important component of the cereals. Protein decides the suitability of wheat for particular type of end use. The result showed that the protein content of wheat varieties *Trimbak* and *Samadhan* flours was 12.76 and 12.06 per cent, respectively (Table 4.1). Jaybhay *et al.* (2014) reported that the protein content in the wheat 11.6 per cent. Zafar *et al.* (2015) determined the crude protein content of wheat varieties in range of 11.46 to 12.45 per cent. Ram *et al*. (2001) estimated protein content from wheat grain ranged from 10.5 to 14.5 per cent. (Mallick *et al*. 2013) reported that protein contained in Indian wheat varieties ranges from 10.71 to 12.83 per cent. The Present investigations results are in the line of literature.

Ash

The result indicated that the ash content in the wheat varieties *Trimbak* and *Samadhan* flours was 1.9 and 2.1 per cent, respectively (Table 4.1). Adsule and Kadam (1986) reported that the ash content of whole wheat flour ranged from 0.82 to 2.50 per cent, ash content varied with the rate of extraction. Jaybhay *et al*. (2014) observed that the ash content in wheat flour 1.6 per cent. Taneja *et al*. (1983) reported that in Indian wheat varieties the ash content ranges between 1.43 to 1.79 per cent.

Crude fibre

Crude fibre content of wheat varieties *Trimbak* and *Samadhan* flours was 1.8 and 0.9 per cent, respectively (Table 4.1). The values for crude fibre content obtained in present investigation are in agreement with the result obtained by Jaybhay *et al*. (2014) reported the crude fibre contained in wheat flour 2.0 per cent. Taneja *et al.* (1983) reported that in Indian wheat varieties the crude fibre content ranges of 0.98 to 1.47 per cent, respectively.

Carbohydrate

The first major component in cereals is carbohydrate. Carbohydrate is an important source of energy for the body. Carbohydrate also impacts the mouthfeel of product by increasing viscosity and texture of the product. The wheat varieties *Trimbak* and *Samadhan* flours contained 67.72 and 68.92 per cent carbohydrate, respectively (Table 4.1). Supekar *et al*. (2005) reported the carbohydrate content in wheat flour from ranges 68.34 to 71.95 per cent.

Gluten content

Wet gluten content in wheat flour *Trimbak* was 27.90 per cent and *Samadhan* was 23.19 per cent. Dry gluten content in wheat flour *Trimbak* was 9.77 per cent and *Samadhan* was 9.30 per cent (Table 4.1).

4.1.2 Proximate Composition of Raw *Moringa* Seed Flour

Moisture

The moisture content of *Moringa* seed flour was 4.8 per cent (Table 4.1). Chinma *et al.* (2017) reported the moisture content in raw *Moringa* seed flour 8.01 per cent. 4.70 per cent moisture content in *Moringa* seed flour determined by Abiodun *et al.* (2012). Nzikou *et al.* (2009) observed that the moisture content of *Moringa* seed flour 5.3 per cent. Amany and Maliha (2016) reported moisture content in *Moringa* seed flour 4.90 per cent.

Fat

The result revealed that the fat content in *Moringa* seed flour was 34.36 per cent. Farooq *et al.* (2006) reported that the oil content in *Moringa* seed in ranges of 30.36 to 38.37 per cent. Sodamade *et al.* (2017) determined the *Moringa* seed contained oil 43.60 per cent. Ojaiko and Okeke (2013) investigated that the *Moringa* seed contained oil 26.9 per cent.

Protein

The protein is an important nutrient necessary for the repair and build the body tissue. The result obtained in present investigation was the 28.62 per cent protein present in *Moringa* seed flour (Table 4.1). Adegbe *et al.* (2016) reported the protein content in *Moringa* seed 39.57 per cent. Farooq *et al.* (2006) reported the protein content of *Moringa* seed flour in ranges of 29.63 to 30.97 per cent. The protein content obtained in present investigation are in agreement with result obtained by Abiodun *et al.* (2012) reported the protein contained in raw *Moringa* seed flour 28.04 per cent.

Ash

Ash content is chiefly composed of minerals like calcium, phosphorus, iron and zinc etc. In present investigation ash content of raw *Moringa* seed flour found 4.06 per cent. Farooq *et al.* (2006) reported that the ash content in *Moringa* seed in ranges from 5.46 to 8.46 per cent. Adegbe *et al.* (2016) reported the ash content in raw *Moringa* seed

5.00 per cent. The ash content obtained in present investigation are in agreement with result obtained by Sodamade *et al.* (2017), Campas *et al.* (2014) and Nzikou *et al.* (2009).

Crude fibre

Crude fibre content in raw *Moringa* seed flour was 6.75 per cent (Table 4.1). Farooq *et al.* (2006) reported that the crude fibre content in *Moringa* seed ranges from 6.60 to 9.00 per cent. The obtained result is closely resembled to the result obtained by Abiodun *et al*. (2012) and Adegbe *et al*. (2016).

Carbohydrate

Carbohydrate content in raw *Moringa* seed flour was 21.41 per cent (Table 4.1). Campas *et al.* (2014) reported that the carbohydrate content in raw *Moringa* seed flour 29.00 per cent. Nzikou *et al.* (2009) reported that the raw *Moringa* seed contained 13.6 per cent carbohydrate.

Gluten content

Wet and dry gluten content was not detected in raw *Moringa* seed flour (Table 4.1).

Table 4.1 Proximate composition of wheat flour (*Trimbak* and *Samadhan*), raw *Moringa* seed flour and defatted *Moringa* seed flour

Parameter (%)	Components			
	Wheat flour		Raw *Moringa* seed flour	Defatted *Moringa* seed flour
	(*Trimbak*)	(*Samadhan*)		
Moisture	14	13.82	4.80	5.10
Fat	1.82	2.2	34.36	2.02
Protein	12.76	12.06	28.62	45.08
Ash	1.9	2.1	4.06	8.42
Crude fibre	1.8	0.9	6.75	10.2
Carbohydrate	67.72	68.92	21.41	29.18
Wet gluten	27.90	23.19	ND	ND
Dry gluten	9.77	9.30	ND	ND

Each value represents the average of four determination. ND- Not Detected

4.1.3 Proximate Composition of Defatted *Moringa* Seed Flour

Moisture

Moisture content of defatted *Moringa* seed flour was contained 5.10 per cent (Table 4.1). Abiodun *et al.* (2012) reported that defatted *Moringa* seed flour contain moisture 5.03 per cent.

Fat

The defatted *Moringa* seed flour contained fat 2.02 per cent (Table 4.1). The defatted *Moringa* seed cake contained 3.06 per cent fat reported by Abiodun *et al*. (2012).

Protein

Protein content in defatted *Moringa* seed flour was found 45.08 per cent (Table 4.1). Abiodun *et al*. (2012) determined the highest protein content in defatted *Moringa* seed flour as compare to raw seed flour as 50.80 per cent.

Ash

The result obtained for ash content was 8.42 per cent (Table 4.1). Ash contained obtained are an agreement with the result by Abiodun *et al*. (2012).

Crude fibre

The crude fibre content of defatted *Moringa* seed flour was 10.20 per cent. Abiodun *et al*. (2012) reported that the crude fibre content in defatted *Moringa* seed cake flour as 12.96 per cent.

Carbohydrate

Present investigation the result found that the carbohydrate content in defatted *Moringa* seed flour was 29.18 per cent (Table 4.1). Peter and Philip (2014) reported the carbohydrate contained in defatted *Moringa* seed flour 57.77 per cent. Wet and dry gluten content was not detected in defatted *Moringa* seed flour (Table 4.1)

Gluten content

Wet and dry gluten content was not detected in raw *Moringa* seed flour.

4.2 Mineral Composition of Wheat Flour (*Trimbak* and *Samadhan*), Raw *Moringa* Seed Flour and Defatted *Moringa* Seed Flour

The mineral composition of wheat flour (*Trimbak* and *Samadhan*), raw *Moringa* seed flour and defatted *Moringa* seed flour are presented in Table 4.2.

4.2.1 Mineral Composition of Wheat Flour

Calcium content of wheat varieties *Trimbak* and *Samadhan* flours was 42.22 and 38.16 mg/100 g respectively (Table 4.2). Lande (2016) reported that the calcium content of different wheat variety ranges from 17.63 to 18.56 mg/100 g respectively. The values for calcium content obtained in present investigation were in agreement with result obtained by Deshmukh (2017); Kulkarni *et al*. (2012) and Mallick *et al*. (2013).

It was found that phosphorus content of wheat varieties *Trimbak* and *Samadhan* flours was 332.18 and 342.20 mg/100 g respectively. Salunke *et al*. (2019) and Deshmukh (2017) recorded similar values for phosphorus content of wheat.

Iron content of wheat varieties *Trimbak* and *Samadhan* flours was 7.50 and 5.00 mg/100 g respectively. Mallick *et al*. (2013) reported the iron content in wheat varieties ranges from 3.82 to 4.45 mg/100 g respectively. The values for iron content obtained in present investigation were in agreement with result obtained by Salunke *et al*. (2019); Kulkarni *et al*. (2012) and Singh *et al*. (2005).

Table 4.2 Mineral composition of wheat flour (*Trimbak* and *Samadhan*), raw *Moringa* seed flour and defatted *Moringa* seed flour

Parameter (mg/100 g)	Components			
	Wheat flour		Raw *Moringa* seed flour	Defatted *Moringa* seed flour
	Trimbak	***Samadhan***		
Calcium	42.22	38.16	358.75	416.39
Phosphorus	332.18	342.20	602.08	270.31
Iron	7.50	5.00	8.75	17.5
Zinc	2.79	2.62	5.31	8.24

Each value represents the average of four determination

Zinc content of wheat varieties *Trimbak* and *Samadhan* flours was 2.79 and 2.62 mg/100 g respectively. Mallick *et al*. (2013) reported the iron content in wheat varieties ranges from 2.50 to 3.95 mg/100 g respectively. Desai *et al*. (2010); Kulkarni *et al*. (2012) and Deshmukh (2017) recorded similar values for zinc content of wheat.

4.2.2 Mineral composition of Raw *Moringa* Seed Flour and Defatted *Moringa* Seed Flour

Calcium content of raw *Moringa* seed flour and defatted *Moringa* seed flour 358.75 and 416.39 mg/100 g respectively. Abiodun *et al.* (2012) reported the calcium contained in raw and defatted *Moringa* seed flour were 203.85 and 249.85 mg/100 g respectively. The values for calcium content obtained in present investigation were in agreement with result obtained by Peter and Philip (2014).

Present investigation the result found that the phosphorus content in raw *Moringa* seed flour and defatted *Moringa* seed flour was 602.08 and 270.31 mg/100 g respectively. Peter and Philip (2014) recorded similar values for phosphorus content were 635.00 and 273.33 mg/100 g respectively.

Iron content of raw *Moringa* seed flour and defatted *Moringa* seed flour 8.75 and 17.50 mg/100 g respectively. The values for iron content obtained in present investigation were in agreement with result obtained by Abiodun *et al*. (2012) and Peter and Philip (2014).

Obtained results found that the zinc content in raw *Moringa* seed flour and defatted *Moringa* seed flour was 5.31 and 8.24 mg/100 g respectively. Peter and Philip (2014) and Abiodun *et al*. (2012) recorded similar values for zinc content.

4.3 Physical Properties of Wheat Grains and *Moringa* Seeds

Physical properties of wheat grain (*Trimbak* and *Samadhan*) and *Moringa* seeds in relation to the design of an oil expeller. The colour of wheat grain was golden yellow and *Moringa* seed was whitish while thousand kernel weight, length, width and thickness are high (Table 4.3). Therefore, the arithmetic mean diameter and geometric mean diameter was also high. The thousand kernel weight, length, width, thickness, arithmetic mean diameter and geometric mean diameter of wheat grain (*Trimbak*) were 45.23g, 6.482 mm, 3.353 mm, 2.530 mm, 4.121mm and 3.802 mm and (*Samadhan*) 43.54g, 6.381 mm, 3.262 mm, 2.402 mm, 4.015 mm and 3.683 respectively. Similar results were recorded by Kheiralipour *et al.* (2008) and Ljiljana *et al.* (2011).

Where the thousand kernel weight, length, width, thickness, arithmetic mean diameter and geometric mean diameter of *Moringa* seed were 222.61 g, 8.372 mm, 7.658 mm, 6.962 mm, 7.663 mm and 7.639 mm respectively. Similar results were observed by Adesina *et al.* (2013) who reported that mass, length, width, thickness and were: 0.258 g, 9.223 mm, 8.423 mm and 7.424 mm respectively. The bulk density and true density of wheat grain (*Trimbak*) were 0.692 and 1.109 (g/cm^3) and (*Samadhan*) were 0.683 and 1.134 (g/cm^3).

Table 4.3. Physical properties of wheat grains and *Moringa* seeds

Sr. No.	Parameter	***Trimbak* (NIAW-301)**	***Samadhan* (NIAW-1994)**	***Moringa* seeds**
1.	Colour	Golden yellow	Golden yellow	Whitish
2.	Thousand kernel weight (g)	45.23	43.54	222.61
3.	Length (mm)	6.482	6.381	8.372
4.	Width (mm)	3.353	3.262	7.658
5.	Thickness (mm)	2.530	2.402	6.962
6.	Arithmetic mean diameter	4.121	4.015	7.663
7.	Geometric mean diameter	3.802	3.683	7.639
8.	Sphericity	0.577	0.600	0.914
9.	Bulk density (g/cm^3)	0.692	0.683	0.480
10.	True density (g/cm^3)	1.109	1.134	0.662
11.	Porosity (%)	27.77	27.95	27.50

Each value represents the average of four determination

The obtained result is closely resembled to the result obtained by Ljiljana *et al.* (2011). The bulk density and true density of *Moringa* seed were found to be low (Table 4.3). The sphericity of the seed can also be found to be 0.914 per cent which shows that the seed was spherical as stated by Kachru *et al*. (1994). The bulk density of *Moringa* seed was 0.480 (g/cm^3) while true density was 0.662 (g/cm^3). The true density of the *Moringa* seeds showed that the seeds are slightly less dense than water and therefore will float on water. Ajav and Fakayode (2013) reported that the average true and bulk densities of *Moringa* seed were 971 and 662 kgm^{-3} respectively. The porosity of the wheat grain *Trimbak* and *Samadhan* was 27.77 and 27.95 per cent respectively and the porosity of the *Moringa* seed was 27.50 per cent. Similar results were recorded by Kheiralipour *et al.* (2008) and Ljiljana *et al.* (2011).

4.4 Physicochemical Characterization of *Moringa* Seed Oil

4.4.1 Physicochemical Properties of *Moringa* Seed Oil

The physical properties of *Moringa* seed oil has colour value such as L* value (44.535), a* value (0.633) and b* value (32.642) (Table 4.4). The oil has 44.838 (mPa.s) viscosity 30^{0}C. Babatunde *et al.* (2014) reported the viscosity at 30^{0}C 43.60 to 43.80 (mPa.s). Stavros and Jhon (2002) reported the viscosity varies between 45.05 to 80.00

(mPa.s) by using different extraction method. Adejumo *et al.* (2013) reported viscosity of *Moringa* seed oil (MSO) varies between 43.50 to 44.40 at 40^{0}C. Specific gravity of oil was 0.908. Adegbe *et al.* (2016) reported the specific gravity of MSO were 0.905. Adejumo *et al.* (2013) reported specific gravity of MSO varies between 0.90 to 0.97 at 30 ^{0}C. The chemical properties of *Moringa* seed oil showed saponification value (180.13 mg KOH/g), iodine value (68.20 g of I_2 absorbed /100g), ester value 175.49, acid value (4.64 mg KOH/g) and peroxide value (1.61 mequiv peroxide/kg oil).

Table 4.4 Physicochemical properties of *Moringa* seed oil

Sr. No.	Parameter	Observation	
1.	Colour	**L* value**	44.535
		a* value	0.633
		b* value	32.642
2.	Viscosity (mPa.s)	44.838	
3.	Specific gravity	0.908	
4.	Saponification value (mg KOH/g)	180.13	
5.	Iodine value (g of I_2 absorbed /100g)	68.20	
6.	Ester value	175.49	
7.	Acid value (mg KOH/g)	4.64	
8.	Peroxide value (mequiv peroxide/kg oil)	1.61	

Each value represents the average of four determination

Saponification value (mg of KOH) of *Moringa* seed oil (MSO) reported by earlier researchers were 190.4 to 191.2 by Babatunde *et al.* (2014), Lalas and Tsaknis (2002) showed 188.0, Rahman *et al.* (2009) reported 180, Hanaa and Gamal (2013) observed it as 179, 183 by Campas *et al.* (2014), and Francisco *et al.* (2016) investigated 179.40 and 180.60. 180.92 by Adegbe *et al.* (2016).

Farooq *et al.* (2006) found 65.86, 67.86 and 70.50 g I_2 /100 g. Nzikou *et al.* (2009) determined its iodine value 67.4 g I_2 /100 g. Hanaa and Gamal (2013) observed 67.9 g I_2 /100 g of iodine value. Dollah *et al.* (2014) reported its iodine value 67.46 g I_2 /100 g. Amany and Maliha (2016) stated that iodine value of *Moringa* seed oil 69.01 g I_2 /100 g.

Abiodun *et al.* (2012) reported acid value of MSO 7.09 mg KOH/g, Ojiako and Okeke (2013) reported 5.038 mg KOH/g, Adejumo *et al.* (2013) reported acid value of MSO between 2.81 and 3.23, Adegbe *et al.* (2016) observed 6.73 mg KOH/g.

Peroxide value of *Moringa* seed oil reported by Lalas and Tsaknis 2002 were 1.83 meq/kg of oil, Farooq *et al.* (2006) reported peroxide value of MSO between 0.81 and 1.73 meq/kg of oil, Nzikou *et al.* (2009) observed 0.89 and 1.67 meq/kg of oil, Amany and Maliha (2016) showed 0.83 meq/kg of oil and Adegbe *et al.* (2016) reported peroxide value of *Moringa* seed oil 2.60 meq/kg of oil.

4.4.2 Fatty Acid Profile of *Moringa* Seed Oil

The fatty acid profile analysis of *Moringa* seed oil (Table 4.5 and Fig. 4.1) showed the presence of major fatty acids such as oleic acid (75.152 %), palmitic acid (5.797 %), stearic acid (5.496 %), behenic acid (5.323 %), arachidic acid (3.330 %), Cis,11-eicosenaoate acid (1.949 %), palmitoleic acid (1.096 %), Cis-13,16-docosadienoic acid (0.868 %), linoleic acid (0.498 %), myristic acid (0.114 %), linolenic acid (0.112 %), erucic acid (0.105 %), butyric acid (0.093 %) and heptadeconoic acid (0.067 %). High amount of monounsaturated fatty acid such as oleic acid proves the significance of *Moringa* seed oil as functional food ingredient.

Stavros and Jhon (2002) stated that the *Moringa* seed oil contained fatty acid such as oleic acid (71.21 %), equal amounts of palmitic (C16:0) and behenic (C22:0) acids of about (6.40 %). Myristic acid (0.13 %), palmitoleic acid (1.36 %), stearic acid (5.88 %), linoleic acid (0.65 %) and linolenic acid (0.18 %). Anwar and Bhangar (2003) observed oleic acid (76.00 %), palmitic acid (6.5 %), palmitoleic acid (1 %), linoleic acid (1.29 %), stearic acid (5.67), Arachidic acid (3 %), ecosenoic acid (1.20 %) and behenic acid (5 %) respectively. Nzikou *et al.* (2009) found palmitic acid (6.24 %), palmitoleic acid (1.6 %), stearic acid (4.71 %), oleic acid (74.93 %), linoleic acid (0.72 %), arachidic acid (3.09 %), Cis,11- ecosenoic acid (2.32 %) and behenic acid (5.33 %) respectively. Babatunde *et al.* (2014) reported oleic acid (78.7 %), palmitic acid (6.1 %), linolenic acid (1.8 %), palmitoleic acid (1.2 %), stearic acid (4.6 %), myristic acid (0.72 %), arachidic acid (2.3 %), behenic acid (4.5 %) respectively. myristic acid (C14:0; 0.23 %), palmitic acid (C16:0; 9.86 %), palmitoleic acid (C16:1n7; 2.16 %), margaric acid (C17:0; 0.08 %), stearic acid (C18:0; 5.38 %), oleic acid (C18:1n9; 68.01 %), vaccenic acid (C18:1n7; 9.81 %), linoleic acid (C18:2n6; 0.67 %), linolenic acid (C18:3n3; 0.16 %), arachidic acid (C20:0; 1.60 %), ecosenoic acid (C20:1n9; 0.64 %) and behenic acid (C22:0; 1.32 %) reported by Campas *et al.* (2014). Hanaa and Gamal (2014) found to contain a high level of oleic acid (C18:1 n-9), which accounted for 65.36 per cent of the total fatty acid, Palmitic (C16:0, 12.44 %) and linoleic (C18:2, 15.32 %) acids were found in high quantity whereas, palmitoleic (C16:1, 1.54 %) and stearic (C18:0, 4.35 %) lower level. Amany and Maliha (2016) reported that the fatty acid compositions of *Moringa* seed oil as high level of oleic acid (65.00 %), palmitic acid (12.31 %), linoleic acid (16.00 %), palmitoleic acid (2.10 %), stearic acid (5.10 %), respectively.

Table 4.5 Fatty acid profile of *Moringa* seed oil

Sr. No.	Component name	Chemical configuration	Time (Min.)	Area (µV.s)	Area (%)
1.	Methyl butyrate	C4:0	7.063	2035	0.093
2.	Methyl myristate	C_{14} :0	18.466	2513	0.114
3.	Methyl palmitate	C_{16}:0	23.599	127434	5.797
4.	Methyl palmitoleate	C_{16}:1	24.900	24085	1.096
5.	Methyl heptadeconeate	C_{17}:0	26.444	1481	0.067
6.	Methyl stearate/Octadecanoate	C_{18}:0	29.499	120819	5.496
7.	Cis-9-oleic acid methyl ester	C_{18}:1n9	30.909	1652050	75.152
8.	Methyl linoleate	C_{18}:2n6	33.212	10951	0.498
9.	Methyl linolenate	C_{18}:3n3	36.326	2464	0.112
10.	Methyl arachidate	C_{20}:0	36.859	73198	3.330
11.	Methyl Cis,11-Eicosenaoate	C_{20}:1	38.509	42849	1.949
12.	Methyl Behenate/docosanoate	C_{22}:0	45.491	117025	5.323
13.	Methyl Erucate	C_{22}:1n9	47.522	2304	0.105
14.	Cis-13,16- Docosadienoic acid methyl ester	C_{22}:2	56.902	19081	0.868
Total Area				2198290	100.00

The overview of fatty acid composition of *Moringa* seed oil showed (Table 4.5) that it contained 16.89 per cent of Total Saturated Fatty Acids (TSFA) and 83.11 per cent of Total Unsaturated Fatty Acids (TUFA). The unsaturated fatty acids contains 78.197 per cent of Monounsaturated Fatty Acids (MUFA) and 4.913 per cent Polyunsaturated Fatty Acids (PUFA).

Table 4.6 Overview of fatty acid composition (%) of *Moringa* seed oil

Sr. No.	Parameter	Observation
1.	Total Saturated Fatty Acids (TSFA)	16.89 %
2.	Total Unsaturated Fatty Acids (TUFA)	83.11 %
3.	Monounsaturated Fatty Acids (MUFA)	78.197 %
4.	Polyunsaturated Fatty Acids (PUFA)	4.913 %
5.	PUFA/TSFA	0.2908 %
6.	TSFA/TUFA	0.2032 %

The trans fatty acids in *Moringa* seed oil was less than 0.01 per cent. The ratio of Total Saturated Fatty Acids (TSFA) to Total Unsaturated Fatty Acids (TUFA) was 0.2032 per cent (Table 4.6). Hanaa and Gamal *et al.* (2013) found 67.44 per cent of monounsaturated fatty acids, 15.32 per cent of polyunsaturated fatty acids and 17.88 per cent of saturated fatty acids. Babatunde *et al.* (2014) reported that 18.30 per cent total saturated fatty acid, 79.9 per cent of monounsaturated fatty acids and 1.8 per cent of polyunsaturated fatty acid. *Moringa* seed oil presented relatively low contents of saturated fatty acids (SFAs), High contents of unsaturated fatty acids (UNFAs).

4.5 Rheological Characteristics of Different Wheat Variety *Trimbak* (NIAW-301) and *Samadhan* (NIAW-1994) Flour Blended With Defatted *Moringa* Seed Flour

The rheological properties of dough with wheat variety flour by various combinations of defatted *Moringa* seed flour were performed and results are reported under following headings.

4.5.1 Amylograph characteristics of dough

Amylograph readings of dough with wheat variety flour by various combinations of defatted *Moringa* seed flour are presented in Table 4.7- 4.9 and Fig. 4.2- 4.13.

In amylograph a suspension of flour and distilled water was heated with a constant heating rate of 1.5^{0}C/min within a rotating bowl. Depending on the viscosity of the suspension, a measuring sensor reaching into the bowl was deflected. This deflection was measured as viscosity over time vs. temperature and recorded on-line. Starch gelatinization is process that breakdown the intermolecular bonds of starch molecules in the presence of water and heat, resulting in exposure of hydrogen bonds (the hydroxyl hydrogen and oxygen) which eventually leads more absorption of water.

4.5.1.1 Beginning of gelatinization

Beginning of gelatinization temperature for *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 60.00 and 59.30 respectively (Table 4.7). Use of defatted *Moringa* seed flour with wheat flour affected the beginning gelatinization temperature. Blend of wheat flour with defatted seed flour recorded gelatinization temperature of 58.85°C (*Trimbak*) and 60.17°C (*Samadhan*). The results presented in Table 11 revealed that treatment T_5 obtained lower value of beginning of gelatinization temperature 58.40 °C (*Trimbak*) as compared to control treatment T_0 which exhibited highest value of beginning gelatinization temperature (60°C). The T_3 showed significantly different for gelatinization temperature (61.40°C) among all treatments. The character of beginning gelatinization decreased significantly as the defatted *Moringa* seed flour percentage increased. It was observed that there was inverse relation of beginning gelatinization temperature and levels of defatted *Moringa* seed flour.

Table 4.7 Interaction effect of wheat variety (*Trimbak* and *Samadhan*) flour with defatted *Moringa* seed flour on beginning of gelatinization (°C)

No.	Treatment	Beginning of gelatinization (°C)		
		V_1 : *Trimbak*	V_2 : *Samadhan*	Mean
T_0	Control	60.00	59.30	59.65
T_1	5% DMSF	58.60	59.30	58.95
T_2	10% DMSF	58.60	59.60	59.10
T_3	15% DMSF	58.90	61.40	60.15
T_4	20% DMSF	58.60	61.30	59.95
T_5	25% DMSF	58.40	60.10	59.25
	Mean	**58.85**	**60.17**	**59.51**
	Factor	**V**	**T**	**V × T**
	SE±	0.050	0.15	0.61
	CD @ 5%	0.14	NS	NS

All results are mean of three replications, DMSF= Defatted *Moringa* seed flour, NS= Non-significant

The combined effect of wheat variety and the different levels of defatted *Moringa* seed flour showed mean beginning gelatinization temperature of 59.51°C. The effect of gelatinization on dough rheological properties was mainly due to the effect of temperature on gluten (Gelinas and Mckinnon, 2004). The decrease in beginning of gelatinization with increase in defatted *Moringa* seed flour up to 25 per cent may be attributed to dilution of starch and gluten of wheat flour.

4.5.1.2 Gelatinization temperature

Gelatinization temperature for *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 89.40 and 89.50^{0}C respectively (Table 4.8). The gelatinization temperature decreased significantly with increased amount of defatted *Moringa* seed flour. The higher gelatinization temperature was recorded for T_1 (*Trimbak*) might be due to intact starch which requires high temperature for disfolding of native structure followed by T_2 where as lowest gelatinization temperature for T_4 (86.60^{0}C) might be due to degradation of starch. Blend of wheat flour with defatted *Moringa* seed flour recorded slightly lower gelatinization temperature 87.97 (*Trimbak*) and 88.20^{0}C (*Samadhan*) compared to wheat flour. The gelatinization temperature was significantly different for wheat flour *Samadhan* among all treatment as compare to wheat flour *Trimbak*.

Table 4.8 Interaction effect of wheat variety (*Trimbak* and *Samadhan*) flour with defatted *Moringa* seed flour on gelatinization temperature (°C)

No.	Treatment	Gelatinization temperature (°C)		
		V_1 : *Trimbak*	**V_2 : *Samadhan***	**Mean**
T_0	Control	89.40	89.50	89.45
T_1	5% DMSF	89.10	88.10	88.60
T_2	10% DMSF	88.40	88.10	88.25
T_3	15% DMSF	87.50	88.00	87.75
T_4	20% DMSF	86.60	88.00	87.30
T_5	25% DMSF	86.80	87.50	87.15
	Mean	**87.97**	**88.20**	**88.08**
	Factor	**V**	**T**	**V × T**
	SE±	0.01	0.037	0.15
	CD @ 5%	0.036	0.10	0.43

All results are mean of three replications, DMSF= Defatted *Moringa* seed flour

The gelatinization temperature varies among the wheat variety might be due to the variation in makeup of starch, its intactness and other structural variations of damaged starch (Leon *et al.,* 2006). Starch granule size and structure, amylose/amylopectin ratio and molecular weight also influenced the pasting properties of flours (Thomas and Atwell, 1999). The combined effect of wheat variety and the different levels of defatted *Moringa* seed flour showed mean gelatinization temperature of 88.08^{0}C.

The pasting temperature was between 65.8 and 75.6^{0}C; peak viscosities ranged between 448 and 521 BU were noted for 25 %-defatted mango kernel (Olugbenga *et al.*, 2018). Pasting properties of wheat flour were influenced by germinated *Moringa* seed flour substitution (Chinma *et al.,* 2014). The nature and content of starch influence pasting temperature in the blends, while gelatinization temperature decreased (Hassan *et al.,* 2015). The pasting properties of starch were considered to be affected by its amylose content and chain length distribution of amylopectin (Jane *et al.,* 1999). Composite flours obtained through different blends between refined wheat flour and defatted flaxseed one. The flaxseed flour was incorporated in wheat flour to a substitution level of 0, 5, 10, 15 and 20 per cent. From the pasting point of view, compared to the control sample, the samples in which flaxseed were incorporated in wheat flour presented a lower falling number value and a higher peak viscosity one (Ana-Maria *et al.,* 2020).

4.5.1.3 Gelatinization maximum

Gelatinization maximum for *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 1090 and 1169 AU respectively (Table 4.9). Blend of wheat flour with defatted *Moringa* seed flour recorded gelatinization maximum 908.33 and 932.00. Wheat flour blended with defatted *Moringa* seed flour recorded highest gelatinization maximum T_1 1046 AU (*Samadhan*) whereas lowest gelatinization maximum i.e. T_5 760 AU (*Samadhan*). The gelatinization maximum was decreased as defatted *Moringa* seed flour per cent increased might be due to reduction in hydrogen bond between starch and gluten. It was observed that there was inverse relation of gelatinization peak and level of defatted seed flour. The combined effect of wheat variety and the different levels of defatted *Moringa* seed flour showed mean gelatinization maximum of 920.42 AU. The effect of temperature on dough rheological properties was mainly due to its effect on gluten rheological properties as resistance to mixing increases in heated gluten (Anusooya *et al.,* 2010).

Starch gelatinization is a process that breaks down the intermolecular bonds of starch molecules in presence of water and heat, resulting in exposure of hydrogen bonds (hydroxyl hydrogen and oxygen) which eventually leads more absorption of water.

Table 4.9 Interaction effect of wheat variety (*Trimbak* and *Samadhan*) flour with defatted *Moringa* seed flour on gelatinization maximum (AU)

No.	Treatment	Gelatinization maximum (AU)		
		V_1 : *Trimbak*	**V_2 : *Samadhan***	**Mean**
T_0	Control	1090.00	1169.00	1129.50
T_1	5% DMSF	1041.00	1046.00	1043.50
T_2	10% DMSF	916.00	948.00	932.00
T_3	15% DMSF	828.00	878.00	853.00
T_4	20% DMSF	814.00	791.00	802.50
T_5	25% DMSF	764.00	760.00	762.00
	Mean	**908.33**	**932.00**	**920.42**
	Factor	**V**	**T**	**V × T**
	SE±	0.41	1.23	4.94
	CD @ 5%	1.18	3.54	14.19

All results are mean of three replications, DMSF= Defatted *Moringa* seed flour

The gelatinization temperature of starch depends on the amount of water present during gelatinization. Starch granules should not gelatinize early in baking cycle which prevents early setting of dough and inhibits expansion. Starch granules should not disrupt and fuse together during gelatinization forming an impermeable gas membrane. Granules should gelatinize individually as wheat starch does, causing a disruption of cell membranes which prevents shrinkage of the loaf during cooling after baking (Kusunose *et al.,* 1999).

Differences in protein composition are also known to affect pasting viscosities and properties (Batey and Curtin, 2000).

4.5.2 Farinograph Characteristics of Dough

The effect of wheat flours of *Trimbak* and *Samadhan* with defatted *Moringa* seed flour at 5, 10, 15, 20, 25 per cent level on farinographic characteristics such as water absorption (corrected for 14 % level), dough development time, dough stability, maximum tolerance index, time to breakdown and farinograph quality number were determined and results are reported in Table 4.10 and Fig. 4.13- 4.25.

The farinograph consists of a drive unit with continuous speed control and an attached measuring mixer for mixing the dough to be tested. The resistance of the dough against the blades, which depends on the dough viscosity, is measured as torque, recorded and plotted online as a function of time in clear colour diagram recording values of water absorption, dough development time, dough stability, degree of softening, consistency and farinograph quality number.

4.5.2.1 Water absorption

The water absorption for *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 86.70 and 85.40 per cent respectively (Table 4.10). Within the cultivars the water absorption was slightly higher in *Trimbak* which is due to higher protein/gluten content. The treatment control T_0 86.70 (*Trimbak*) and 85.40 (*Samadhan*) reported lower value of water absorption at 500 BU at 14% moisture as compared to T_1 88.80 (*Trimbak*) and 87.40 (*Samadhan*) and T_4 88.10 (*Trimbak*) and 87.90 (*Samadhan*). The water absorption at 14% moisture content showed significant differences among treatments and varieties.

The water absorption was observed to decrease from 88.80 (T_1) to 88.10 (T_5) for wheat flour *Trimbak*. The combined effect of wheat variety and the different levels of defatted *Moringa* seed flour showed mean water absorption 87.86 per cent. Incremental addition of defatted *Moringa* seed flour resulted in decreased water absorption.

The effects of replacing wheat flour with 0 to15 per cent debittered *Moringa* seed) flour decreased farinograph water absorption (Ogunsina *et al.,* 2011).

The water absorption is significantly affected with increasing DSF addition. It is decreased with increased addition of DSF (Haroon and Sekhon 2014). Incremental addition of flaxseed flour in wheat flour reduced the water absorption capacity of dough and dough stability (Ana-Maria *et al.,* 2020).

The major factors contributing to the farinograph water absorption include protein content, starch, damaged starch, pentosans and gluten strength (Vizitiu and Danciu, 2011). The higher water absorption is an indication of better dough development (Farooq *et al.,* 2014).

The differences in farinographic properties of flours depend on the wheat cultivars and also molecular weight polymers (Sliwinski *et al.,* 2004). The water absorption is affected by damaged starch and had direct relationship (Vetrimani *et al.,* 2005).

Table 4.10 Interaction effect of wheat variety (*Trimbak* and *Samadhan*) flour with defatted *Moringa* seed flour on farinographic characteristics of dough

No.	Treatment	Water absorption (%)			Development time (min)			Stability			Tolerance index			Time to breakdown			Farinograph quality number		
		V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_0	Control	86.70	85.40	86.05	4.40	5.00	4.70	2.20	2.10	2.15	87.0	92.00	89.50	5.90	5.80	5.85	59.00	58.00	58.50
T_1	5% DMSF	88.80	87.40	88.10	3.90	4.00	3.95	1.30	1.40	1.35	124.0	130.0	127.0	4.80	4.80	4.80	48.00	48.00	48.00
T_2	10% DMSF	88.60	88.30	88.45	3.90	3.80	3.85	1.30	1.30	1.30	130.0	130.0	130.0	4.80	4.70	4.75	48.00	47.00	47.50
T_3	15% DMSF	88.20	88.60	88.40	3.30	3.50	3.40	0.90	1.10	1.00	150.0	140.0	145.0	4.30	4.20	4.25	43.00	42.00	42.50
T_4	20% DMSF	88.20	88.10	88.15	4.30	3.80	4.05	1.10	1.20	1.15	111.0	130.0	120.5	4.80	5.40	5.10	48.00	54.00	51.00
T_5	25% DMSF	88.10	87.90	88.00	4.30	3.90	4.10	1.50	1.30	1.40	101.0	93.00	97.00	5.00	5.50	5.25	50.00	55.00	52.50
	Mean	**88.10**	**87.62**	**87.86**	**4.20**	**4.00**	**4.01**	**1.38**	**1.40**	**1.39**	**117.17**	**119.17**	**118.17**	**4.93**	**5.07**	**5.00**	**49.33**	**50.67**	**50.00**
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.016	0.501	0.200	0.017	0.052	0.211	0.014	0.044	0.178	0.269	0.809	3.237	0.023	0.071	0.287	0.362	1.086	4.346
	CD @ 5%	0.047	0.143	0.575	NS	0.156	NS	NS	0.024	NS	NS	2.128	9.287	NS	0.206	NS	NS	3.116	NS

All results are mean of three replications, DMSF= Defatted *Moringa* seed flour, V_1 = *Trimbak*, V_2 = *Samadhan,* NS= Non-significant

4.5.2.2 Dough development time

Dough development time represents the necessary time to reach the required consistency. Dough development time of control samples of *Trimbak* and *Samadhan* wheat flour was 4.40 and 5.00 min respectively (Table 4.10). It is seen that wheat flour blended with defatted *Moringa* seed flour recorded dough development time of 4.20 and 4.00 min. Wheat flour blended with defatted *Moringa* seed flour recorded lowest dough development time of T_3 was 3.30 min (*Trimbak*) and 3.50 min (*Samadhan*) where as highest dough development time of T_4 and T_5 was 4.30 min (*Trimbak*). The combined effect of wheat variety and different levels of defatted *Moringa* seed flour showed mean dough development time of 4.01 min. The dough development time significantly different as compared to control. During this phase of mixing, water hydrates, the flour components and the dough are developed (Kohajdova *et al.,* 2011; Mohammed *et al.,* 2012).

Dough development time represents the necessary time to reach the required dough consistency. The dough development time is affected by the protein content, higher the protein content, lower the dough development time and higher maximum consistency (Alami *et al.,* 2007; Irvine *et al.,* 1961).

The dough development time also varied with different cultivars of wheat. Dough development showed a positive correlation with water absorption which might be due to the starch swelling leading to the changes in rheological properties especially in case of Lu-31 wheat cultivar (Farooq *et al.,* 2014).

4.5.2.3 Dough stability

The dough stability is defined as the time between the first and second interesting point of the upper trace of the torque curve with the consistency line (i.e the time during which a sector of the torque curve exceeds the consistency line). Dough stability, which is an index of dough strength, was 2.20 and 2.10 min for control treatments of *Trimbak* and *Samadhan* wheat flours respectively (Table 4.10). Dough stability which indicates dough strength, was decreased with increasing defatted *Moringa* seed flour from 0 to 15 per cent and increased from 20 to 25 per cent. It was observed that wheat flour blended with defatted *Moringa* seed four recorded lowest dough stability for T_3 0.90 min (*Trimbak*) and T_3 1.10 min (*Samadhan*). The starch-gluten network is one of the major factors determining the stability of dough (Delcour *et al.,* 1991).

Majzoobi *et al.* (2012) also showed that dough stability decreased with increasing the percentage of oat flour in the formulation. Hussein and Abdalla (1976) reported decreased dough stability with increased addition of maize and sorghum in wheat flour due to weakening of dough. Mahmoud *et al.* (2018) evaluated the effect of FFF and DFF at different addition levels (5, 10 and 15 %) on the flour characteristics, showed that flour water absorption and dough stability were decreased as FFF or DFF addition levels increased. Dough stability decreased with decreased protein (Veterimani *et al.,* 2005). Longer the dough resistance time stronger will be the flour. The cohesive gluten network development through inter and intra-molecular bonding was responsible to render the dough stronger and less stretchable (Sim *et al.,* 2009).

4.5.2.4 Mixing Tolerance Index

The mixing tolerance index (MIT) is defined as the difference in BU/FU value at the top of the curve at peak time and the value at the top of the curve 5 minutes after the peak. This indicates the degree of softening during mixing. The degree of softening, which denotes the elastic proportion of dough followed a different pattern. Degree of softening for control treatment of *Trimbak* and *Samadhan* varieties, which were 87.00 and 92.00 FU (Table 4.10). Blend of wheat flour with defatted *Moringa* seed flour recorded lowest degree of softening for T_5 93.00 FU (*Samadhan*). Blend of wheat flour with defatted *Moringa* seed flour recorded higher degree of softening for T_3 150.00 FU (*Trimbak*) followed by T_3 140.00 FU (*Samadhan*). The combined effect of wheat variety and different levels of defatted *Moringa* seed flour showed mean degree of softening was 118.17 FU. In general, flours which have low softening value are stronger and vice versa. Reduction of MTI can be observed due to interactions between fibre and gluten (Wang *et al.,* 2002; Bouaziz *et al.,* 2010).

4.5.2.5 Farinograph quality number

The farinograph quality number is the point of the curve in which the curve has decreased by 30 FU after the maximum (based on middle line of the diagram). The distance mixing start (addition of water) to this point is determined in (mm) (this corresponds to the time up to this point in minutes multiplied by 10). The farinograph quality number is a measure for the flour quality. Higher the farinograph quality number, stronger the wheat flour and vice versa. Farinograph quality number decreased from control as level of defatted *Moringa* seed flour in wheat flour increased upto 15%. Control samples of *Trimbak* and *Samadhan* wheat variety flour had highest farinograph quality number, *viz.* 59.00 and 58.00, respectively (Table 4.10). Blend of wheat flour with defatted *Moringa* seed flour recorded lowest farinograph quality number of (*Trimbak*) T_3 43 FU and (*Samadhan*) T_3 42 FU. Treatment showed lowest farinograph quality number indicated poor flour which weakens early and quickly. T_0 indicated significantly different among all treatment followed by T_5 with strong flour quality which weakens late and slowly. The combined effect of wheat variety and different levels of defatted *Moringa* seed flour showed mean farinograph quality number was 50.00 FU. Similar effects on water absorption were observed when rice bran was added.

Zanwar (2020) reported increasing addition of deoiled linseed flour from 5 to 20 per cent, caused increase in water absorption (at 500 FU and 14 % moisture content), dough development time, time to breakdown and farinograph quality number whereas reduction was observed in dough stability and mixing tolerance index.

4.5.3 Extensograph Characteristics of Dough

The present investigation extensographic characteristics like energy required for extension, resistance to extension, extensibility, maximum (highest point of curve), ratio number and ratio number (max) were determined (Fig. 4.26-4.37). An extensograph gives information about the viscoelastic behaviour of a dough and measure dough extensibility and resistance and good extensibility was desirable dough properties. The energy (cm^2) values i.e. area under the curve indicates the extensibility and stretchability of dough which is related to the absolute level of elastic and viscous component of dough. An extensograph gives information about resistance to dough extension in BU. It measures the force to pull a hook through a rod shaped piece of dough. The resistance to extension is related to elastic properties of dough and viscous component.

4.5.3.1 Energy required for extension

The results with respect to extensographic characteristics of the dough are presented in Table 4.11. It is clear from the results that energy value differences of all treatments significant were found to be statistically significant for all the proving time. Area under curve or energy, which indicates the dough strength, of the control samples at 30 min of proofing was 48.00 and 46.00 cm^2 for *Trimbak* and *Samadhan* wheat variety flours respectively (Table 4.11). Energy (area under curve) was recorded maximum for the control samples. Time analysis showed that energy gradually increased with increase in proofing time from 30 to 90 min. In control wheat flour, it was observed that the energy value increased from 47 cm^2 at 30 min to 49 cm^2 at 60 and 90 min.

Addition of defatted *Moringa* seed flour caused changes in the energy values. At 30 min of proofing, blend of wheat flour with defatted *Moringa* seed flour recorded lowest energy value 14.83 cm^2 (*Trimbak*) and 15.00 cm^2 (*Samadhan*).

Table 4.11 Interaction effect of wheat variety (*Trimbak* and *Samadhan*) flour with defatted *Moringa* seed flour on energy (cm^2)

No.	Treatment	30 min			60 min			90 min		
		V_1 : *Trimbak*	V_2 : *Samadhan*	Mean	V_1 : *Trimbak*	V_2 : *Samadhan*	Mean	V_1 : *Trimbak*	V_2 : *Samadhan*	Mean
T_0	Control	48.00	46.00	47.00	52.00	46.00	49.00	53.00	45.00	49.00
T_1	5% DMSF	19.00	18.00	18.50	20.00	19.00	19.50	23.00	19.00	21.00
T_2	10% DMSF	8.00	10.00	9.00	13.00	10.00	11.50	11.00	13.00	12.00
T_3	15% DMSF	7.00	10.00	8.50	8.00	9.00	8.50	8.00	10.00	9.00
T_4	20% DMSF	4.00	4.00	4.00	5.00	4.50	4.75	5.00	5.00	5.00
T_5	25% DMSF	3.00	2.00	2.50	4.00	5.00	4.50	5.00	4.00	4.50
	Mean	**14.83**	**15.00**	**14.92**	**17.00**	**15.58**	**16.29**	**17.50**	**16.00**	**16.75**
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.10	0.30	1.23	0.10	0.31	1.24	0.12	0.37	1.49
	CD @ 5%	NS	0.88	NS	NS	0.89	NS	NS	1.07	4.28

All results are mean of three replications, DMSF= Defatted *Moringa* seed flour, NS= Non-significant

The time analysis showed that the energy gradually increased with increasing proofing time from 30 to 90 min. The combined effect of wheat variety and different levels of defatted *Moringa* seed flour showed mean energy value increased from 14.92 cm^2 at 30 min, 16.29 cm^2 at 60 min and 16.75 cm^2 at 90 min (Table 4.11).

It was observed that as with the increased concentration of defatted *Moringa* seed flour the energy was decreased might be due to reduced gluten content in 25 per cent replacement of defatted *Moringa* seed flour with both the varieties of wheat. (Zanwar, 2020) reported that the increasing addition of deoiled linseed flour from 5 to 20 per cent the extensograph parameters revealed reduction in the energy. Hassan *et al.,* (2015) studied that ratios of starch used in wheat flour were 5, 10 and 15 per cent with 5 per cent lentil flour. The energy and the extensibility of the dough of wheat flour decreased with addition of different starches percentages. The developed dough hydrated with water when subjected to mechanical action plays major role in modification of protein structure in dough (Gras *et al.* 2000).

4.5.3.2 Resistance to extension

The results (Table 4.12) revealed that highest resistance to extension was observed for control samples of wheat varieties *Trimbak* and *Samadhan* i.e., 396.00 and 377.00 BU respectively at 30 min proofing time. Addition of defatted *Moringa* seed flour caused changes in the resistance to extension. At 30 min of proofing, blend of wheat flour with defatted *Moringa* seed flour recorded resistance to extension of 104.50 BU (*Trimbak*) and 103.83 BU (*Samadhan*). The differences in resistance to extension values (Table 4.12) among all treatments to be significantly different at all the proving time.

Resistance to extension was recorded maximum for the control samples. Time analysis showed that resistance to extension gradually increased with increase in proofing time from 30 to 90 min. In control wheat flour, it was observed that the resistance to extension value increased from 386.50 BU, 399.50 and 405.50 BU.

The combined effect of wheat variety with defatted *Moringa* seed flour showed mean resistance to extension value increased from 104.17 BU at 30 min, 107.46 BU at 60 min and 112.25 BU at 90 min.

Table 4.12 Interaction effect of wheat variety (*Trimbak* and *Samadhan*) flour with defatted *Moringa* seed flour on resistance to extension (BU)

No.	Treatment	30 min			60 min			90 min		
		V_1 : *Trimbak*	V_2 : *Samadhan*	Mean	V_1 : *Trimbak*	V_2 : *Samadhan*	Mean	V_1 : *Trimbak*	V_2 : *Samadhan*	Mean
T_0	Control	396.00	377.00	386.50	417.00	382.00	399.50	429.00	382.00	405.50
T_1	5% DMSF	122.00	118.00	120.00	119.00	119.00	119.00	142.00	137.00	139.50
T_2	10% DMSF	35.00	27.00	31.00	63.00	48.50	55.75	46.00	37.00	41.50
T_3	15% DMSF	29.00	42.00	35.50	21.00	29.00	25.00	25.00	38.00	31.50
T_4	20% DMSF	25.00	26.00	25.50	27.00	23.00	25.00	27.00	20.00	23.50
T_5	25% DMSF	20.00	33.00	26.50	21.00	20.00	20.50	31.00	33.00	32.00
	Mean	**104.50**	**103.83**	**104.17**	**111.33**	**103.58**	**107.46**	**116.67**	**107.83**	**112.25**
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.14	0.43	1.75	0.36	1.09	4.39	0.17	0.52	2.08
	CD @ 5%	NS	1.259	5.03	1.05	3.15	12.60	0.49	1.49	5.98

All results are mean of three replications. DMSF= Defatted *Moringa* seed flour, NS= Non-significant

Hussein and Abdalla (1976) reported that addition of maize and sorghum significantly decreased the resistance to extension of dough. The extensograph properties of dough are significantly influenced by polymeric protein structure (Bangur *et al.* 1997). Gluten has viscoelastic behaviour in which gliadin fraction represents viscous behaviour and glutenin fraction represents elastic behaviour due to difference in molecular size of these fractions (Tsiami *et al.,* 1997; Spies, 1997 and Edward *et al.,* 2001). As concentration of bran increased elasticity decreased when it reaches to peak value. Strength of dough was related to the mixing properties of a particular cultivar and resistance to extension of dough after mixing (Edward *et al.,* 2001). Hassan *et al.* (2015)

studied that ratios of starch used in wheat flour were 5, 10 and 15with 5 per cent lentil flour. The addition of different starches percentages and the dough resistance to extension increased.

4.5.3.3 Extensibility

Extensibility indicates elasticity of the dough which has significant effects on quality of bakery product. Extensibility was the length of the curve in mm from the beginning of torque increase up to the point when the torque has fallen down to zero (Fig. 4.26-4.37 and Table 4.13). Differences of extensibility values in all the treatments with variety of wheat flour were significant for all proving time. At 30 min proving time treatment T_1 (77.00 mm) of variety *Samadhan* was statistically superior over the all treatment. Treatment T_1 (73.00 mm) of variety *Trimbak* shows nearest significance.

Addition of defatted *Moringa* seed flour affected on extensibility of dough. At 30 min of proving, blend of wheat flour with defatted *Moringa* seed flour recorded extensibility of 49.17 mm (*Trimbak*) and 52.33 mm (*Samadhan*).

Table 4.13 Interaction effect of wheat variety (*Trimbak* and *Samadhan*) flour with defatted *Moringa* seed flour on extensibility (mm)

No.	Treatment	30 min			60 min			90 min		
		V_1 : *Trimbak*	V_2 : *Samadhan*	Mean	V_1 : *Trimbak*	V_2 : *Samadhan*	Mean	V_1 : *Trimbak*	V_2 : *Samadhan*	Mean
T_0	Control	72.00	72.00	72.00	79.00	84.00	81.50	70.00	74.00	72.00
T_1	5% DMSF	73.00	77.00	75.00	71.00	72.00	71.50	72.00	69.00	70.50
T_2	10% DMSF	58.00	53.00	55.50	66.00	55.00	60.50	60.00	63.00	61.50
T_3	15% DMSF	41.00	58.00	49.50	43.00	53.00	48.00	42.00	55.00	48.50
T_4	20% DMSF	28.00	33.00	30.50	33.00	35.00	34.00	31.00	38.00	34.50
T_5	25% DMSF	23.00	21.00	22.00	26.00	32.00	29.00	31.00	30.00	30.50
	Mean	**49.17**	**52.33**	**50.75**	**53.00**	**55.17**	**54.08**	**51.00**	**54.83**	**52.92**
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.12	0.38	1.55	0.14	0.43	1.72	0.16	0.50	2.03
	CD @ 5%	0.37	1.11	4.44	0.41	1.23	4.95	0.48	1.46	5.84

All results are mean of three replications, DMSF= Defatted *Moringa* seed flour

The time analysis showed that the extensibility gradually increased with the increased in proving time from 30 to 60 min but decreased from 60 to 90 min. The combined effect of wheat variety and defatted *Moringa* seed flour showed mean extensibility value increased from 50.75, 54.08 and 52.92 mm at 30, 60 and 90 min respectively. It was revealed that extensibility was reduced with increased per cent of defatted *Moringa* seed flour. Extensibility is the property of the dough to be stretched. Dough with good extensibility are easy to stretched and for manual shaping.

To produce bread with good volume dough should have a high viscosity and extensibility to prevent sudden breakage in gas cell membranes (Sliwinski *et al.,* 2004). Hydration plays major role in modification of protein structure in dough (Gras *et al.,* 2000). The increased extensibility of common wheat dough relative to durum dough of comparable extensograph strength was attributed to higher molecular weight fraction in the polypeptide chains, similar in some respect to end-linked bimodal polymer network (Edward *et al.,* 2001).

4.5.3.4 Maximum (highest point of curve)

Maximum was the highest point of curve in BU (Table 4.14). Differences of maximum values for all treatments were significantly different for all proving time. Maximum was significantly influenced by addition of defatted *Moringa* seed flour in wheat flour (Table 4.14). It was observed the control samples of wheat varieties *Trimbak* and *Samadhan* 492.00 and 491.00 BU, respectively at 30 min Proving time. The maximum went on increasing with time behaviour when analyzed at 30, 60 and 90 min of proving time. Control sample had maximum 491.50, 501.50 and 568.00 BU at 30, 60 and 90 min of proving time, respectively.

Table 4.14 Interaction effect of wheat variety (*Trimbak* and *Samadhan*) flour with defatted *Moringa* seed flour on maximum (BU)

No.	Treatment	30 min			60 min			90 min		
		V_1 : *Trimbak*	V_2 : *Samadhan*	Mean	V_1 : *Trimbak*	V_2 : *Samadhan*	Mean	V_1 : *Trimbak*	V_2 : *Samadhan*	Mean
T_0	Control	492.00	491.00	491.50	527.00	476.00	501.50	565.00	571.00	568.00
T_1	5% DMSF	226.00	219.00	222.50	249.00	242.00	245.50	276.00	274.00	275.00
T_2	10% DMSF	132.00	159.00	145.50	181.00	169.00	175.00	176.00	177.00	176.50
T_3	15% DMSF	138.00	187.00	162.50	150.00	187.00	168.50	170.00	202.00	186.00
T_4	20% DMSF	107.00	117.00	112.00	133.00	127.00	130.00	134.00	132.00	133.00
T_5	25% DMSF	93.00	93.00	93.00	111.00	131.00	121.00	150.00	123.00	136.50
	Mean	**198.00**	**211.00**	**204.50**	**225.17**	**222.00**	**223.58**	**245.17**	**246.50**	**245.83**
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.159	0.477	1.911	0.152	0.457	1.829	0.156	0.469	1.878
	CD @ 5%	0.456	1.370	5.481	0.437	1.311	5.247	NS	1.346	5.387

All results are mean of three replications, DMSF= Defatted *Moringa* seed flour, NS= Non-significant

Addition of defatted *Moringa* seed flour caused changes in the extensibility. At 30 min of proving, the blend of wheat flour with defatted *Moringa* seed flour recorded maximum of 198.00 and 211.00 BU for *Trimbak* and *Samadhan* respectively. The time analysis showed that the extensibility gradually increased with the increased in proving time from 30 to 90 min among all treatments.

The combined effect of wheat variety and defatted *Moringa* seed flour showed mean maximum value increased from 204.50, 223.58 and 245.83 BU at 30, 60 and 90 min respectively. The mean value of maximum (BU) went on decreasing with the incremental addition of defatted *Moringa* seed flour (Table 4.14).

Maximum had similar behaviour as resistance to extension and both these characteristics are highly dependant on the protein content of the flour. Time analysis showed that the maximum gradually increased with the increase in proving time from 30 to 60 and 60 to 90 min. The changes in level of treatments significantly changes values due to corresponding wheat variety flour and their content of protein, gluten and starch.

4.5.3.5 Ratio number

Ratio number was the quotient of resistance to extension and extensibility. If extensibility was less, ratio number was increased and vice versa. The ratio number for control samples of wheat varieties *Trimbak* and *Samadhan* was recorded as 6.50 and 5.30 respectively at 30 min proving time (Table 4.15).

Table 4.15 Interaction effect of wheat variety (*Trimbak* and *Samadhan*) flour with defatted *Moringa* seed flour on ratio number

No.	Treatment	30 min			60 min			90 min		
		V_1 : *Trimbak*	V_2 : *Samadhan*	Mean	V_1 : *Trimbak*	V_2 : *Samadhan*	Mean	V_1 : *Trimbak*	V_2 : *Samadhan*	Mean
T_0	Control	6.50	5.30	5.90	5.30	4.60	4.95	6.10	5.20	5.65
T_1	5% DMSF	1.70	1.50	1.60	1.70	1.70	1.70	2.00	1.80	1.90
T_2	10% DMSF	0.60	0.50	0.55	1.00	0.70	0.85	0.80	1.00	0.90
T_3	15% DMSF	0.70	0.70	0.70	0.50	0.50	0.50	0.60	0.70	0.65
T_4	20% DMSF	0.90	0.80	0.85	0.80	0.70	0.75	0.90	0.50	0.70
T_5	25% DMSF	0.90	1.60	1.25	0.80	0.60	0.70	1.00	1.10	1.05
	Mean	**1.88**	**1.73**	**1.81**	**1.68**	**1.47**	**1.58**	**1.90**	**1.72**	**1.81**
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.013	0.040	0.160	0.011	0.035	0.141	0.012	0.038	0.154
	CD @ 5%	NS	0.114	0.459	0.033	0.101	NS	0.036	0.110	0.443

All results are mean of three replications, DMSF= Defatted *Moringa* seed flour, NS= Non-significant

Ratio number was significantly influenced by addition of defatted *Moringa* seed flour in wheat flour. Control sample had ratio number 5.90, 4.95 and 5.65 at 30, 60 and 90 min of proving time, respectively. Time analysis showed that the ratio number gradually decreased with increasing proving time from 30 to 60 min but increased from 60 to 90 min. Addition of defatted *Moringa* seed flour caused changes in the ratio number. At 30 min of proving, the blend of wheat flour with defatted *Moringa* seed flour recorded ratio number of 1.88 and 1.73.

The combined effect of wheat variety and defatted *Moringa* seed flour showed mean ratio number value decreased from 1.81 at 30 min to 1.58 at 60 min and increased to 1.81 at 90 min, respectively. The mean value of ratio number went on decreasing with the incremental addition of defatted *Moringa* seed flour up to 10 per cent (Table 4.15).

Rosell *et al.* (2001) also found lower values for the control sample while evaluating the rheological characteristics and quality of bread.

4.5.3.6 Ratio number (maximum)

Ratio number (max) was quotient of maximum resistance to extension (highest point of curve BU) and extensibility Table 4.16. If extensibility is less, ratio number (max) is more and vice versa. For the character ratio number maximum i.e. quotient of maximum resistance to extension and extensibility the differences among treatments were significantly different.

Table 4.16 Interaction effect of wheat variety (*Trimbak* and *Samadhan*) flour with defatted *Moringa* seed flour on ratio number max

No.	Treatment	30 min			60 min			90 min		
		V_1 : *Trimbak*	V_2 : *Samadhan*	Mean	V_1 : *Trimbak*	V_2 : *Samadhan*	Mean	V_1 : *Trimbak*	V_2 : *Samadhan*	Mean
T_0	Control	6.80	6.80	6.80	6.70	5.70	6.20	8.00	6.40	7.20
T_1	5% DMSF	3.10	2.50	2.80	3.50	3.50	3.50	3.80	3.70	3.75
T_2	10% DMSF	2.30	3.00	2.65	2.70	3.10	2.90	3.00	2.80	2.90
T_3	15% DMSF	3.30	3.20	3.25	3.50	3.50	3.50	4.00	3.70	3.85
T_4	20% DMSF	3.90	3.60	3.75	4.00	3.70	3.85	4.30	3.50	3.90
T_5	25% DMSF	4.10	4.50	4.30	4.20	4.10	4.15	4.90	4.10	4.50
	Mean	**3.92**	**3.93**	**3.93**	**4.10**	**3.93**	**4.02**	**4.67**	**4.03**	**4.35**
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.015	0.047	0.18	0.014	0.04	0.17	0.03	0.09	0.39
	CD @ 5%	NS	0.13	0.54	NS	0.12	0.51	0.09	0.28	NS

All results are mean of three replications, DMSF= Defatted *Moringa* seed flour, NS= Non-significant

The ratio number maximum for control samples of wheat varieties *Trimbak* and *Samadhan* was recorded as each 6.80 at 30 min proving time (Table 4.16). At 30 min of proving, the blend of wheat flour with defatted *Moringa* seed flour recorded maximum of 3.92 and 3.93. Time analysis showed that the ratio number maximum gradually increased with increasing proving time from 30 to 90 min.

Addition of defatted *Moringa* seed flour caused changes in the ratio number (max). Control sample had ratio number maximum 6.80, 6.20 and 7.20 at 30, 60 and 90 min of proving time, respectively. The combined effect of wheat variety and defatted *Moringa* seed flour showed mean ratio number (max) value increased from 3.93 at 30 min to 4.02 at 60 min and increased to 4.35 at 90 min, respectively.

These results indicated that the ratio number maximum decreased up to 10 per cent thereafter it was increased but not more than control. As concentration of defatted *Moringa* seed flour increases resulted in reduction of extensibility and elastic properties of dough.

4.6 Sensory Evaluation, Physical Properties, Chemical, Micronutrient Composition and Textural Characteristics of Biscuits

4.6.1 Sensory Evaluation

4.6.1.1 Sensory evaluation of *Moringa* seed oil biscuits

Generally, consumer accepts the biscuits on the basis of its sensory quality parameter such as colour and appearance, texture, flavour, taste and overall acceptability (Appendix I). The effect of different level of incorporation of *Moringa* seed oil on sensory characteristics of biscuits was judged by the semi trained panellist on 9 point Hedonic scale (Plate 4.1-4.2) and results obtained are summarized in Table 4.17. The differences for the sensory characteristics like colour and appearance, texture, flavour, taste and overall acceptability were statistically significant among all the treatments. The biscuits samples prepared with treatment T_2 (40 % MSO) were statistically superior for overall acceptability parameter over all other treatments to the proportion of same variety (*Trimbak* and *Samadhan*).

Colour and appearance

The colour and appearance score of biscuits from *Trimbak* and *Samadhan* wheat flour of control sample was 8.11 and 8.16 respectively. The biscuits samples prepared with treatment T_2 (40 % MSO) from *Trimbak* and *Samadhan* wheat flour had colour and appearance score 7.96 and 8.00 and showed mean colour and appearance score of treatment T_2 was 7.98.

The value of colour and appearance was decreased with increased incorporation of *Moringa* seed oil. The combined effect of wheat variety and different level of *Moringa* seed oil showed mean colour appearance score 7.55.

Texture

The texture score of biscuits from *Trimbak* and *Samadhan* wheat flour of control sample was 8.03 and 8.02 respectively. The biscuits samples prepared with treatment T_2 (40 % MSO) from *Trimbak* and *Samadhan* wheat flour had texture score 7.87 and 8.12 and showed mean texture score of treatment T_2 was 8.00.

The incorporation of *Moringa* seed oil level increased in biscuits which effects on the texture of biscuits as its reduction in brittleness. The combined effect of wheat variety and different level of *Moringa* seed oil showed mean texture score 7.45. Similar result were obtained by Muhammad *et al.* (2008) for cookies were prepared from wheat germ oil (WGO) upto 50 % which had higher scores than the control.

Flavour

The flavour score of biscuits from *Trimbak* and *Samadhan* wheat flour of control sample was 8.45 and 8.24 respectively. The biscuits samples prepared with treatment T_2 (40 % MSO) from *Trimbak* and *Samadhan* wheat flour had flavour score 8.05 and 7.86 and showed mean flavour score value of treatment T_2 was 7.96.

The incorporation of *Moringa* seed oil level increased in biscuits which causes changes in flavour of biscuits. The combined effect of wheat variety and different level of *Moringa* seed oil showed mean flavour score 7.39. Similar results were obtained by Abdul *et al.* (2010) for cookies were prepared from cottonseed oil blends upto 50% which had higher scores than the control.

Taste

The taste score of biscuits from *Trimbak* and *Samadhan* wheat flour of control sample was significantly superior had score 8.32 and 8.00 respectively followed by treatment T_2 (40 % MSO) from *Trimbak* and *Samadhan* wheat flour had taste score 7.95 and 7.70 and showed mean taste score value of treatment T_2 was 7.83.

The *Moringa* seed oil level increased in biscuits which effects on taste of biscuits. The combined effect of wheat variety and different level of *Moringa* seed oil showed mean taste score 7.23. Similar results were obtained by Rangrej *et al.* (2015) for flaxseed oil cookies.

Table 4.17 Sensory evaluation of biscuits prepared with addition of different levels of *Moringa* seed oil

No.	Treatment	Colour and appearance			Texture			Flavour			Taste			Overall acceptability		
		V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_0	Control	8.11	8.16	8.14	8.03	8.02	8.03	8.45	8.24	8.35	8.32	8.00	8.16	8.22	8.10	8.16
T_1	20% MSO	8.04	7.75	7.90	7.55	8.00	7.78	7.91	7.50	7.71	7.64	7.75	7.70	7.78	7.75	7.77
T_2	**40% MSO**	**7.96**	**8.00**	**7.98**	**7.87**	**8.12**	**8.00**	**8.05**	**7.86**	**7.96**	**7.95**	**7.70**	**7.83**	**7.95**	**7.92**	**7.94**
T_3	60% MSO	7.63	7.60	7.62	7.50	7.50	7.50	7.42	7.25	7.34	7.12	7.03	7.08	7.41	7.34	7.38
T_4	80% MSO	7.15	7.12	7.14	7.05	7.00	7.03	6.68	6.65	6.67	6.60	6.50	6.55	6.87	6.81	6.84
T_5	100% MSO	6.62	6.50	6.56	6.54	6.25	6.40	6.36	6.25	6.31	6.12	6.00	6.06	6.41	6.25	6.33
	Mean	7.59	7.52	7.55	7.42	7.48	7.45	7.48	7.29	7.39	7.29	7.16	7.23	7.44	7.36	7.40
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.015	0.046	0.184	0.033	0.101	0.405	0.014	0.044	0.178	0.014	0.043	0.174	0.014	0.044	0.179
	CD @ 5%	NS	0.132	NS	NS	0.291	NS	NS	0.128	NS	NS	0.124	NS	NS	0.128	NS

All results are mean of 10 replications. V_1 = *Trimbak* V_2 = *Samadhan*. MSO= *Moringa* seed oil. NS= Non-significant. Maximum score out of 9.0

Overall acceptability

The overall acceptability score of biscuits from *Trimbak* and *Samadhan* wheat flour of control sample was significantly superior had score 8.22 and 8.10, respectively. The treatment T_2 (40 % MSO) from *Trimbak* and *Samadhan* wheat flour had overall acceptability score 7.95 and 7.92 and showed mean overall acceptability score value of treatment T_2 was 7.94.

The combined effect of wheat variety and different level of *Moringa* seed oil showed mean overall acceptability score 7.40. It could be observed that all the treatments were in acceptable range. Highest mean score for overall acceptability of biscuits were observed in treatment T_2 (7.94) which are at par with T_0 (8.16). Similar results were obtained by Rangrej *et al.* (2015) for flaxseed oil cookies.

4.6.1.2 Sensory evaluation of defatted *Moringa* seed flour biscuits

On the basis of rheological properties of dough which indicated optimum level of defatted *Moringa* seed flour (DMSF) can be used for preparation of biscuits of acceptability quality (Plate 4.3-4.4).

The differences for the sensory characteristics like colour and appearance, texture, flavour, taste and overall acceptability (Appendix II) were statistically significant different among all treatments (Table 4.18). The biscuits sample prepared with treatment T_2 (10 % DMSF) were statistically superior and which are at par with T_0 for overall acceptability parameter to the proportion of same variety (*Trimbak* and *Samadhan*).

Colour and appearance

The colour and appearance score of biscuits from *Trimbak* and *Samadhan* wheat flour of control sample was 8.11 and 8.16 respectively. The biscuits samples prepared with treatment T_2 (10 % DMSF) from *Trimbak* and *Samadhan* wheat flour had colour and appearance score 7.93 and 7.92 and showed mean colour and appearance score of treatment T_2 was 7.93.

The value of colour and appearance was decreased with increased incorporation of defatted *Moringa* seed flour. The combined effect of wheat variety and different level of defatted *Moringa* seed flour showed mean colour appearance score 7.60.

Table 4.18 Sensory evaluation of biscuits prepared with addition of different levels of defatted *Moringa* seed flour

No.	Treatment	Colour and appearance			Texture			Flavour			Taste			Overall acceptability		
		V_1	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**
T_0	Control	8.11	8.16	8.14	8.03	8.02	8.03	8.45	8.24	8.35	8.32	8.00	8.16	8.22	8.10	8.16
T_1	5% DMSF	8.02	8.02	8.02	7.94	7.91	7.93	7.81	7.65	7.73	7.64	7.34	7.49	7.85	7.73	7.79
T_2	**10% DMSF**	**7.93**	**7.92**	**7.93**	**8.33**	**7.84**	**8.09**	**8.00**	**7.92**	**7.96**	**7.82**	**7.65**	**7.74**	**8.02**	**7.83**	**7.90**
T_3	15% DMSF	7.55	7.33	7.44	7.36	7.04	7.20	7.16	6.52	6.84	6.53	6.24	6.39	7.15	6.78	6.97
T_4	20% DMSF	7.16	7.05	7.11	6.92	6.71	6.82	6.57	6.22	6.40	6.08	6.03	6.06	6.68	6.50	6.59
T_5	25% DMSF	7.07	6.82	6.95	6.86	6.56	6.71	6.03	5.94	5.99	5.85	5.72	5.79	6.45	6.26	6.36
	Mean	7.64	7.55	7.60	7.57	7.35	7.46	7.34	7.08	7.21	7.04	6.83	6.94	7.40	7.20	7.30
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.015	0.046	0.186	0.015	0.045	0.182	0.014	0.043	0.172	0.013	0.041	0.165	0.014	0.044	0.176
	CD @ 5%	NS	0.133	NS	0.043	0.13	NS	0.041	0.123	NS	0.039	0.118	NS	NS	0.126	NS

All results are mean of 10 replications. **V_1** = *Trimbak* **V_2** = *Samadhan*. DMSF= Defatted *Moringa* seed flour. NS= Non-significant. Maximum score out of 9.0

Texture

The texture score of biscuits from *Trimbak* and *Samadhan* wheat flour of control sample was 8.03 and 8.02, respectively. The biscuits samples prepared with treatment T_2 (10 % DMSF) from *Trimbak* and *Samadhan* wheat flour had texture score 8.33 and 7.84 and showed mean texture score of treatment T_2 was 8.09.

The incorporation of defatted *Moringa* seed flour level of increased in biscuits which effects on the texture of biscuits. The combined effect of wheat variety and different level of defatted *Moringa* seed flour showed mean texture score 7.46. It was observed that addition of defatted seed flour during preparation of biscuits to decrease water absorption capacity of flour eventually resulted in hard texture of biscuits.

Flavour

The flavour score of biscuits from *Trimbak* and *Samadhan* wheat flour of control sample was 8.45 and 8.24, respectively. The biscuits samples prepared with treatment T_2 (10 % DMSF) from *Trimbak* and *Samadhan* wheat flour had flavour score 8.00 and 7.92 and showed mean flavour score value of treatment T_2 was 7.96.

The incorporation of defatted *Moringa* seed flour level increased in biscuits which causes changes in flavour of biscuits. The combined effect of wheat variety and different level of defatted *Moringa* seed flour showed mean flavour score 7.21.

Taste

The taste score of biscuits from *Trimbak* and *Samadhan* wheat flour of control sample was significantly superior had score 8.32 and 8.00 respectively followed by treatment T_2 (40 % MSO) from *Trimbak* and *Samadhan* wheat flour had taste score 7.82 and 7.65 and showed mean taste score value of treatment T_2 was 7.74.

The defatted *Moringa* seed flour level increased in biscuits which effects on taste of biscuits. The combined effect of wheat variety and different level of defatted *Moringa* seed flour showed mean taste score 6.94.

Overall acceptability

The overall acceptability score of biscuits from *Trimbak* and *Samadhan* wheat flour of control sample was significantly superior had score 8.22 and 8.10 respectively. The treatment T_2 (10 % DMSF) from *Trimbak* and *Samadhan* wheat flour had overall acceptability score 8.02 and 7.83 and showed mean taste score value of treatment T_2 was 7.90.

The combined effect of wheat variety and different level of defatted *Moringa* seed flour showed mean overall acceptability score 7.30. Highest mean score for overall acceptability of biscuits were observed in treatment T_2 (7.90) which are at par with T_0 (8.16). Azza *et al.* (2016) evaluated that the biscuits containing 25% defatted flaxseed flour showed maximum sensory scores compared to other samples.

4.6.2 Physical Properties of Biscuits

4.6.2.1 Physical parameter of biscuits affected by wheat variety flour with the different level of *Moringa* seed oil

The significance of addition of *Moringa* seed oil (MSO) on physical properties such as weight, diameter, thickness, spread ratio and spread factor were determined. The results about physical parameter of biscuits incorporated with different levels of *Moringa* seed oil is shown in Table 4.19.

Weight

The results obtained was statistically significant for weight of control biscuits sample from *Trimbak* and *Samadhan* wheat flour was 9.32 and 9.25 g which is at par with T_1 and followed by T_2. The addition of different levels of *Moringa* seed oil which effects on weight of biscuits. Weight of acceptable product (T_2 40 % MSO) which can be obtained on basis of sensory parameter was 9.21 and 9.17 g respectively and mean weight showed 9.19 g.

The combined effect of wheat variety with different levels of *Moringa* seed oil (MSO) showed mean weight of 9.16 g. The reduction in weight of biscuits after adding *Moringa* seed oil may be due to the dough density which depends upon the type of fat used.

Diameter

The biscuits prepared from *Trimbak* and *Samadhan* wheat flour of control sample statistically superior in diameter was 48.14 and 47.63 mm, respectively. For treatment T_2 prepared from the *Trimbak* and *Samadhan* wheat flour blend with the 40 per cent MSO was 47.63 and 47.17 mm and mean diameter of biscuits was 47.40 mm (Table 4.19).

Table 4.19 Physical parameter of biscuits affected by wheat variety flour with the different level of *Moringa* seed oil

No.	Treatment	Weight (g)			Diameter (mm)			Thickness (mm)			Spread ratio			Spread factor (%)		
		V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_0	Control	9.32	9.25	9.29	48.14	47.63	47.89	8.38	8.25	8.32	5.74	5.77	5.76	100.00	100.00	100.00
T_1	20% MSO	9.28	9.22	9.25	47.85	47.37	47.61	7.46	7.23	7.35	6.41	6.55	6.48	111.67	113.51	112.59
T_2	40% MSO	9.21	9.17	9.19	47.63	47.17	47.40	7.57	7.42	7.50	6.29	6.35	6.32	109.58	110.07	109.83
T_3	60% MSO	9.18	9.12	9.15	47.34	46.89	47.12	7.89	7.87	7.88	6.00	5.96	5.98	104.52	103.63	104.08
T_4	80% MSO	9.11	9.04	9.08	47.12	46.73	46.93	8.17	8.12	8.15	5.76	5.75	5.76	100.34	99.65	100.00
T_5	100% MSO	9.02	8.95	8.99	46.92	46.54	46.73	8.36	8.34	8.35	5.61	5.58	5.60	97.73	96.77	97.25
	Mean	9.19	9.13	9.16	47.50	47.06	47.28	7.97	7.87	7.92	5.97	5.99	5.98	103.97	103.94	103.96
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.001	0.003	0.013	0.001	0.004	0.019	0.007	0.005	0.020	0.001	0.003	0.015	0.022	0.068	0.272
	CD @ 5%	0.003	0.009	NS	0.004	0.013	0.054	0.004	0.014	0.059	0.003	0.010	0.043	NS	0.195	0.781

Each value represents the average of three determination. $\mathbf{V_1}$ = *Trimbak* $\mathbf{V_2}$ = *Samadhan*. MSO= *Moringa* seed oil. NS= Non-significant

The *Moringa* seed oil was affected on the diameter of biscuits. Combined effect of wheat variety and different levels of MSO substitute with the vanaspati showed mean diameter 47.28 mm. Muhammad *et al.* (2008) investigated that the physical characteristics as diameter of cookies prepared from replacing wheat germ oil.

Thickness

The results revealed from Table 4.19 was that the thickness of control (T_0) biscuits prepared from *Trimbak and* Samadhan wheat flour was 8.38 and 8.25 mm, respectively. The mean thickness value of T_5 (8.35 mm) showed statistically significant followed by T_0 (8.32 mm). The treatment T_1 (7.35 mm) recorded lowest mean valve of thickness.

The MSO cause changes in thickness of biscuits. The thickness of biscuits increased with increasing level of MSO. The treatment T_2 (40 % MSO) recorded the thickness value for *Trimbak* and *Samadhan* wheat flour was 7.57 and 7.42 mm and showed mean thickness of 7.50 mm. The combined effect of wheat variety and different levels of *Moringa* seed oil (MSO) substitute with vanaspati showed mean thickness 7.92 mm. Rangrej *et al.* (2015) reported that the flaxseed oil content increased, significant increase in cookies thickness was observed.

Spread ratio

The observation recorded for spread ratio of control biscuits prepared from *Trimbak* and *Samadhan* wheat flour was 5.74 and 5.77 respectively. Spread ratio is the quotient of diameter and thickness of biscuits therefore *Moringa* seed oil (MSO) can also affected on the spread ratio of biscuits. The treatment T_1 (6.48) statistically superior in mean spread ratio followed by treatment T_2 (6.32).

The spread ratio of T_5 showed lowest mean value among all other treatments. The treatment T_2 (40 % MSO) recorded spread ratio for *Trimbak* and *Samadhan* wheat flour 6.29 and 6.35 and mean spread ratio was 6.32. The combined effect of wheat flour with different level of *Moringa* seed oil (MSO) observed mean spread ratio 5.98.

Spread factor

The results from present study revealed that spread factor of biscuits prepared from *Trimbak* and *Samadhan* wheat flour was 100.00 per cent. Spread factor was highest for treatment T_1 was 111.67 per cent (*Trimbak*) and 113.51 per cent (*Samadhan*) and mean spread factor of biscuits 112.59 per cent followed by treatment T_2 was 109.83 per cent. The combined effect of wheat flour with different level of *Moringa* seed oil (MSO) showed mean spread factor 103.96 per cent.

The inclusion of *Moringa* seed oil was also observed (Table 4.19) to reduce the spread factor because oil emulsion could reduce the viscoelastic property of gluten structure in a dough mix; as more enhancements in the elastic network of gluten is formed in the aqueous phase than in oil based emulsions (Bengoechea *et al.,* 2006) in effect the product made from dough with low gluten structures will result in softer biscuits.

The combined effect of wheat flour with different level of *Moringa* seed oil (MSO) showed mean spread factor 103.96 per cent.

4.6.2.2 Physical parameter of biscuits affected by wheat variety flour with the different level of defatted *Moringa* seed flour

The significance of addition of defatted *Moringa* seed flour (DMSF) on physical properties such as weight, diameter, thickness, spread ratio and spread factor were determined. The results about physical parameter of biscuits incorporated with different levels of defatted *Moringa* seed flour is shown in Table 4.20.

Weight

The weight of biscuits prepared from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 9.32 and 9.25 g respectively and mean weight showed 9.29 g. The T_5 showed statistically significant in mean weight among all treatments. The weight of biscuits increased as level of defatted *Moringa* seed flour increased. Weight of optimized product T_2 was 9.70 g (*Trimbak*), 9.62 g (*Samadhan*) and showed mean weight of biscuits was 9.66 g.

The combined effect of wheat variety and different levels of defatted *Moringa* seed flour in biscuits showed mean weight of 9.61 g. Changes in level of treatments significantly changes values due to corresponding wheat variety flour.

Diameter

The results revealed that diameter of biscuits from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 48.14 and 47.63 mm and showed biscuits mean diameter of 47.89 mm. The diameter of biscuits increased with increased in levels of DMSF. The treatment T_5 showed significantly different in diameter among all other 50.62 mm (*Trimbak*), 50.05 mm (*Samadhan*) and showed mean diameter of 50.34 mm.

Table 4.20 Physical parameter of biscuits affected by wheat variety flour with the different level of defatted *Moringa* seed flour

No.	Treatment	Weight (g)			Diameter (mm)			Thickness (mm)			Spread ratio			Spread factor (%)		
		V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_0	Control	9.32	9.25	9.29	48.14	47.63	47.89	8.38	8.25	8.31	5.74	5.77	5.76	100.00	100.00	100.00
T_1	5% DMSF	9.52	9.44	9.48	48.48	48.44	48.46	7.87	7.81	7.84	6.16	6.13	6.15	107.32	106.20	106.76
T_2	10% DMSF	9.70	9.62	9.66	49.02	48.46	48.74	7.46	7.42	7.44	6.57	6.53	6.55	114.45	113.13	113.79
T_3	15% DMSF	9.76	9.63	9.70	50.15	49.42	49.79	7.15	7.09	7.12	7.01	6.97	6.99	122.12	120.74	121.43
T_4	20% DMSF	9.82	9.68	9.75	50.36	49.76	50.06	6.89	6.83	6.86	7.30	7.28	7.29	127.20	126.16	126.68
T_5	25% DMSF	9.90	9.72	9.81	50.62	50.05	50.34	6.78	6.69	6.74	7.46	7.48	7.47	130.00	129.59	129.79
	Mean	9.67	9.56	9.61	49.46	48.96	49.21	7.42	7.35	7.38	6.71	6.69	6.70	116.85	115.97	116.41
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.001	0.002	0.009	0.007	0.022	0.088	0.001	0.004	0.019	0.001	0.004	0.019	0.024	0.072	0.291
	CD @ 5%	0.002	0.006	0.026	0.021	0.063	0.252	0.004	0.013	NS	NS	0.013	NS	0.069	0.208	NS

Each value represents the average of three determination. $\mathbf{V_1}$ = *Trimbak*, $\mathbf{V_2}$ = *Samadhan*. DMSF= Defatted *Moringa* seed flour, NS = Non-significant

The acceptable treatment T_2 showed diameter 49.02 mm (*Trimbak*), 48.46 mm (*Samadhan*) and observed mean diameter of 48.74 mm. The combined effect of wheat variety and different levels of defatted *Moringa* seed flour in biscuits showed mean diameter of 49.21 mm. Azza *et al.* (2016) indicated that diameter of biscuit was slightly increased with increasing substitution percentage of flaxseed flour compared with control biscuit. Yadav *et al.* (2012) studied that there was increased in diameter as the level of DPMF increased.

Thickness

The thickness of biscuits prepared from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 8.38 and 8.25 mm and showed biscuits mean diameter of 8.31 mm. The DMSF causes the changes in thickness of biscuits. The thickness of biscuits decreased with increased level of DMSF.

The mean value of T_0 (8.31 mm) was statistically significant for thickness followed by T_1 (7.84 mm) and at par with T_2 (7.44 mm). The combined effect of wheat variety and different levels of defatted *Moringa* seed flour (DMSF) in biscuits showed mean thickness of 7.38 mm. Yadav *et al.* (2012) studied there was decreased in thickness as the level of DPMF increased. Simona *et al.* (2019) reported that the decrease in thickness of biscuits with DSSF inclusion might be due to the dilution of gluten or increase in fibre content.

Spread ratio

Changes in diameter and thickness were reflected in spread ratio of biscuits. The spread factor of treatment T_0 biscuits 5.74 (*Trimbak*), 5.77 (*Samadhan*) respectively. The lowest mean value for spread ratio was 5.76 (T_0) whereas highest mean value for spread ratio was 7.47 (T_5).

The acceptable product treatment T_2 had spread ratio 6.57 (*Trimbak*), 6.53 (*Samadhan*) and showed mean spread ratio of T_2 was 6.55. The combined effect of wheat variety and different levels of defatted *Moringa* seed flour in biscuits showed mean spread ratio of 6.70. Simona *et al.* (2019) investigated that physical properties of biscuits with the 36 per cent DSSF biscuits had a significantly higher spread ratio. Spread ratio increased with the DPMF level increased reported by Yadav *et al.* (2012).

Spread factor

The biscuits prepared from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour had spread factor 100 per cent. The treatment T_5 was significantly different for spread factor among all other treatment.

The spread factor of acceptable treatment T_2 was 114.45 per cent (*Trimbak*), 113.13 per cent (*Samadhan*) and showed mean spread factor of 113.79 per cent. The combined effect of wheat variety and different levels of defatted *Moringa* seed flour (DMSF) in biscuits observed mean spread factor of 116.41 per cent.

4.6.3 Chemical Composition of Biscuits

4.6.3.1 Chemical composition of biscuits incorporated with *Moringa* seed oil

Effects of different levels of *Moringa* seed oil on proximate composition of biscuits showed that with increase in MSO level in biscuits do not affects on chemical composition of biscuits significantly (Table 4.21). There were non significant changes in moisture, protein, crude fibre and ash content was observed but significantly changes in fat and carbohydrate.

Moisture

The moisture content of biscuits prepared from *Trimbak* and *Samadhan* wheat flour for T_0 was 3.69 and 3.39 per cent respectively and showed mean moisture content of 3.54 per cent. There was a non significant change in moisture. The moisture content of biscuits ranges from 3.53 to 3.69 per cent (*Trimbak*) and 3.25 to 3.39 per cent (*Samadhan*).

The moisture content of biscuits ranges of mean from 3.39 to 3.54 per cent. The combined effect of wheat variety with different levels of *Moringa* seed oil (MSO) showed mean moisture 3.46 per cent. Variation in moisture content among treatments seemed to be due to differences in affinities of oil and shortening blends towards water as the cookies made from standard shortening attained maximum moisture content were reported by Sharoon *et al.* (2014). The present findings are in conformity with the reported results of Sukeerthi and Singh, (2017).

Protein

There was a lower change in protein content. The protein content of biscuits from *Trimbak* and *Samadhan* wheat flour for T_0 was 7.24 and 6.66 per cent and showed mean protein content 6.95 per cent. The protein content of biscuits ranges from 7.12 to 7.24 per cent (*Trimbak*), 6.61 to 6.66 per cent (*Samadhan*) and protein content of biscuits ranges of mean from 6.87 to 6.93 per cent.

The combined effect of wheat variety and different levels of *Moringa* seed oil (MSO) showed mean protein content of 6.92 per cent. The similar findings of protein content are reported by Sharif *et al.* (2004).

Table 4.21 Proximate composition of biscuits affected by wheat variety with incorporation of *Moringa* seed oil

No.	Treatment	Moisture (%)			Protein (%)			Fat (%)			Crude fibre (%)			Ash (%)			Carbohydrate (%)		
		V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_0	Control	3.69	3.39	3.54	7.24	6.66	6.95	25.69	25.57	25.63	1.12	0.85	0.99	1.07	1.27	1.17	61.19	62.26	61.73
T_1	20% MSO	3.65	3.37	3.51	7.21	6.66	6.94	25.92	25.80	25.86	1.12	0.85	0.99	1.08	1.28	1.18	61.02	62.04	61.53
T_2	40% MSO	3.61	3.32	3.47	7.24	6.65	6.95	26.42	26.29	26.36	1.14	0.86	1.00	1.09	1.29	1.19	60.50	61.59	61.05
T_3	60% MSO	3.59	3.29	3.44	7.22	6.64	6.93	26.73	26.58	26.66	1.14	0.86	1.00	1.10	1.27	1.18	60.23	61.36	60.80
T_4	80% MSO	3.56	3.27	3.42	7.20	6.62	6.91	26.95	26.79	26.87	1.12	0.85	0.99	1.08	1.26	1.17	60.09	61.21	60.65
T_5	100% MSO	3.53	3.25	3.39	7.12	6.61	6.87	27.46	26.87	27.17	1.11	0.84	0.98	1.07	1.24	1.16	59.71	61.19	60.45
	Mean	3.61	3.32	3.46	7.21	6.64	6.92	26.53	26.32	26.42	1.13	0.85	0.99	1.08	1.27	1.17	60.46	61.61	61.03
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.004	0.013	0.051	0.014	0.043	0.174	0.011	0.035	0.139	0.002	0.006	0.025	0.003	0.009	0.038	0.011	0.033	0.133
	CD @ 5%	0.012	NS	NS	0.041	NS	NS	0.033	0.100	NS	0.005	NS	NS	0.009	NS	NS	0.032	0.095	NS

Each value represents the average of three determination. $\mathbf{V_1}$ **=** *Trimbak*, $\mathbf{V_2}$ **=** *Samadhan*, MSO= *Moringa* seed oil, NS = Non-significant

Fat

There was a significant change among the treatments. The fat content for T_0 was 25.69 per cent (*Trimbak*), 25.57 per cent (*Samadhan*) and showed mean fat content of 25.63 per cent. The fat content of biscuits ranges from 25.69 to 27.46 per cent (*Trimbak*), 25.57 to
26.87 per cent (*Samadhan*) and fat content of biscuits ranges of mean from 25.63 to 26.17 per cent.

The combined effects of wheat variety and different levels of *Moringa* seed oil showed mean fat content of 26.42 per cent. The results obtained in present investigation were in agreement with results obtained by Rangrej *et al.* (2015).

Crude fibre

There was a lower change in crude fibre content. The crude fibre content of biscuits from *Trimbak* and *Samadhan* wheat flour for treatment T_0 was 1.12 and 0.85 per cent and showed mean value 0.99 per cent.

The fibre content of biscuits ranges from 1.11 to 1.14 per cent (*Trimbak*) and 0.84 to 0.86 per cent (*Samadhan*). The Fibre content of biscuits ranges of mean from 0.98 to 1.00 per cent. The combined effect of wheat variety and different levels of *Moringa* seed oil showed mean crude fibre 0.99 per cent. The similar findings of protein content are reported by Sharif *et al.* (2004).

Ash

Ash content of biscuits from *Trimbak* and *Samadhan* wheat flour for treatment T_0 was 1.07 and 1.27 per cent and showed mean ash content of 1.17 per cent.

The ash content of biscuits ranges from 1.07 to 1.10 per cent (*Trimbak*) and 1.24 to 1.29 per cent (*Samadhan*). The ash content of biscuits ranges of mean from 1.16 to 1.19 per cent. The combined effect of wheat variety and different levels of *Moringa* seed oil (MSO) showed mean ash content of 1.17 per cent. Similar results were obtained by Abdul *et al.* (2010) for cookies were prepared from cottonseed oil.

Carbohydrate

The carbohydrate content of biscuits from *Trimbak* and *Samadhan* wheat flour for treatment T_0 was 61.19 and 62.26 per cent and showed mean carbohydrate content 61.73 per cent.

There was a significant change in carbohydrate content. The carbohydrate content of biscuits ranged from 59.71 to 61.19 per cent (*Trimbak*) and 61.19 to 62.26 per cent

(*Samadhan*). The carbohydrate content of biscuits ranged of mean from 60.45 to 61.73 per cent. The combined effect of wheat variety and different levels of *Moringa* seed oil showed mean carbohydrate of 61.03 per cent. Similar results were obtained by Abdul *et al.* (2010) for cookies were prepared from cottonseed oil.

4.6.3.2 Chemical composition of biscuits incorporated with defatted *Moringa* seed flour

The results with respect to proximate composition of biscuits like moisture, fat, protein, crude fibre, ash and carbohydrate are presented in Table 4.22 The observation for moisture, fat, protein, crude fibre, ash and carbohydrate of biscuits showed statistically significant difference among the variety and treatments.

Moisture

The moisture content biscuits prepared from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 3.69 and 3.39 per cent respectively and showed the mean moisture content of 3.54 per cent (Table 4.22). There was a significant change in moisture content T_5 is significantly superior to all over treatments.

The moisture content of biscuits increased with incremental addition of level of defatted *Moringa* seed flour. The moisture content of optimized product T_2 was 3.95 per cent (*Trimbak*) and 3.72 per cent (*Samadhan*) and observed the mean moisture content of 3.84 per cent. The combined effect of wheat variety and different levels of defatted *Moringa* seed flour recorded mean moisture content of 3.97 per cent. The present findings are in conformity with the reported results of Zarka and Neelash, (2018).

Protein

The protein content of biscuits from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 7.25 and 6.66 per cent respectively and observed the mean protein content of 6.95 per cent. There was increased in protein content as defatted *Moringa* seed flour level increased.

The protein content of optimized product T_2 was 10.94 per cent (*Trimbak*) and 10.40 per cent (*Samadhan*) and recorded mean protein content in biscuits was 10.67 per cent. The combined effect of wheat variety and different levels of defatted *Moringa* seed flour found the mean protein content of 11.65 per cent. Ogunsina *et al.* (2011) studied the effects of replacing wheat flour with 0–15 per cent debittered *Moringa* seed flour cookies with 20 per cent DBMS grits had more protein. Mirsaeedghazi *et al.* (2008) reported that increase of protein in dough causes greater consistency of dough. The interactions (including physical and chemical forces) among protein molecules play key role on the rheological properties (Shiau and Yeh, 2001).

Fat

The fat content of biscuits from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 25.69 and 25.57 per cent respectively and the results of mean fat content of 25.63 per cent. There was decreased in fat content with increased the levels of defatted *Moringa* seed flour (Table 4.22).

The treatment T_0 was statistically superior for fat content followed by T_1 and at par with T_2. The fat content of optimized product T_2 was 24.37 per cent (*Trimbak*) and 24.29 per cent (*Samadhan*) and resulted the mean fat content of 24.33 per cent. The combined effect of wheat variety and different levels of defatted *Moringa* seed flour showed mean fat content of 24.18 per cent. The present findings are in conformity with reported results of Aleem zaker *et al.* (2012). Zarka and Neelash (2018) reported that, the cookies produced with defatted soy flour substitution, upto 30%, observed fat and free fatty acids of cookie sample decreased with corresponding increase in the percentage of defatted soy flour.

Crude fibre

The crude fibre content of biscuits prepared from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 1.12 and 0.85 per cent and showed mean crude fibre content of 0.99 per cent. The crude fibre content of biscuits increased as the level of defatted *Moringa* seed flour increased.

The crude fibre content of optimized product T_2 was 2.01 per cent (*Trimbak*) and 1.77 per cent (*Samadhan*) and observed the mean crude fibre content of 1.89 per cent (Table 4.22). The combined effect of wheat variety and different level of defatted *Moringa* seed flour showed crude fibre content of 2.11 per cent. Islamiyat *et al.* (2019) reported that *Moringa* seed powder addition significantly increased ash (0.63–1.76 %). The crude fibre content obtained in present investigation are in agreement with result obtained by Aleem Zaker *et al.* (2012).

Table 4.22 Proximate composition of biscuits affected by wheat variety with incorporation of defatted *Moringa* seed flour

No.	Treatment	Moisture (%)			Protein (%)			Fat (%)			Crude fibre (%)			Ash (%)			Carbohydrate (%)		
		V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_0	Control	3.69	3.39	3.54	7.25	6.66	6.95	25.69	25.57	25.63	1.12	0.85	0.99	1.07	1.27	1.17	61.19	62.26	61.73
T_1	5% DMSF	3.80	3.57	3.69	9.08	8.53	8.81	25.12	24.98	25.05	1.56	1.32	1.44	1.43	1.60	1.52	59.01	60.00	59.51
T_2	10% DMSF	3.95	3.72	3.84	10.94	10.40	10.67	24.37	24.29	24.33	2.01	1.77	1.89	1.80	1.94	1.87	56.93	57.88	57.41
T_3	15% DMSF	4.11	4.08	4.10	12.89	12.36	12.62	23.50	23.73	23.62	2.45	2.22	2.34	2.17	2.28	2.22	54.88	55.33	55.11
T_4	20% DMSF	4.26	4.25	4.26	14.78	14.27	14.52	23.22	23.45	23.34	2.90	2.68	2.79	2.53	2.62	2.58	52.31	52.73	52.52
T_5	25% DMSF	4.41	4.38	4.40	16.48	16.19	16.34	23.01	23.19	23.10	3.34	3.14	3.24	2.90	2.95	2.93	49.86	50.15	50.01
	Mean	4.04	3.90	3.97	11.90	11.40	11.65	24.15	24.20	24.18	2.23	2.00	2.11	1.98	2.11	2.05	55.70	56.39	56.04
	Factor	**V**	**T**	**V ×T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.004	0.013	0.052	0.017	0.053	0.212	0.012	0.038	0.153	0.005	0.014	0.057	0.003	0.010	0.042	0.010	0.030	0.121
	CD @ 5%	0.012	0.037	0.150	0.050	0.152	NS	NS	0.109	NS	0.013	0.041	NS	0.009	0.029	NS	0.029	0.087	0.349

Each value represents the average of three determination. **V_1 =** *Trimbak*, **V_2 =** *Samadhan*, DMSF= Defatted *Moringa* seed flour, NS = Non-significant

Ash

The ash content of biscuits prepared from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 1.07 and 1.27 per cent and showed mean ashcontent of 1.17 per cent. The ash content of biscuits increased as the level of defatted *Moringa* seed flour increased.

The ash content of optimized product T_2 was 1.80 per cent (*Trimbak*) and 1.94 per cent (*Samadhan*) and observed the mean ash content of 1.87 per cent. The combined effect of wheat variety and different level of defatted *Moringa* seed flour showed ash content of 2.05 per cent. Its is well known that the ash content of cookies depends on the flour extraction and the inclusion of other ingredients, such as non-fat dry milk and salt, in the cookies formula by Sawaya *et al.* (1984). Kaur *et al.* (2017) evaluated that the cookies containing flaxseed flour were higher in ash content.

Carbohydrate

The carbohydrate content of biscuits prepared from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour (DMSF) was 61.19 and 62.26 per cent and showed mean carbohydrate content of 61.73 per cent. The carbohydrate content of biscuits decreased as the level of defatted *Moringa* seed flour increased (Table 4.22).

The carbohydrate content of optimized product T_2 was 56.93 per cent (*Trimbak*) and 57.88 per cent (*Samadhan*) and observed the mean carbohydrate content of 57.41 per cent. The combined effect of wheat variety and different level of defatted *Moringa* seed flour showed carbohydrate content of 56.04 per cent. These carbohydrate content results were in agreement with the results reported by Ayo *et al.* (2018); Zarka and Neelash (2018).

Biscuits were prepared by Ayo *et al.* (2018) from acha-*Moringa* seed flour blends at different level. The proximate composition, physical and sensory quality of the biscuits prepared from acha-*Moringa* seed flour blends were analyzed. The moisture content of sample in range of 8.79-8.60 per cent, the protein content, fibre content increased as the percentage of acha-*Moringa* seed flour increased. The protein content 12.25-14.19 per cent, fibre content 2.56-4.15 per cent and carbohydrate content decreased as 52.86-46.80 per cent, respectively. The reports are available on the use of oat bran, wheat bran, and rice bran as source of dietary fibre content in bread and other bakery products (Laurikainen *et al.,* 1998; Sidhu *et al.,* 1999). In this study we tried to explore by product of *Moringa* seed such as defatted *Moringa* seed flour as novel source of protein, fibre with some advanced health benefit.

4.6.4 Mineral Composition of Biscuits

4.6.4.1 Mineral composition of biscuits incorporated with *Moringa* seed oil

It was observed from Table 4.23 that with increased the level of *Moringa* seed oil (MSO) in biscuits, does not affects mineral composition of biscuits. The slight non-significant change in calcium, phosphorus, iron and zinc was observed.

Calcium

Calcium content of biscuits from *Trimbak* and *Samadhan* wheat flour in ranged from 35.26 to 35.29 mg/100g and 32.09 to 32.13 mg/100g, respectively. The mean calcium content ranged from 33.68 to 33.71 mg/100g. The combined effect of wheat variety and different level of *Moringa* seed oil showed mean calcium content of 33.69 mg/100g.

Phosphorus

Phosphorus content of biscuits from *Trimbak* and *Samadhan* wheat flour in ranged from 343.19 to 343.26 mg/100g and 325.96 to 326.03 mg/100g, respectively. The mean phosphorus content in biscuits ranged from 334.59 to 334.65 mg/100g. The combined effect of wheat variety and different level of *Moringa* seed oil showed mean phosphorus content of 334.61 mg/100g.

Iron

There was non significant change in iron content. Iron content of biscuits from *Trimbak* and *Samadhan* wheat flour in ranged from 4.23 to 4.33 mg/100 g and 2.68 to 2.71 mg/100g respectively. The mean iron content in biscuits ranged from 3.46 to 3.52 mg/100g. The combined effect of wheat variety and different level of *Moringa* seed oil (MSO) showed mean iron content of 3.50 mg/100g.

Zinc

Zinc content of biscuits from *Trimbak* and *Samadhan* wheat flour is ranged from 1.92 to 1.96 mg/100g and 2.06 to 2.13 mg/100g, respectively. The mean zinc content of biscuits is ranged from 1.99 to 2.05 mg/100g. The combined effect of wheat variety and different level of *Moringa* seed oil showed mean zinc content of 2.03 mg/100g.

Table 4.23 Mineral content of biscuits affected by wheat variety with incorporation of *Moringa* seed oil

No.	Treatment	Calcium (mg/100 g)			Phosphorus (mg/100 g)			Iron (mg/100 g)			Zinc (mg/100 g)		
		V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_0	Control	35.29	32.13	33.71	343.26	326.03	334.65	4.33	2.71	3.52	1.96	2.13	2.05
T_1	20% MSO	35.26	32.10	33.68	343.21	326.00	334.61	4.23	2.69	3.46	1.95	2.11	2.03
T_2	40% MSO	35.28	32.11	33.70	343.23	326.03	334.63	4.31	2.70	3.51	1.96	2.12	2.04
T_3	60% MSO	35.29	32.11	33.70	343.20	326.02	334.61	4.31	2.70	3.51	1.95	2.12	2.04
T_4	80% MSO	35.27	32.10	33.69	343.19	326.00	334.60	4.30	2.68	3.49	1.94	2.10	2.02
T_5	100% MSO	35.26	32.09	33.68	343.22	325.96	334.59	4.29	2.69	3.49	1.92	2.06	1.99
	Mean	35.28	32.11	33.69	343.22	326.01	334.61	4.30	2.70	3.50	1.95	2.11	2.03
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.021	0.065	0.263	0.015	0.045	0.180	0.009	0.027	0.110	0.003	0.009	0.036
	CD @ 5%	0.062	NS	NS	0.043	NS	NS	0.026	NS	NS	0.008	NS	NS

Each value represents the average of three determination. V_1 = *Trimbak*. V_2 = *Samadhan*, MSO= *Moringa* seed oil, NS = Non-significant

4.6.4.2 Mineral composition of biscuits incorporated with defatted *Moringa* seed flour

The biscuits were prepared from *Trimbak* and *Samadhan* wheat flour with addition of different levels of defatted *Moringa* seed flour and evaluated for calcium, phosphorus, iron and zinc. The results (Table 4.24) obtained for calcium, phosphorus, iron and zinc of biscuits prepared with addition of defatted *Moringa* seed flour showed significant difference for calcium, phosphorus, iron and zinc among all treatments.

Calcium

The calcium content of biscuits prepared from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 35.29 and 32.13 mg/100g respectively and showed the mean calcium content of 33.71 mg/100g. The calcium content in biscuits ranged from 35.29 to 130.47 mg/100g (*Trimbak*) and 32.13 to 128.10 mg/100g (*Samadhan*) and the mean calcium content of biscuits ranged from 33.71 to 129.28 mg/100g.

Increased calcium content was observed with increase in concentration of defatted *Moringa* seed flour. The combined effect of wheat variety and different level of defatted *Moringa* seed flour showed mean calcium content of 81.22 mg/100g. Similar results were reported by Muhammad *et al.* (2016) by using defatted sesame meal upto 16 per cent.

Phosphorus

The data revealed from Table 4.24 the phosphorus content of biscuits prepared from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 343.26 and 326.03 mg/100g respectively and showed the mean phosphorus content of 334.65 mg/100g. Treatment T_5 was statistically superior in phosphorus content over all other treatments.

The results revealed that phosphorus content in biscuits ranged from 343.26 to 371.04 mg/100g (*Trimbak*) and 326.03 to 342.35 mg/100g (*Samadhan*) and the mean phosphorus content of biscuits ranged from 334.65 to 356.70 mg/100g. The combined effect of wheat variety and different level of defatted *Moringa* seed flour showed mean phosphorus content of 343.89 mg/100g. These results were in agreement with the results reported by Muhammad *et al.* (2016).

Iron

The iron content of biscuits prepared from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 4.33 and 2.71 mg/100g respectively and showed

Table 4.24 Mineral content of biscuits affected by wheat variety with incorporation of defatted *Moringa* seed flour

No.	Treatment	Calcium (mg/100 g)			Phosphorus (mg/100 g)			Iron (mg/100 g)			Zinc (mg/100 g)		
		V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_0	Control	35.29	32.13	33.71	343.26	326.03	334.65	4.33	2.71	3.52	1.96	2.13	2.05
T_1	5% DMSF	53.52	51.32	52.42	346.78	329.08	337.93	4.98	3.43	4.21	2.07	2.22	2.15
T_2	10% DMSF	71.06	70.51	70.79	349.80	332.58	341.19	5.63	4.14	4.89	2.18	2.31	2.25
T_3	15% DMSF	92.40	89.70	91.05	353.33	335.68	344.51	6.29	4.86	5.58	2.29	2.41	2.35
T_4	20% DMSF	111.23	108.90	110.07	357.55	339.24	348.40	6.95	5.56	6.26	2.41	2.54	2.48
T_5	25% DMSF	130.47	128.10	129.28	371.04	342.35	356.70	7.61	6.28	6.95	2.52	2.59	2.56
	Mean	82.33	80.11	81.22	353.63	334.16	343.89	5.97	4.50	5.23	2.24	2.37	2.30
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.015	0.046	0.186	0.009	0.028	0.114	0.007	0.021	0.085	0.005	0.016	0.064
	CD @ 5%	0.044	0.133	0.535	0.027	0.081	0.327	0.020	0.061	NS	0.015	0.046	NS

Each value represents the average of three determination. $\mathbf{V_1}$ = *Trimbak*. $\mathbf{V_2}$ = *Samadhan*, DMSF= Defatted *Moringa* seed flour, NS = Non-significant the mean value iron content of 3.52 mg/100g. Iron content in biscuits prepared with treatment T_5 was statistically significant over all other treatments.

It was observed that iron content of biscuits ranged from 4.33 to 7.61 mg/100g (*Trimbak*) and 2.71 to 6.28 mg/100g (*Samadhan*) whereas the ranged of mean iron content of biscuits from 3.52 to 6.95 mg/100g. The combined effect of wheat variety and different level of defatted *Moringa* seed flour showed mean iron content of 5.23 mg/100g.

Zinc

The zinc content of biscuits prepared from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 1.96 and 2.13 mg/100g respectively. Zinc content of biscuits ranged from 1.96 to 2.52 mg/100g (*Trimbak*) and 2.13 to 2.59 mg/100g (*Samadhan*) whereas the data observed ranged of mean zinc content from 2.05 to 2.56 mg/100g (Table 4.24).

The combined effect of wheat variety and different level of defatted *Moringa* seed flour showed mean zinc content of 2.30 mg/100g. The present findings are in conformity with reported results of Muhammad *et al.* (2016).

4.6.5 Textural Characteristics of Biscuits

4.6.5.1 Textural characteristics of biscuits affected by wheat variety with different level of *Moringa* seed oil

Texture is very important characteristics which makes a significant contribution to the overall acceptability of the food products. It is one of the three main acceptability factors used by consumer to evaluate food, the other two being appearance and flavour (Bourne, 2002).

The results with respect to textural characteristics of biscuits affected by the wheat variety (*Trimbak* and *Samadhan*) with incorporation of different level of *Moringa* seed oil like crushing force, cutting force, and penetration force are presented in Table 4.25. It was observed that there was significant decrease in hardness of biscuits with increased addition of *Moringa* seed oil.

Crushing force

The crushing force for crushing biscuits prepared from *Trimbak* and *Samadhan* wheat flour with incorporation of different level of *Moringa* seed oil (MSO) ranged from 35.48 to 48.71 N and 37.14 to 50.04 N respectively whereas the ranged of mean crushing

Table 4.25 Textural characteristics of biscuits affected by wheat variety flour with the different level of *Moringa* seed oil

No.	Treatment	Crushing Force (N)			Cutting force (N)			Penetration force (N)		
		V_1	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**
T_0	Control	35.48	37.14	36.31	31.91	30.21	31.06	10.02	10.06	10.04
T_1	20% MSO	37.14	40.02	38.58	34.14	35.18	34.66	11.34	11.45	11.40
T_2	40% MSO	40.42	44.22	42.32	38.94	41.70	40.32	12.78	12.93	12.86
T_3	60% MSO	42.68	46.18	44.43	44.36	46.54	45.45	14.98	15.25	15.12
T_4	80% MSO	45.22	48.71	46.97	50.51	52.62	51.57	17.02	17.18	17.10
T_5	100% MSO	48.71	50.04	49.38	54.19	57.27	55.73	22.48	22.71	22.60
	Mean	41.61	44.39	43.00	42.34	43.92	43.13	14.77	14.93	14.85
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.001	0.004	0.016	0.001	0.003	0.013	0.001	0.003	0.014
	CD @ 5%	0.004	0.012	0.050	0.003	0.009	0.038	0.003	0.010	0.042

Each value represents the average of three determination. **V_1** = *Trimbak*, **V_2** = *Samadhan*, MSO= *Moringa* seed oil.

force from 36.31 to 49.38 N. The combined effect of wheat variety and different level of *Moringa* seed oil showed mean crushing force of 43.00 N.

Jissy and Leelavathi, (2006) reported that the cookie dough containing the non-emulsified hydrogenated fat ('dalda') was the hardest requiring more strength to compress it to the required extent. Cookie dough containing 'margarine' was the softest requiring the least force to compress it. It is possible that dough made with oil is generally more cohesive and viscous and hence softer.

Cutting force

The results from Table 4.25 the cutting force for cutting biscuits prepared from *Trimbak* and *Samadhan* wheat flour with incorporation of different level of *Moringa* seed oil ranged from 31.91 to 54.19 N and 30.21 to 57.27 N respectively whereas the ranged of mean cutting force from 31.06 to 55.73 N. Combined effect of wheat variety and different level of *Moringa* seed oil showed mean cutting force of 43.13 N. Rangrej *et al.* (2015) breaking strength of cookies showed that cookies containing more flaxseed oil were the hardest.

Penetration force

The penetration force of biscuits prepared from *Trimbak* and *Samadhan* wheat flour with incorporation of different level of *Moringa* seed oil (MSO) ranged from 10.02 to 22.48 N and 10.06 to 22.71 N respectively whereas the ranged of mean penetration force from 10.04 to 22.60 N. Combined effect of wheat variety and different level of *Moringa* seed oil showed mean penetration force of 14.85 N. The similar finding of increase in hardness of cookies by replacement of vanaspati with garden cress seed oil has been reported by Deshmukh (2017).

4.6.5.2 Textural characteristics of biscuits affected by wheat variety with different level of defatted *Moringa* seed flour

The results with respect to textural characteristics of biscuits affected by wheat variety (*Trimbak* and *Samadhan*) with incorporation of different level of defatted *Moringa* seed flour like crushing force, cutting force and penetration force are presented in Table 4.26.

It was observed that there was significant increase in hardness of biscuits with increased addition of defatted *Moringa* seed flour.

Crushing force

The crushing force of biscuits prepared from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 35.48 and 37.14 N respectively whereas the mean crushing force of 36.31 N. The crushing force of defatted *Moringa* seed flour incorporated biscuits ranged from 39.27 to 101.08 N (*Trimbak*) and 40.47 to 105.63 N (*Samadhan*) whereas the ranged for mean crushing force from 39.87 to 103.36 N.

The combined effect of wheat variety and different level defatted *Moringa* seed flour showed mean crushing force 66.70 N. The crushing force of the biscuits increased due to dilution of wheat proteins with defatted *Moringa* seed flour. The similar finding of increase in hardness of cookies by replacement of wheat flour with garden cress seed bran has been reported by Deshmukh (2017).

Cutting force

The cutting force of biscuits prepared from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 31.91 and 30.21 N respectively whereas the mean cutting force of 31.06 N. The cutting force of defatted *Moringa* seed flour incorporated biscuits ranged from 40.58 to 72.58 N (*Trimbak*) and 42.63 to 74.94 N (*Samadhan*) whereas the ranged for mean cutting force from 41.61 to 73.76 N. (Table 4.26).

The combined effect of wheat variety and different level defatted *Moringa* seed flour showed mean cutting force 53.64 N. The interaction of proteins from both sources with starch made cookies compact, thus increasing the hardness. Rajiv *et al.* (2012) reported increased breaking strength of cookies with increased addition of roasted flaxseed flour from 5 to 20 per cent.

Penetration force

The penetration force of biscuits prepared from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 10.02 and 10.06 N respectively whereas the mean penetration force of 10.04 N. The penetration force of defatted *Moringa* seed flour incorporated biscuits ranged from 20.74 to 41.63 N (*Trimbak*) and 20.92 to 42.54 N (*Samadhan*) whereas the ranged for mean penetration force from 20.83 to 42.09 N.

The combined effect of wheat variety and different level defatted *Moringa* seed flour showed mean penetration force 27.74 N. Similar results were observed by Singh *et al.* (1996) who reported increased hardness in biscuit with increased levels of defatted soy flour up to 50 per cent.

Table 4.26 Textural characteristics of biscuits affected by wheat variety flour with the different level of defatted *Moringa* seed flour

No.	Treatment	Crushing Force (N)			Cutting force (N)			Penetration force (N)		
		V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_0	Control	35.48	37.14	36.31	31.91	30.21	31.06	10.02	10.06	10.04
T_1	5% DMSF	39.27	40.47	39.87	40.58	42.63	41.61	20.74	20.92	20.83
T_2	10% DMSF	52.68	54.53	53.61	48.33	52.07	50.20	22.85	23.40	23.13
T_3	15% DMSF	78.60	81.04	79.82	53.80	57.81	55.81	32.41	34.99	33.70
T_4	20% DMSF	85.36	89.15	87.26	68.72	70.04	69.38	36.08	37.28	36.68
T_5	25% DMSF	101.08	105.63	103.36	72.58	74.94	73.76	41.63	42.54	42.09
	Mean	65.41	67.99	66.70	52.65	54.62	53.64	27.29	28.20	27.74
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.001	0.003	0.013	0.001	0.003	0.013	0.001	0.003	0.013
	CD @ 5%	0.003	0.009	0.038	0.003	0.009	0.038	0.003	0.009	0.037

Each value represents the average of three determination. V_1 = *Trimbak*, V_2 = *Samadhan*. DMSF= Defatted *Moringa* seed flour.

4.7 Storage Quality of Biscuits

The control biscuits and standardized biscuits from *Trimbak* and *Samadhan* wheat flour, containing 40 per cent *Moringa* seed oil and 10 per cent defatted *Moringa* seed flour were packed in LDPE and laminated pouch and stored at ambient temperature for 3 months (90 days). The biscuits were evaluated for their sensory and proximate qualities. The results of quality evaluation of biscuits obtained during storage are presented under following captions.

4.7.1 Effects of Packaging Material on Changes in Sensory Quality of *Moringa* Seed Oil and Defatted Seed Flour Biscuits During Storage

The biscuits were evaluated for their sensory qualities at an interval of every 30 days. The results revealed that the treatments and packaging material showed non-significant effect on all the sensory parameters of biscuits while wheat variety showed non-significant effect for the sensory quality of biscuits.

The results of mean scores for different sensory attributes such as colour and appearance, texture, flavour, taste and overall acceptability of biscuits are presented as referred below (Table 4.27 - 4.31).

4.7.1.1 Changes in colour and appearance

Score for colour and appearance of *Moringa* seed oil and defatted seed flour biscuits prepared from *Trimbak* and *Samadhan* wheat flour as influenced by storage period and packaging material are presented in Table 4.27. A gradual decrease in mean score for colour and appearance of control (*Trimbak*) from 8.10 to 7.89 in LDPE and 8.11 to 8.00 in laminated pouch, whereas control (*Samadhan*) from 8.16 to 7.94 in LDPE and 8.17 to 8.01 in laminated pouch was observed for 90th days of storage. The all-interaction effects showed statistically significant among the treatments whereas non-significant for packaging material and wheat variety.

The sample prepared from *Trimbak* wheat flour with MSO showed colour and appearance from 7.96 to 7.82 in LDPE and 7.97 to 7.85 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed colour and appearance from 8.00 to 7.83 in LDPE and 8.02 to 7.90 in laminated pouch. The sample prepared from *Trimbak* wheat flour with DMSF showed colour and appearance from 7.93 to 7.80 in LDPE and 7.95 to 7.83 in laminated pouch.

Table 4.27. Effect of packaging material on changes in colour and appearance of *Moringa* seed oil and defatted seed flour biscuits during storage

No.	Treatment	Storage period			
		0 Days	30 Days	60 Days	90 Days
	Treatment				
T_0	Control	8.14	8.10	8.06	7.96
T_1	*Moringa* seed oil	7.99	7.94	7.91	7.85
T_2	Defatted *Moringa* seed flour	7.93	7.90	7.86	7.80
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03	NS
	Variety				
V_1	*Trimbak* (NIAW-301)	8.00	7.97	7.93	7.87
V_2	*Samadhan* (NIAW-1994)	8.03	7.99	7.95	7.87
	SE±	0.01	0.01	0.01	0.01
	CD@ 5%	NS	0.03	0.03	0.03
	Packaging material				
P_1	LDPE	8.01	7.97	7.93	7.84
P_2	Laminated pouch	8.03	7.99	7.95	7.90
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03	0.03
	Interaction				
	$T_0 V_1 P_1$	8.10	8.07	8.03	7.89
	$T_0 V_1 P_2$	8.11	8.08	8.04	8.00
	$T_0 V_2 P_1$	8.16	8.11	8.07	7.94
	$T_0 V_2 P_2$	8.17	8.13	8.09	8.01
	$T_1 V_1 P_1$	7.96	7.91	7.88	7.82
	$T_1 V_1 P_2$	7.97	7.93	7.90	7.85
	$T_1 V_2 P_1$	8.00	7.95	7.92	7.83
	$T_1 V_2 P_2$	8.02	7.97	7.94	7.90
	$T_2 V_1 P_1$	7.93	7.89	7.86	7.80
	$T_2 V_1 P_2$	7.95	7.91	7.88	7.83
	$T_2 V_2 P_1$	7.92	7.88	7.84	7.75
	$T_2 V_2 P_2$	7.93	7.90	7.86	7.82
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	NS	NS	NS	0.04

Each value represents the average of three determination. NS = Non-significant

The sample prepared from *Samadhan* wheat flour with DMSF showed colour and appearance from 7.92 to 7.75 in LDPE and 7.93 to 7.82 in laminated pouch. Significant decreased in colour and appearance was observed for treatments and packaging material whereas non-significant reduction was found among wheat variety. The sample packed in laminated pouch showed maximum colour and appearance followed by LDPE package on the 90th day of storage.

The colour changes during storage might be due to acceleration of Maillard reaction, absorption of moisture contents during storage stimulates Maillard reaction in cookies (Bender, 1996). Jood *et al.* (2001) reported gradual decrease in organoleptic characteristics of biscuits. Dayanand *et al.* (2012) reported gradual decrease in colour and appearance of cookies in HDPE followed by LDPE and PP packages for 90 days of storage. Prashant and Shere (2017) studied that the decrease in colour and appearance score of cookies was less in PET jar as compared to LDPE pouch.

4.7.1.2 Changes in texture

Score for texture of *Moringa* seed oil and defatted seed flour biscuits prepared from *Trimbak* and *Samadhan* wheat flour as influenced by storage period and packaging material are presented in Table 4.28. A gradual decrease in mean score for texture of control (*Trimbak*) from 8.01 to 7.85 in LDPE and 8.06 to 7.95 in laminated pouch whereas control (*Samadhan*) from 8.03 to 7.87 in LDPE and 8.02 to 7.91 in laminated pouch was observed for 90th days of storage. Changes in level of treatments significantly changes values due to corresponding packaging material.

The sample prepared from *Trimbak* wheat flour with MSO showed texture from 7.87 to 7.71 in LDPE and 7.88 to 7.77 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed texture from 8.10 to 7.96 in LDPE and 8.08 to 7.95 in laminated pouch. The sample prepared from *Trimbak* wheat flour with DMSF showed texture from 8.34 to 8.19 in LDPE and 8.33 to 8.21 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed texture from 7.82 to 7.69 in LDPE and 7.84 to 7.75 in laminated pouch. Significant decreased in texture was observed for treatments and packaging material whereas nonsignificant reduction was found among wheat variety. The sample packed in laminated pouch showed maximum texture score followed by LDPE package on the 90th day of storage.

Table 4.28 Effect of packaging material on changes in texture of *Moringa* seed oil and defatted seed flour biscuits during storage

No.	Treatment	Storage period			
		0 Days	**30 Days**	**60 Days**	**90 Days**
	Treatment				
T_0	Control	8.03	7.98	7.92	7.89
T_1	*Moringa* seed oil	7.98	7.94	7.90	7.85
T_2	Defatted *Moringa* seed flour	8.08	8.04	8.00	7.96
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03	0.03
	Variety				
V_1	*Trimbak* (NIAW-301)	8.08	8.03	7.99	7.95
V_2	*Samadhan* (NIAW-1994)	7.98	7.94	7.89	7.85
	SE±	0.01	0.01	0.01	0.01
	CD@ 5%	NS	0.03	0.03	0.03
	Packaging material				
P_1	LDPE	8.03	7.98	7.92	7.88
P_2	Laminated pouch	8.03	8.00	7.96	7.92
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03	0.03
	Interaction				
	$T_0 V_1 P_1$	8.01	7.95	7.88	7.85
	$T_0 V_1 P_2$	8.06	8.03	7.97	7.95
	$T_0 V_2 P_1$	8.03	7.97	7.91	7.87
	$T_0 V_2 P_2$	8.02	7.98	7.93	7.91
	$T_1 V_1 P_1$	7.87	7.81	7.77	7.71
	$T_1 V_1 P_2$	7.88	7.85	7.81	7.77
	$T_1 V_2 P_1$	8.10	8.07	8.02	7.96
	$T_1 V_2 P_2$	8.08	8.04	7.99	7.95
	$T_2 V_1 P_1$	8.34	8.28	8.24	8.19
	$T_2 V_1 P_2$	8.33	8.29	8.27	8.21
	$T_2 V_2 P_1$	7.82	7.79	7.73	7.69
	$T_2 V_2 P_2$	7.84	7.81	7.78	7.75
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.04	0.04	0.04	0.04

Each value represents the average of three determination. NS = Non-significant

The gradual decrease in texture score was due to softening effect resulting from gain of moisture during storage. Biscuits packed in LDPE showed more moisture gain during storage and become soft compared to laminated pouch. This might be due to high WVTR of LDPE as compared to laminated pouch.

Sathe and Salunkhe (1981) reported softening of crackers packed in PP bags and stored at ambient conditions. This might be due to high water vapour transmission rate (WVTR). Kulthe *et al.* (2014) reported higher reduction in crispiness of cookies packed in LDPE and PP pouches than those packed in HDPE pouches during storage for 90 days.

Kulthe *et al.* (2018) investigated that the gradual decrease in texture score was due to softening effect resulting from gain of moisture in β-carotene enriched pearl millet cookies during storage. Cookies packed in LDPE (P_1) showed more moisture gain during storage and became soft compared to HDPE (P_2) and Laminate (P_3).

4.7.1.3 Changes in flavour

Score for flavour of *Moringa* seed oil and defatted seed flour biscuits prepared from *Trimbak* and *Samadhan* wheat flour as influenced by storage period and packaging material are presented in Table 4.29. A gradual decrease in mean score for flavour of control (*Trimbak*) from 8.45 to 8.24 in LDPE and 8.46 to 8.33 in laminated pouch whereas control (*Samadhan*) from 8.24 to 8.10 in LDPE and 8.24 to 8.10 in laminated pouch was observed for 90th days of storage. The all-interaction effects showed among the treatment and packaging material.

The sample prepared from *Trimbak* wheat flour with MSO showed flavour from 8.05 to 7.87 in LDPE and 8.07 to 7.89 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed flavour from 7.86 to 7.64 in LDPE and 7.87 to 7.71 in laminated pouch. The sample prepared from *Trimbak* wheat flour with DMSF showed flavour from 8.00 to 7.84 in LDPE and 8.01 to 7.88 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed flavour from 7.94 to 7.77 in LDPE and 7.93 to 7.80 in laminated pouch. Decreased in flavour was observed by change in level of treatments significantly changes value due to corresponding packaging material whereas non-significant reduction was found among wheat variety. The flavouring compounds might be lost at higher rate during storage that lowered the flavour score.

Table 4.29 Effect of packaging material on changes in flavour of *Moringa* seed oil and defatted seed flour biscuits during storage

No.	Treatment	Storage period			
		0 Days	**30 Days**	**60 Days**	**90 Days**
	Treatment				
T_0	Control	8.35	8.30	8.27	8.19
T_1	*Moringa* seed oil	7.96	7.87	7.80	7.78
T_2	Defatted *Moringa* seed flour	7.97	7.91	7.87	7.82
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03	0.03
	Variety				
V_1	*Trimbak* (NIAW-301)	8.17	8.10	8.07	8.01
V_2	*Samadhan* (NIAW-1994)	8.01	7.96	7.90	7.85
	SE±	0.01	0.01	0.01	0.01
	CD@ 5%	NS	0.03	0.03	0.03
	Packaging material				
P_1	LDPE	8.09	8.02	7.97	7.91
P_2	Laminated pouch	8.10	8.04	8.00	7.95
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03	0.03
	Interaction				
	$T_0 V_1 P_1$	8.45	8.41	8.37	8.24
	$T_0 V_1 P_2$	8.46	8.41	8.39	8.33
	$T_0 V_2 P_1$	8.24	8.19	8.16	8.10
	$T_0 V_2 P_2$	8.24	8.21	8.18	8.10
	$T_1 V_1 P_1$	8.05	7.90	7.90	7.87
	$T_1 V_1 P_2$	8.07	8.00	7.90	7.89
	$T_1 V_2 P_1$	7.86	7.78	7.65	7.64
	$T_1 V_2 P_2$	7.87	7.81	7.76	7.71
	$T_2 V_1 P_1$	8.00	7.95	7.91	7.84
	$T_2 V_1 P_2$	8.01	7.92	7.92	7.88
	$T_2 V_2 P_1$	7.94	7.86	7.82	7.77
	$T_2 V_2 P_2$	7.93	7.91	7.82	7.80
	SE±	0.01	0.01	0.02	0.02
	CD @ 5%	NS	0.04	0.06	0.06

Each value represents the average of three determination. NS = Non-significant

Sample packed in aluminium laminated pouch showed maximum score for flavour followed by LDPE packages on the 90th day of storage. Kaur *et al.* (2005) reported that flavour changes were higher in case of cookies stored in LDPE as compared to those stored in laminate package because of the fact that aluminium laminates protects the biscuits from light which acts as catalyst for oxidation.

The scores for flavour gradually and significantly decreased throughout the storage period from 30 day onward. Between two packages, the score of flavour were significantly higher for aluminum laminated pouch when compared to polyethylene pack (Surekha *et al.,* 2013).

4.7.1.4 Changes in taste

Score for taste of *Moringa* seed oil and defatted seed flour biscuits prepared from *Trimbak* and *Samadhan* wheat flour as influenced by storage period and packaging material are presented in Table 4.30. A gradual decrease in mean score for taste of control (*Trimbak*) from 8.32 to 8.11 in LDPE and 8.32 to 8.12 in laminated pouch whereas control (*Samadhan*) from 7.95 to 7.78 in LDPE and 8.00 to 7.89 in laminated pouch was observed for 90th days of storage. The all-interaction effects showed statistically significant difference among the treatments and packaging material.

The sample prepared from *Trimbak* wheat flour with MSO showed taste from 7.95 to 7.76 in LDPE and 7.95 to 7.81 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed taste from 7.70 to 7.51 in LDPE and 7.70 to 7.58 in laminated pouch. The sample prepared from *Trimbak* wheat flour with DMSF showed taste from 7.82 to 7.71 in LDPE and 7.83 to 7.72 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed taste from 7.65 to 7.52 in LDPE and 7.66 to 7.50 in laminated pouch. Significant decreased in taste was observed for treatment and packaging material whereas non-significant reduction was found among wheat variety. The sample packed in laminated pouch showed maximum taste followed by LDPE package on the 90th day of storage.

This might be due to low WVTR and GTR of laminated pouch as compared to LDPE package. It was determined that taste score decreased during storage with respect to storage condition and period of storage. High protein low calorie cookies packed in HDPE package

Table 4.30 Effect of packaging material on changes in taste of *Moringa* seed oil and defatted seed flour biscuits during storage

No.	Treatment	Storage period			
		0 Days	**30 Days**	**60 Days**	**90 Days**
	Treatment				
T_0	Control	8.15	8.12	8.07	7.97
T_1	*Moringa* seed oil	7.83	7.79	7.74	7.67
T_2	Defatted *Moringa* seed flour	7.74	7.71	7.64	7.61
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03	0.03
	Variety				
V_1	*Trimbak* (NIAW-301)	8.03	7.99	7.94	7.87
V_2	*Samadhan* (NIAW-1994)	7.78	7.76	7.69	7.63
	SE±	0.01	0.01	0.01	0.01
	CD@ 5%	NS	0.03	0.03	0.03
	Packaging material				
P_1	LDPE	7.90	7.84	7.80	7.73
P_2	Laminated pouch	7.91	7.91	7.84	7.77
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03	0.03
	Interaction				
	T_0 V_1 P_1	8.32	8.24	8.20	8.11
	T_0 V_1 P_2	8.32	8.38	8.25	8.12
	T_0 V_2 P_1	7.95	7.92	7.91	7.78
	T_0 V_2 P_2	8.00	8.00	7.94	7.89
	T_1 V_1 P_1	7.95	7.90	7.82	7.76
	T_1 V_1 P_2	7.95	7.93	7.91	7.81
	T_1 V_2 P_1	7.70	7.65	7.56	7.51
	T_1 V_2 P_2	7.70	7.70	7.67	7.58
	T_2 V_1 P_1	7.82	7.76	7.73	7.71
	T_2 V_1 P_2	7.83	7.81	7.76	7.72
	T_2 V_2 P_1	7.65	7.61	7.57	7.52
	T_2 V_2 P_2	7.66	7.66	7.52	7.50
	SE±	0.01	0.01	0.01	0.02
	CD @ 5%	NS	0.04	0.04	0.06

Each value represents the average of three determination. NS = Non-significant

stored for 3 months at ambient temperature have better organoleptic properties compared to other packages (Dayanand *et al.,* 2012).

4.7.1.5 Changes in overall acceptability

Score for overall acceptability of *Moringa* seed oil and defatted seed flour biscuits prepared from *Trimbak* and *Samadhan* wheat flour as influenced by storage period and packaging material are presented in Table 4.31. A gradual decrease in mean score for overall acceptability of control (*Trimbak*) from 8.22 to 7.93 in LDPE and 8.25 to 7.99 in laminated pouch whereas control (*Samadhan*) from 8.00 to 7.82 in LDPE and 8.10 to 7.80 in laminated pouch was observed for 90^{th} days of storage. The all-interaction effects showed statistically significant difference among the treatment and packaging material. Non-significant difference found in wheat variety.

The sample prepared from *Trimbak* wheat flour with MSO showed overall acceptability from 7.95 to 7.73 in LDPE and 7.93 to 7.82 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed overall acceptability from 7.92 to 7.70 in LDPE and 7.92 to 7.81 in laminated pouch. The sample prepared from *Trimbak* wheat flour with DMSF showed overall acceptability from 8.02 to 7.81 in LDPE and 8.03 to 7.80 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed overall acceptability from 7.83 to 7.64 in LDPE and 7.80 to 7.65 in laminated pouch. Decreased in overall acceptability by change in level of treatments significantly changes values due to corresponding packaging material whereas non-significant reduction was found among wheat variety. The sample packed in laminated pouch showed maximum overall acceptability followed by LDPE package on the 90^{th} day of storage.

Samples stored in laminated pouch showed maximum score for overall acceptability followed by LDPE packages on the 90^{th} day of storage which might be due to slower deterioration in colour and appearance, flavour, taste of biscuits packed in laminated pouch. The results obtained in present investigation for biscuits are an agreement with literature.

Kulthe *et al.* (2014) reported similar decrease in overall acceptability while studying effect of packaging material on sensory quality of high protein low calorie cookies during storage for 90 days. Cookies packed in HDPE package stored for 3 months at ambient temperature have better organoleptic properties compared to other packages (Dayanand *et al.,* 2012; Surekha *et al.,* 2013).

Table 4.31 Effect of packaging material on changes in overall acceptability of *Moringa* seed oil and defatted seed flour biscuits during storage

No.	Treatment	Storage period			
		0 Days	30 Days	60 Days	90 Days
	Treatment				
T_0	Control	8.14	8.05	7.99	7.88
T_1	*Moringa* seed oil	7.93	7.85	7.81	7.76
T_2	Defatted *Moringa* seed flour	7.92	7.87	7.81	7.72
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.04	0.03	0.03
	Variety				
V_1	*Trimbak* (NIAW-301)	8.06	7.98	7.92	7.85
V_2	*Samadhan* (NIAW-1994)	7.93	7.87	7.82	7.73
	SE±	0.01	0.01	0.01	0.01
	CD@ 5%	NS	NS	0.03	0.03
	Packaging material				
P_1	LDPE	7.99	7.92	7.86	7.77
P_2	Laminated pouch	8.00	7.93	7.88	7.81
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03	0.03
	Interaction				
	T_0 V_1 P_1	8.22	8.12	8.07	7.93
	T_0 V_1 P_2	8.25	8.15	8.00	7.99
	T_0 V_2 P_1	8.00	8.00	7.95	7.82
	T_0 V_2 P_2	8.10	7.95	7.94	7.80
	T_1 V_1 P_1	7.95	7.84	7.78	7.73
	T_1 V_1 P_2	7.93	7.88	7.86	7.82
	T_1 V_2 P_1	7.92	7.83	7.77	7.70
	T_1 V_2 P_2	7.92	7.85	7.83	7.81
	T_2 V_1 P_1	8.02	7.96	7.89	7.81
	T_2 V_1 P_2	8.03	7.95	7.92	7.80
	T_2 V_2 P_1	7.83	7.77	7.70	7.64
	T_2 V_2 P_2	7.80	7.80	7.73	7.65
	SE±	0.01	0.02	0.01	0.02
	CD @ 5%	0.04	0.06	0.04	0.06

Each value represents the average of three determination. NS = Non-significant

4.7.2 Effects of Packaging Material on Changes in Chemical Composition of *Moringa* Seed Oil and Defatted Seed Flour Biscuits During Storage

4.7.2.1 Changes in moisture

It was obtained from Table 4.32 that the moisture increased for control (*Trimbak*) from 3.69 to 3.83 in LDPE and 3.68 to 3.78 in laminated pouch whereas control (*Samadhan*) from 3.39 to 3.64 in LDPE and 3.38 to 3.43 in laminated pouch was observed for 90 days of storage.

The sample prepared from *Trimbak* wheat flour with MSO showed increased in moisture content from 3.61 to 3.77 in LDPE and 3.62 to 3.69 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed moisture content increased from 3.32 to 3.48 in LDPE and 3.35 to 3.44 in laminated pouch.

The sample prepared from *Trimbak* wheat flour with DMSF showed increased in moisture content from 3.95 to 4.16 in LDPE and 3.92 to 4.08 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed moisture increased from 3.77 to 3.90 in LDPE and 3.75 to 3.83 in laminated pouch. Increase in moisture content was observed by change in level of treatments significantly changes moisture values due to corresponding packaging material whereas nonsignificant among wheat variety. The sample packed in LDPE showed maximum moisture followed by laminated pouch on 90th day of storage. This may be due to higher WVTR and GTR of LDPE than laminated pouch.

Cookies absorbed moisture from surrounding atmosphere due to hygroscopic behaviour of wheat flour. An increase in moisture contents of cookie samples during storage has also been changes on nutrient quality reported by Leelavathi and Rao (1993).

Sharoon *et al.* (2014) reported considerable increment the moisture content in all cookies prepared with linseed oil substitution with increased storage duration. The increase was primarily due to packaging material (Polythene bags). The packaging material and lack of temperature control resulted in an increase in moisture content of cookies during storage.

Table 4.32. Effect of packaging material on changes in moisture (%) of *Moringa* seed oil and defatted seed flour biscuits during storage

No.	Treatment	Storage period			
		0 Days	**30 Days**	**60 Days**	**90 Days**
	Treatment				
T_0	Control	3.54	3.56	3.62	3.67
T_1	*Moringa* seed oil	3.49	3.51	3.55	3.59
T_2	Defatted *Moringa* seed flour	3.81	3.87	3.92	4.00
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.04	0.03	0.03
	Variety				
V_1	*Trimbak* (NIAW-301)	3.73	3.79	3.85	3.88
V_2	*Samadhan* (NIAW-1994)	3.49	3.51	3.55	3.62
	SE±	0.01	0.01	0.01	0.01
	CD@ 5%	NS	NS	0.03	0.03
	Packaging material				
P_1	LDPE	3.62	3.66	3.72	3.80
P_2	Laminated pouch	3.60	3.64	3.67	3.71
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.04	0.03	0.03	0.04
	Interaction				
	T_0 V_1 P_1	3.69	3.73	3.80	3.83
	T_0 V_1 P_2	3.68	3.70	3.76	3.78
	T_0 V_2 P_1	3.39	3.46	3.52	3.64
	T_0 V_2 P_2	3.38	3.39	3.41	3.43
	T_1 V_1 P_1	3.61	3.65	3.67	3.77
	T_1 V_1 P_2	3.62	3.64	3.66	3.69
	T_1 V_2 P_1	3.32	3.34	3.40	3.48
	T_1 V_2 P_2	3.35	3.35	3.36	3.44
	T_2 V_1 P_1	3.95	4.02	4.08	4.16
	T_2 V_1 P_2	3.92	3.97	4.01	4.08
	T_2 V_2 P_1	3.77	3.77	3.83	3.90
	T_2 V_2 P_2	3.75	3.74	3.76	3.83
	SE±	0.03	0.01	0.01	0.03
	CD @ 5%	0.09	0.04	0.04	0.09

Each value represents the average of three determination. NS = Non-significant

4.7.2.2 Changes in protein

The result revealed from Table 4.33 that the protein decreased for control (*Trimbak*) from 7.24 to 7.13 in LDPE and 7.24 to 7.16 in laminated pouch whereas control (*Samadhan*) from 6.66 to 6.54 in LDPE and 6.66 to 6.57 in laminated pouch was observed for 90 days of storage.

The sample prepared from *Trimbak* wheat flour with MSO showed decreased in protein content from 7.23 to 7.10 in LDPE and 7.24 to 7.12 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed protein content decreased from 6.64 to 6.50 in LDPE and 6.64 to 6.57 in laminated pouch.

The sample prepared from *Trimbak* wheat flour with DMSF showed decreased in protein content from 10.94 to 10.76 in LDPE and 10.95 to 10.85 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed protein decreased from 10.40 to 10.24 in LDPE and 10.42 to 10.28 in laminated pouch. Significant decrease in protein content was observed for treatments, packaging material and wheat variety. The sample packed in laminated pouch showed maximum protein followed by LDPE on 90th day of storage.

Sharoon *et al.* (2014) investigated that the reduction in protein content of linseed oil substituted cookies throughout storage might be due to increasing level of moisture which enhances proteolytic activity. Sujitha and Thirumani (2014) reported that decrease in protein content from 6.51 to 5.68 per cent of flaxseed cookies during 60 days of storage period. Biradar *et al.* (2020) investigated that the optimum level of little millet flour with wheat flour for the preparation of quality cookies. Protein decreased in ambient temperature during storage period of 3 month. This is due to increase in moisture was more rapid in the samples stored in PP than LDPE during the storage period.

4.7.2.3 Changes in carbohydrate

The results changes in carbohydrates of biscuits as influenced by storage are presented in Table 4.34. The carbohydrate decreased for control (*Trimbak*) from 61.15 to 60.94 in LDPE and 61.17 to 60.97 in laminated pouch whereas control (*Samadhan*) from 62.27 to 61.90 in LDPE and 62.25 to 61.95 in laminated pouch was observed for 90 days of storage.

Table 4.33 Effect of packaging material on changes in protein (%) of *Moringa* seed oil and defatted seed flour biscuits during storage

No.	Treatment	Storage period			
		0 Days	**30 Days**	**60 Days**	**90 Days**
	Treatment				
T_0	Control	6.95	6.91	6.89	6.85
T_1	*Moringa* seed oil	6.94	6.90	6.86	6.82
T_2	Defatted *Moringa* seed flour	10.68	10.63	10.58	10.53
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.04	0.03	0.03	0.03
	Variety				
V_1	*Trimbak* (NIAW-301)	8.47	8.43	8.39	8.35
V_2	*Samadhan* (NIAW-1994)	7.90	7.86	7.83	7.78
	SE±	0.01	0.01	0.01	0.01
	CD@ 5%	NS	0.03	0.03	0.04
	Packaging material				
P_1	LDPE	8.19	8.13	8.08	8.05
P_2	Laminated pouch	8.19	8.16	8.13	8.09
	SE±	0.02	0.01	0.01	0.01
	CD @ 5%	0.06	0.03	0.03	0.03
	Interaction				
	T_0 V_1 P_1	7.24	7.18	7.16	7.13
	T_0 V_1 P_2	7.24	7.21	7.19	7.16
	T_0 V_2 P_1	6.66	6.62	6.59	6.54
	T_0 V_2 P_2	6.66	6.63	6.60	6.57
	T_1 V_1 P_1	7.23	7.18	7.15	7.10
	T_1 V_1 P_2	7.24	7.19	7.15	7.12
	T_1 V_2 P_1	6.64	6.60	6.55	6.50
	T_1 V_2 P_2	6.64	6.62	6.60	6.57
	T_2 V_1 P_1	10.94	10.88	10.81	10.76
	T_2 V_1 P_2	10.95	10.92	10.90	10.85
	T_2 V_2 P_1	10.40	10.33	10.27	10.24
	T_2 V_2 P_2	10.42	10.40	10.35	10.28
	SE±	0.03	0.01	0.01	0.01
	CD @ 5%	NS	0.04	0.04	0.04

Each value represents the average of three determination. NS = Non-significant

Table 4.34 Effect of packaging material on changes in carbohydrate (%) of *Moringa* seed oil and defatted seed flour biscuits during storage

No.	Treatment	Storage period			
		0 Days	**30 Days**	**60 Days**	**90 Days**
	Treatment				
T_0	Control	61.70	61.59	61.49	61.40
T_1	*Moringa* seed oil	60.84	60.77	60.64	60.52
T_2	Defatted *Moringa* seed flour	57.38	57.34	57.20	57.07
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03	0.03
	Variety				
V_1	*Trimbak* (NIAW-301)	59.39	59.30	59.19	59.12
V_2	*Samadhan* (NIAW-1994)	60.56	60.50	60.36	60.20
	SE±	0.01	0.01	0.01	0.01
	CD@ 5%	NS	NS	0.03	0.03
	Packaging material				
P_1	LDPE	59.97	59.90	59.76	59.64
P_2	Laminated pouch	59.98	59.90	59.78	59.68
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03	0.03
	Interaction				
	$T_0 V_1 P_1$	61.15	61.08	60.99	60.94
	$T_0 V_1 P_2$	61.17	61.11	61.05	60.97
	$T_0 V_2 P_1$	62.27	62.18	62.03	61.90
	$T_0 V_2 P_2$	62.25	62.17	62.05	61.95
	$T_1 V_1 P_1$	60.05	59.99	59.85	59.77
	$T_1 V_1 P_2$	60.06	60.03	59.88	59.83
	$T_1 V_2 P_1$	61.59	61.52	61.39	61.22
	$T_1 V_2 P_2$	61.59	61.55	61.42	61.26
	$T_2 V_1 P_1$	56.93	56.85	56.74	56.65
	$T_2 V_1 P_2$	56.92	56.86	56.77	56.74
	$T_2 V_2 P_1$	57.83	57.79	57.63	57.46
	$T_2 V_2 P_2$	57.85	57.82	57.65	57.50
	SE±	0.01	0.01	0.02	0.01
	CD @ 5%	0.04	NS	NS	0.04

Each value represents the average of three determination. NS = Non-significant

The sample prepared from *Trimbak* wheat flour with MSO showed decreased in carbohydrate content from 60.05 to 59.77 in LDPE and 60.06 to 59.83 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed carbohydrate content decreased from 61.59 to 61.22 in LDPE and 61.59 to 61.26 in laminated pouch (Table 4.34).

The sample prepared from *Trimbak* wheat flour with DMSF showed decreased in carbohydrate content from 56.93 to 56.65 in LDPE and 56.92 to 56.74 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed carbohydrate decreased from 57.83 to 57.46 in LDPE and 57.85 to 57.50 in laminated pouch. Significant decrease in carbohydrate content was observed for treatments and packaging material whereas nonsignificant among wheat variety.

The decrease in carbohydrate content of cookies during storage has also been reported by Butt *et al.* (2004) and Sharif *et al.* (2005). Biradar *et al.* (2020) investigated that the cookies prepared by little millet flour with wheat flour there was carbohydrate content decreased rapid in PP than LDPE during 90 days of storage period.

4.7.2.4 Changes in fat

It was obtained from Table 4.35 that the fat decreased for control (*Trimbak*) from 25.60 to 25.47 in LDPE and 25.62 to 25.50 in laminated pouch whereas control (*Samadhan*) from 25.55 to 25.36 in LDPE and 25.57 to 25.41 in laminated pouch was observed for 90 days of storage.

The sample prepared from *Trimbak* wheat flour with MSO showed decreased in fat content from 26.32 to 26.19 in LDPE and 26.34 to 26.21 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed fat content decreased from 26.25 to 26.05 in LDPE and 26.25 to 26.10 in laminated pouch.

The sample prepared from *Trimbak* wheat flour with DMSF showed decreased in fat content from 24.28 to 24.15 in LDPE and 24.32 to 24.17 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed fat decreased from 24.22 to 24.05 in LDPE and 24.24 to 24.12 in laminated pouch. Decrease in fat content was observed by change in level of treatments significantly changes fat value due to corresponding wheat variety whereas nonsignificant among packaging material.

Table 4.35 Effect of packaging material on changes in fat (%) of *Moringa* seed oil and defatted seed flour biscuits during storage

No.	Treatment	Storage period			
		0 Days	30 Days	60 Days	90 Days
	Treatment				
T_0	Control	25.52	25.48	25.44	25.38
T_1	*Moringa* seed oil	26.27	26.25	26.21	26.14
T_2	Defatted *Moringa* seed flour	24.26	24.22	24.18	24.12
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03	0.03
	Variety				
V_1	*Trimbak* (NIAW-301)	25.40	25.36	25.33	25.26
V_2	*Samadhan* (NIAW-1994)	25.30	25.27	25.23	25.18
	SE±	0.01	0.01	0.01	0.01
	CD@ 5%	NS	NS	NS	NS
	Packaging material				
P_1	LDPE	25.35	25.31	25.28	25.21
P_2	Laminated pouch	25.35	25.32	25.28	25.22
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03	0.03
	Interaction				
	$T_0 V_1 P_1$	25.60	25.58	25.54	25.47
	$T_0 V_1 P_2$	25.62	25.60	25.55	25.50
	$T_0 V_2 P_1$	25.55	25.48	25.40	25.36
	$T_0 V_2 P_2$	25.57	25.51	25.46	25.41
	$T_1 V_1 P_1$	26.32	26.28	26.24	26.19
	$T_1 V_1 P_2$	26.34	26.31	26.28	26.21
	$T_1 V_2 P_1$	26.25	26.20	26.14	26.05
	$T_1 V_2 P_2$	26.25	26.21	26.17	26.10
	$T_2 V_1 P_1$	24.28	24.25	24.22	24.15
	$T_2 V_1 P_2$	24.32	24.26	24.21	24.17
	$T_2 V_2 P_1$	24.22	24.17	24.13	24.05
	$T_2 V_2 P_2$	24.24	24.20	24.17	24.12
	SE±	0.01	0.01	0.02	0.01
	CD @ 5%	NS	NS	NS	NS

Each value represents the average of three determination. NS = Non-significant

The decline in fat content throughout storage might be due to moisture uptake by biscuits from the surrounding air and breakdown of fats to different compound. Sharoon *et al.* (2014) reported that decline in fat content throughout storage might be due to moisture uptake by cookies from the surrounding air and break down of fats to different compounds. Biradar *et al.* (2020) investigated that the cookies prepared by little millet flour with wheat flour. The fat content decreased rapid in PP than LDPE during 90 days of storage period due to rapid increase in moisture content in PP than LDPE.

4.7.2.5 Changes in crude fibre

The results on change in crude fibre of biscuits as influenced by storage are presented in Table 4.36. It was observed that the crude fibre decreased for control (*Trimbak*) from 1.11 to 1.00 in LDPE and 1.10 to 1.02 in laminated pouch whereas control (*Samadhan*) from 0.86 to 0.72 in LDPE and 0.84 to 0.72 in laminated pouch was observed for 90 days of storage.

The sample prepared from *Trimbak* wheat flour with MSO showed decreased in crude fibre content from 1.14 to 0.96 in LDPE and 1.13 to 1.02 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed crude fibre content decreased from 0.86 to 0.74 in LDPE and 0.87 to 0.76 in laminated pouch.

The sample prepared from *Trimbak* wheat flour with DMSF showed decreased in crude fibre content from 1.97 to 1.81 in LDPE and 1.96 to 1.87 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed crude fibre increased from 1.72 to 1.58 in LDPE and 1.71 to 1.60 in laminated pouch. Significant decrease in crude fibre content was observed for treatments and packaging material whereas nonsignificant among wheat variety. The sample packed in LDPE showed slight lower in crude fibre followed by laminated pouch on 90th day of storage. Jemziya and Mahendran (2018) determined that the reaction during processing that may affect the crude fiber content and its properties are leakage into the processing water, formation of maillard reaction products thus adding to the lignin content and formation of resistant starch fraction. According to DMRT, fiber content decreased significantly through the storage period.

Decreased in crude fibre of cookies during storage might be due to increase in moisture content which was engrossed from air as reported by Pasha *et al.* (2002). Sharif *et al.* (2005) determined reduction in crude fibre content of rice bran oil cookies throughout storage might be due to increasing level of moisture which enhances amylase activity.

Table 4.36 Effect of packaging material on changes in crude fibre (%) of *Moringa* seed oil and defatted seed flour biscuits during storage

No.	Treatment	Storage period			
		0 Days	**30 Days**	**60 Days**	**90 Days**
	Treatment				
T_0	Control	0.97	0.94	0.90	0.87
T_1	*Moringa* seed oil	0.99	0.96	0.91	0.85
T_2	Defatted *Moringa* seed flour	1.83	1.83	1.81	1.74
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.04	0.03	0.03	0.03
	Variety				
V_1	*Trimbak* (NIAW-301)	1.38	1.36	1.33	1.27
V_2	*Samadhan* (NIAW-1994)	1.14	1.13	1.08	1.03
	SE±	0.01	0.01	0.01	0.01
	CD@ 5%	0.03	0.03	NS	NS
	Packaging material				
P_1	LDPE	1.27	1.25	1.21	1.15
P_2	Laminated pouch	1.25	1.24	1.21	1.16
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03	0.03
	Interaction				
	T_0 V_1 P_1	1.11	1.06	1.03	1.00
	T_0 V_1 P_2	1.10	1.07	1.03	1.02
	T_0 V_2 P_1	0.86	0.84	0.76	0.72
	T_0 V_2 P_2	0.84	0.78	0.75	0.72
	T_1 V_1 P_1	1.14	1.08	1.02	0.96
	T_1 V_1 P_2	1.13	1.10	1.05	1.02
	T_1 V_2 P_1	0.86	0.82	0.77	0.74
	T_1 V_2 P_2	0.87	0.83	0.81	0.76
	T_2 V_1 P_1	1.97	1.94	1.89	1.81
	T_2 V_1 P_2	1.96	1.93	1.91	1.87
	T_2 V_2 P_1	1.72	1.67	1.62	1.58
	T_2 V_2 P_2	1.71	1.69	1.66	1.60
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	NS	NS	0.04	0.04

Each value represents the average of three determination. NS = Non-significant

4.7.2.6 Changes in ash

The results on changes in ash of biscuits as influenced by storage and packaging material are presented in Table 4.37. It was found that the ash decreased for control (*Trimbak*) from 1.06 to 0.93 in LDPE and 1.07 to 0.94 in laminated pouch whereas control (*Samadhan*) from 1.25 to 1.08 in LDPE and 1.27 to 1.12 in laminated pouch was observed for 90 days of storage.

The sample prepared from *Trimbak* wheat flour with MSO showed decreased in ash content from 1.10 to 0.93 in LDPE and 1.09 to 0.97 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed ash content decreased from 1.29 to 1.20 in LDPE and 1.28 to 1.22 in laminated pouch.

The sample prepared from *Trimbak* wheat flour with DMSF showed decreased in ash content from 1.80 to 1.69 in LDPE and 1.81 to 1.70 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed ash decreased from 1.94 to 1.81 in LDPE and 1.93 to 1.83 in laminated pouch. Significant decrease in ash content was observed for treatments and packaging material whereas nonsignificant among wheat variety. The sample packed in LDPE showed slightly lower ash followed by laminated pouch on 90th day of storage.

Decreased in ash of cookies during storage might be due to increase in moisture content which was engrossed from air as reported by Pasha *et al.* (2002); Butt *et al.* (2004) and Sharif *et al.* (2005).

4.7.2.7 Changes in free fatty acids

The results on changes in free fatty acids of biscuits as influenced by storage periods and packaging material are presented in Table 4.38.

It was found from Table 4.38 that the free fatty acids gradually increased for control (*Trimbak*) from 0.19 to 0.47 in LDPE and 0.18 to 0.21 in laminated pouch whereas control (*Samadhan*) from 0.20 to 0.44 in LDPE and 0.19 to 0.22 in laminated pouch was observed for 90 days of storage.

Table 4.37 Effect of packaging material on changes in ash (%) of *Moringa* seed oil and defatted seed flour biscuits during storage

No.	Treatment	Storage period			
		0 Days	**30 Days**	**60 Days**	**90 Days**
	Treatment				
T_0	Control	1.15	1.12	1.07	1.02
T_1	*Moringa* seed oil	1.19	1.15	1.13	1.08
T_2	Defatted *Moringa* seed flour	1.88	1.83	1.80	1.76
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03	0.03
	Variety				
V_1	*Trimbak* (NIAW-301)	1.32	1.28	1.25	1.19
V_2	*Samadhan* (NIAW-1994)	1.49	1.45	1.42	1.38
	SE±	0.01	0.01	0.01	0.01
	CD@ 5%	NS	NS	NS	NS
	Packaging material				
P_1	LDPE	1.40	1.37	1.33	1.28
P_2	Laminated pouch	1.41	1.37	1.34	1.29
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03	0.03
	Interaction				
	$T_0 V_1 P_1$	1.06	1.01	0.98	0.93
	$T_0 V_1 P_2$	1.07	1.05	0.99	0.94
	$T_0 V_2 P_1$	1.25	1.20	1.15	1.08
	$T_0 V_2 P_2$	1.27	1.24	1.17	1.12
	$T_1 V_1 P_1$	1.10	1.05	1.01	0.93
	$T_1 V_1 P_2$	1.09	1.06	1.04	0.97
	$T_1 V_2 P_1$	1.29	1.25	1.23	1.20
	$T_1 V_2 P_2$	1.28	1.26	1.24	1.22
	$T_2 V_1 P_1$	1.80	1.77	1.73	1.69
	$T_2 V_1 P_2$	1.81	1.76	1.75	1.70
	$T_2 V_2 P_1$	1.94	1.89	1.85	1.81
	$T_2 V_2 P_2$	1.93	1.90	1.87	1.83
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	NS	NS	0.04	0.04

Each value represents the average of three determination. NS = Non-significant

Table 4.38 Influence of packaging material on changes in free fatty acid (%) of *Moringa* seed oil and defatted seed flour biscuits during storage

No.	Treatment	Storage period			
		0 Days	**30 Days**	**60 Days**	**90 Days**
	Treatment				
T_0	Control	0.19	0.21	0.29	0.34
T_1	*Moringa* seed oil	0.25	0.27	0.29	0.35
T_2	Defatted *Moringa* seed flour	0.19	0.21	0.25	0.29
	SE±	0.01	0.01	0.02	0.01
	CD @ 5%	NS	0.03	NS	NS
	Variety				
V_1	*Trimbak* (NIAW-301)	0.21	0.23	0.27	0.33
V_2	*Samadhan* (NIAW-1994)	0.21	0.23	0.28	0.33
	SE±	0.01	0.01	0.02	0.01
	CD@ 5%	NS	NS	NS	0.03
	Packaging material				
P_1	LDPE	0.21	0.25	0.32	0.40
P_2	Laminated pouch	0.21	0.21	0.24	0.26
	SE±	0.01	0.01	0.002	0.01
	CD @ 5%	NS	0.03	0.010	0.03
	Interaction				
	T_0 V_1 P_1	0.19	0.25	0.37	0.47
	T_0 V_1 P_2	0.18	0.18	0.21	0.21
	T_0 V_2 P_1	0.20	0.23	0.35	0.44
	T_0 V_2 P_2	0.19	0.20	0.22	0.22
	T_1 V_1 P_1	0.26	0.31	0.31	0.41
	T_1 V_1 P_2	0.23	0.24	0.27	0.30
	T_1 V_2 P_1	0.24	0.28	0.31	0.35
	T_1 V_2 P_2	0.25	0.26	0.29	0.34
	T_2 V_1 P_1	0.18	0.22	0.27	0.34
	T_2 V_1 P_2	0.19	0.19	0.21	0.23
	T_2 V_2 P_1	0.19	0.23	0.30	0.37
	T_2 V_2 P_2	0.20	0.21	0.23	0.25
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.04	0.03	0.04

Each value represents the average of three determination. NS = Non-significant

The sample prepared from *Trimbak* wheat flour with MSO showed increased in free fatty acids content from 0.26 to 0.41 in LDPE and 0.23 to 0.30 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed free fatty acids content increased from 0.24 to 0.35 in LDPE and 0.25 to 0.34 in laminated pouch.

The sample prepared from *Trimbak* wheat flour with DMSF showed increased in free fatty acids content from 0.18 to 0.34 in LDPE and 0.19 to 0.23 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed free fatty acids increased from 0.19 to 0.37 in LDPE and 0.20 to 0.25 in laminated pouch. The all-interaction effects showed statistically significant difference among the different factor. Changes in level of treatments significantly changes free fatty acid value due to corresponding packaging material. The sample packed in LDPE showed higher free fatty acids followed by laminated pouch on 90th day of storage. This might be due to higher WVTR and GTR of LDPE than aluminium laminated pouch.

Singh *et al.* (2000) studied that free fatty acid content of soy-fortified biscuits and reported its increase with storage period. The increase in FFA content of soy biscuits was due to greater increase in their moisture content which promoted fat hydrolysis during storage. Kaur (2005) reported that formation of free fatty acids was higher in case of cookies stored in LDPE as compared to those stored in aluminium laminates and this could have been because of the fact that aluminium laminates protect biscuits against light, as light acts as catalyst for oxidation. Nagi *et al.* (2012) studied that the packaging material and storage period tangibly affected free fatty acid content of biscuits containing full fat cereal brans. The free fatty acid content was higher in the product packed in HDPE pouches, than the laminate pouches.

4.7.2.8 Changes in peroxide value

The results on changes in peroxide value of biscuits as influenced by storage periods and packaging material are presented in Table 4.39.

It was observed from Table 4.39 that the peroxide value gradually increased for control (*Trimbak*) from 2.50 to 4.40 in LDPE and 2.44 to 3.03 in laminated pouch whereas control (*Samadhan*) from 2.40 to 3.83 in LDPE and 2.50 to 3.13 in laminated pouch was observed for 90 days of storage.

Table 4.39 Influence of packaging material on changes in peroxide value (meq/kg) of *Moringa* seed oil and defatted seed flour biscuits during storage

No.	Treatment	Storage period			
		0 Days	**30 Days**	**60 Days**	**90 Days**
	Treatment				
T_0	Control	2.46	2.59	2.98	3.40
T_1	*Moringa* seed oil	3.15	3.28	3.78	4.00
T_2	Defatted *Moringa* seed flour	2.50	2.60	3.00	3.30
	SE±	0.01	0.01	0.01	0.02
	CD @ 5%	NS	0.03	0.04	NS
	Variety				
V_1	*Trimbak* (NIAW-301)	2.70	2.84	3.20	3.58
V_2	*Samadhan* (NIAW-1994)	2.70	2.80	3.30	3.55
	SE±	0.01	0.01	0.01	0.02
	CD@ 5%	0.03	0.03	0.04	0.04
	Packaging material				
P_1	LDPE	2.74	2.98	3.68	4.15
P_2	Laminated pouch	2.67	2.67	2.82	2.98
	SE±	0.01	0.01	0.02	0.02
	CD @ 5%	0.03	0.03	0.06	0.06
	Interaction				
	$T_0 V_1 P_1$	2.50	2.80	3.15	4.40
	$T_0 V_1 P_2$	2.44	2.63	2.75	3.03
	$T_0 V_2 P_1$	2.40	2.60	2.95	3.83
	$T_0 V_2 P_2$	2.50	2.70	2.89	3.13
	$T_1 V_1 P_1$	3.20	3.46	3.75	4.60
	$T_1 V_1 P_2$	3.10	3.21	3.33	3.75
	$T_1 V_2 P_1$	3.25	3.50	3.85	4.80
	$T_1 V_2 P_2$	3.13	3.21	3.35	3.78
	$T_2 V_1 P_1$	2.60	2.80	3.20	3.70
	$T_2 V_1 P_2$	2.55	2.65	2.78	3.00
	$T_2 V_2 P_1$	2.40	2.55	3.03	3.40
	$T_2 V_2 P_2$	2.44	2.50	2.80	3.10
	SE±	0.03	0.04	0.04	0.03
	CD @ 5%	0.09	0.12	0.12	0.10

Each value represents the average of three determination. NS = Non-significant

The sample prepared from *Trimbak* wheat flour with MSO showed increased in peroxide value from 3.20 to 4.60 in LDPE and 3.10 to 3.75 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed peroxide value increased from 3.25 to 4.80 in LDPE and 3.13 to 3.78 in laminated pouch.

The sample prepared from *Trimbak* wheat flour with DMSF showed increased in peroxide value content from 2.60 to 3.70 in LDPE and 2.55 to 3.00 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed peroxide value increased from 2.40 to 3.40 in LDPE and 2.44 to 3.10 in laminated pouch. The all-interaction effects showed statistically significant difference among the different factor. Changes in level of treatments significantly changes peroxide value due to corresponding packaging material. The sample packed in LDPE showed higher free fatty acids followed by laminated pouch on 90th day of storage. This might be due to higher WVTR and GTR of LDPE than aluminium laminated pouch.

Jyotsna *et al.* (2012) reported that the there was some increase in the peroxide value of the control and flaxseed cookies.

Divyashree *et al.* (2016) investigated that the buckwheat-chia seeds fortified biscuits were stored in poly propylene pouches at room temperature and stored for 60 days. Peroxide value, the indicator of rate of auto oxidation, was increased significantly during storage from 7.09 to 22.18 meq O_2/kg fat at the end of 60 days.

4.7.3 Effects of Packaging Material on Changes in Mineral Composition of *Moringa* Seed Oil and Defatted Seed Flour Biscuits During Storage

The results on change in minerals content such as calcium, phosphorus, iron and zinc of biscuits as influenced by storage and packaging material are presented in Table 4.40 to 4.43.

4.7.3.1 Changes in calcium

It was observed from Table 4.40 that the calcium decreased for control (*Trimbak*) from 35.29 to 35.15 in LDPE and 35.28 to 35.18 in laminated pouch whereas control (*Samadhan*) from 32.13 to 32.03 in LDPE and 32.14 to 32.05 in laminated pouch was observed for 90 days of storage.

Table 4.40 Effect of packaging material on changes in calcium (mg/100 g) of *Moringa* seed oil and defatted seed flour biscuits during storage

No.	Treatment	Storage period			
		0 Days	30 Days	60 Days	90 Days
	Treatment				
T_0	Control	33.73	33.67	33.64	33.61
T_1	*Moringa* seed oil	33.66	33.64	33.63	33.60
T_2	Defatted *Moringa* seed flour	70.79	70.76	70.73	70.69
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03	0.03
	Variety				
V_1	*Trimbak* (NIAW-301)	47.20	47.17	47.15	47.10
V_2	*Samadhan* (NIAW-1994)	44.92	44.88	44.85	44.84
	SE±	0.01	0.01	0.01	0.01
	CD@ 5%	NS	0.03	0.04	NS
	Packaging material				
P_1	LDPE	46.07	46.04	46.01	45.97
P_2	Laminated pouch	46.05	46.01	45.99	45.97
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03	0.03
	Interaction				
	$T_0 V_1 P_1$	35.29	35.23	35.19	35.15
	$T_0 V_1 P_2$	35.28	35.24	35.21	35.18
	$T_0 V_2 P_1$	32.13	32.10	32.06	32.03
	$T_0 V_2 P_2$	32.14	32.11	32.08	32.05
	$T_1 V_1 P_1$	35.26	35.23	35.20	35.15
	$T_1 V_1 P_2$	35.28	35.26	35.24	35.18
	$T_1 V_2 P_1$	32.10	32.06	32.02	31.97
	$T_1 V_2 P_2$	32.11	32.07	32.04	32.00
	$T_2 V_1 P_1$	71.06	71.02	71.00	70.92
	$T_2 V_1 P_2$	71.05	71.03	71.00	70.96
	$T_2 V_2 P_1$	70.52	70.48	70.45	70.41
	$T_2 V_2 P_2$	70.51	70.50	70.47	70.44
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.04	0.04	0.04	0.04

Each value represents the average of three determination. NS = Non-significant

The sample prepared from *Trimbak* wheat flour with MSO showed decreased in calcium content from 35.26 to 35.15 in LDPE and 35.28 to 35.18 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed calcium content decreased from 32.10 to 31.97 in LDPE and 32.11 to 32.00 in laminated pouch.

The sample prepared from *Trimbak* wheat flour with DMSF showed decreased in calcium content from 71.06 to 70.92 in LDPE and 71.05 to 70.96 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed calcium decreased from 70.52 to 70.41 in LDPE and 70.51 to 70.44 in laminated pouch. Decrease in calcium content was observed by change in level of treatments significantly changes values due to corresponding of packaging material whereas nonsignificant among wheat variety.

4.7.3.2 Changes in phosphorus

It was observed from Table 4.41 that the phosphorus decreased for control (*Trimbak*) from 343.26 to 343.04 in LDPE and 343.24 to 343.06 in laminated pouch whereas control (*Samadhan*) from 326.03 to 325.83 in LDPE and 326.00 to 325.87 in laminated pouch was observed for 90 days of storage.

The sample prepared from *Trimbak* wheat flour with MSO showed decreased in phosphorus content from 343.23 to 343.08 in LDPE and 343.19 to 343.11 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed phosphorus content decreased from 326.03 to 325.78 in LDPE and 326.00 to 325.80 in laminated pouch (Table 4.41).

The sample prepared from *Trimbak* wheat flour with DMSF showed decreased in phosphorus content from 349.80 to 349.65 in LDPE and 349.79 to 379.68 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed phosphorus decreased from 332.58 to 332.29 in LDPE and 332.57 to 332.36 in laminated pouch. Decrease in phosphorus content was observed change in treatments significantly changes values due to corresponding other factor like packaging material and wheat variety.

Table 4.41 Effect of packaging material on changes in phosphorus (mg/100g) of *Moringa* seed oil and defatted seed flour biscuits during storage

No.	Treatment	Storage period			
		0 Days	**30 Days**	**60 Days**	**90 Days**
	Treatment				
T_0	Control	334.63	334.53	334.51	334.45
T_1	*Moringa* seed oil	334.61	334.56	334.49	334.44
T_2	Defatted *Moringa* seed flour	341.18	341.11	341.06	340.98
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.04	0.03	0.04
	Variety				
V_1	*Trimbak* (NIAW-301)	345.41	345.36	345.32	345.26
V_2	*Samadhan* (NIAW-1994)	328.20	328.12	328.05	327.99
	SE±	0.01	0.01	0.01	0.01
	CD@ 5%	0.03	NS	0.03	0.03
	Packaging material				
P_1	LDPE	336.82	336.74	336.68	336.61
P_2	Laminated pouch	336.79	336.73	336.69	336.63
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03	0.03
	Interaction				
	$T_0 V_1 P_1$	343.26	343.16	343.11	343.04
	$T_0 V_1 P_2$	343.24	343.17	343.15	343.06
	$T_0 V_2 P_1$	326.03	325.92	325.87	325.83
	$T_0 V_2 P_2$	326.00	325.95	325.89	325.87
	$T_1 V_1 P_1$	343.23	343.18	343.12	343.08
	$T_1 V_1 P_2$	343.19	343.16	343.15	343.11
	$T_1 V_2 P_1$	326.03	325.97	325.83	325.78
	$T_1 V_2 P_2$	326.00	325.93	325.85	325.80
	$T_2 V_1 P_1$	349.80	349.76	349.70	349.65
	$T_2 V_1 P_2$	349.79	349.76	349.72	349.68
	$T_2 V_2 P_1$	332.58	332.48	332.43	332.29
	$T_2 V_2 P_2$	332.57	332.49	332.46	332.36
	SE±	0.01	0.02	0.01	0.01
	CD @ 5%	NS	NS	0.04	0.04

Each value represents the average of three determination. NS = Non-significant

4.7.3.3 Changes in iron

It was observed from Table 4.42 that the iron decreased for control (*Trimbak*) from 4.33 to 4.10 in LDPE and 4.32 to 4.17 in laminated pouch whereas control (*Samadhan*) from 2.70 to 2.50 in LDPE and 2.70 to 2.53 in laminated pouch was observed for 90 days of storage.

The sample prepared from *Trimbak* wheat flour with MSO showed decreased in iron content from 4.33 to 4.11 in LDPE and 4.31 to 4.23 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed iron content decreased from 2.69 to 2.53 in LDPE and 2.71 to 2.55 in laminated pouch.

The sample prepared from *Trimbak* wheat flour with DMSF showed decreased in iron content from 5.63 to 5.48 in LDPE and 5.65 to 5.50 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed iron decreased from 4.14 to 3.85 in LDPE and 4.13 to 3.87 in laminated pouch. Significant decrease in iron content was observed for treatments and wheat variety whereas nonsignificant among packaging material.

4.7.3.4 Changes in zinc

It was observed from Table 4.43 that the zinc decreased for control (*Trimbak*) from 1.95 to 1.76 in LDPE and from 1.96 to 1.78 in laminated pouch whereas control (*Samadhan*) from 2.14 to 2.01 in LDPE and 2.15 to 2.03 in laminated pouch was observed for 90 days of storage.

The sample prepared from *Trimbak* wheat flour with MSO showed decreased in zinc content from 1.96 to 1.76 in LDPE and 1.96 to 1.80 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed zinc content decreased from 2.11 to 1.98 in LDPE and 2.13 to 2.00 in laminated pouch (Table 4.43).

The sample prepared from *Trimbak* wheat flour with DMSF showed decreased in zinc content from 2.18 to 2.02 in LDPE and 2.19 to 2.10 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed zinc decreased from 2.31 to 2.20 in LDPE and 2.32 to 2.23 in laminated pouch. Decrease in zinc content was observed by change in levels of treatments significantly changes values due to corresponding wheat variety whereas nonsignificant among packaging material.

Table 4.42 Effect of packaging material on changes in iron (mg/100g) of *Moringa* seed oil and defatted seed flour biscuits during storage

No.	Treatment	Storage period			
		0 Days	**30 Days**	**60 Days**	**90 Days**
	Treatment				
T_0	Control	3.51	3.43	3.39	3.32
T_1	*Moringa* seed oil	3.50	3.45	3.41	3.34
T_2	Defatted *Moringa* seed flour	4.89	4.82	4.75	4.65
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.04	0.04
	Variety				
V_1	*Trimbak* (NIAW-301)	4.76	4.69	4.65	4.58
V_2	*Samadhan* (NIAW-1994)	3.17	3.10	3.05	2.96
	SE±	0.01	0.01	0.01	0.01
	CD@ 5%	0.03	0.03	0.03	0.03
	Packaging material				
P_1	LDPE	3.96	3.89	3.85	3.76
P_2	Laminated pouch	3.97	3.90	3.85	3.78
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	NS	NS	NS	NS
	Interaction				
	T_0 V_1 P_1	4.33	4.22	4.19	4.10
	T_0 V_1 P_2	4.32	4.22	4.20	4.17
	T_0 V_2 P_1	2.70	2.59	2.57	2.50
	T_0 V_2 P_2	2.70	2.67	2.60	2.53
	T_1 V_1 P_1	4.33	4.27	4.23	4.11
	T_1 V_1 P_2	4.31	4.27	4.25	4.23
	T_1 V_2 P_1	2.69	2.63	2.60	2.53
	T_1 V_2 P_2	2.71	2.65	2.61	2.55
	T_2 V_1 P_1	5.63	5.61	5.52	5.48
	T_2 V_1 P_2	5.65	5.62	5.56	5.50
	T_2 V_2 P_1	4.14	4.04	4.00	3.85
	T_2 V_2 P_2	4.13	4.06	4.01	3.87
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.04	0.04	0.04	0.04

Each value represents the average of three determination. NS = Non-significant

Table 4.43 Effect of packaging material on changes in zinc (mg/100g) of *Moringa* seed oil and defatted seed flour biscuits during storage

No.	Treatment	Storage period			
		0 Days	**30 Days**	**60 Days**	**90 Days**
	Treatment				
T_0	Control	2.05	2.01	1.94	1.88
T_1	*Moringa* seed oil	2.01	2.02	1.94	1.90
T_2	Defatted *Moringa* seed flour	2.26	2.22	2.17	2.13
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03	0.03
	Variety				
V_1	*Trimbak* (NIAW-301)	2.04	2.00	1.92	1.86
V_2	*Samadhan* (NIAW-1994)	2.18	2.17	2.11	2.08
	SE±	0.01	0.01	0.01	0.01
	CD@ 5%	0.03	0.03	0.03	0.03
	Packaging material				
P_1	LDPE	2.11	2.08	2.01	1.97
P_2	Laminated pouch	2.11	2.08	2.03	1.99
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	NS	NS	0.03	NS
	Interaction				
	$T_0 V_1 P_1$	1.95	1.93	1.84	1.76
	$T_0 V_1 P_2$	1.96	1.94	1.86	1.78
	$T_0 V_2 P_1$	2.14	2.06	2.04	2.01
	$T_0 V_2 P_2$	2.15	2.12	2.07	2.03
	$T_1 V_1 P_1$	1.96	1.93	1.86	1.76
	$T_1 V_1 P_2$	1.96	1.92	1.85	1.80
	$T_1 V_2 P_1$	2.11	2.06	2.02	1.98
	$T_1 V_2 P_2$	2.13	2.08	2.05	2.00
	$T_2 V_1 P_1$	2.18	2.14	2.06	2.02
	$T_2 V_1 P_2$	2.19	2.15	2.13	2.10
	$T_2 V_2 P_1$	2.31	2.29	2.25	2.20
	$T_2 V_2 P_2$	2.32	2.32	2.27	2.23
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	0.04	0.04	0.04	0.04

Each value represents the average of three determination. NS = Non-significant

4.7.4 Effect of Storage Period and Packaging Material on Changes in Microbial Quality of *Moringa* Seed Oil and Defatted Seed Flour Biscuits

The control biscuits and standardized biscuits from *Trimbak* and *Samadhan* wheat flour, containing 40 per cent *Moringa* seed oil (MSO) and 10 per cent defatted *Moringa* seed flour were packed in LDPE and laminated pouch and stored at ambient temperature for 3 months (90 days). The biscuits were evaluated for microbial quality on 0 day and 90 day of storage. The microbial quality was studied for Total Plate Count (TPC) and Yeast and Mould Count. It was determined by using serial dilution pour plate method. The number of colonies appearing on dilution plates were counted, averaged and reported as cells per gram (cfu/gm) of the sample.

4.7.4.1 Total plate count

The results for total plate count of biscuits obtained in present investigation as influenced by packaging material and storage period are presented in Table 4.44 It was observed that the total plate count gradually increased for control (*Trimbak*) from 1.03 to 2.30 in LDPE and 1.02 to 1.38 in laminated pouch whereas control (*Samadhan*) from 1.01 to 2.28 in LDPE and 1.01 to 1.34 in laminated pouch was observed for 90 days of storage.

The sample prepared from *Trimbak* wheat flour with MSO showed increased in total plate count was observed from 1.02 to 2.78 in LDPE and 1.01 to 1.93 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO observed total plate count increased from 1.02 to 2.68 in LDPE and 1.01 to 1.85 in laminated pouch.

The sample prepared from *Trimbak* wheat flour with DMSF observed increased in total plate count from 1.03 to 2.38 in LDPE and 1.02 to 1.49 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF observed total plate count increased from 1.02 to 2.35 in LDPE and 1.01 to 1.39 in laminated pouch. Samples packed in LDPE showed higher plate count value followed by laminated pouch on 90th day of storage. This might be due to higher WVTR and GTR of LDPE then laminated pouch.

Nagi *et al.* (2012) stated that the packaging material had non-significant effect on the microbial quality of biscuits, however, growth was observed more in biscuits packed in HDPE than the laminate packed biscuits.

4.7.4.2. Yeast and mould count

The data for yeast and mould count of biscuits obtained in present investigation as influenced by packaging material and storage period are presented in Table 48. It was observed that yeast and mould count gradually increased for control (*Trimbak*) from 1.05 to 2.66 in LDPE and 1.05 to 1.37 in laminated pouch whereas control (*Samadhan*) from 1.05 to 2.58 in LDPE and 1.03 to 1.28 in laminated pouch was observed for 90 days of storage.

The sample prepared from *Trimbak* wheat flour with MSO showed increased in yeast and mould count was observed from 1.05 to 2.83 in LDPE and 1.05 to 1.26 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO observed yeast and mould count increased from 1.06 to 2.67 in LDPE and 1.04 to 1.18 in laminated pouch.

The sample prepared from *Trimbak* wheat flour with DMSF observed increased in yeast and mould count from 1.23 to 2.38 in LDPE and 1.22 to 1.39 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF observed yeast and mould increased from 1.20 to 2.27 in LDPE and 1.20 to 1.39 in laminated pouch. Samples packed in LDPE showed higher yeast and mould value followed by laminated pouch on 90th day of storage. This might be due to higher WVTR and GTR of LDPE then laminated pouch.

Berwal *et al.* (2013) investigated that the yeast and mould growth was only detected after 60th day of storage and had very less growth 3 to 9 cfu/g in chicken meat mince incorporated cookies throughout the storage period.

Deshmukh (2017) studied that the yeast and mould count gradually increased in garden cress seed oil incorporated cookies during storage period. The sample packed in LDPE showed higher yeast and mould count than the HDPE and aluminium foil packages on the 180th of the storage.

Table 4.44 Effect of storage period and packaging material on changes in microbial quality of *Moringa* seed oil and defatted seed flour biscuits

No.	Treatment	Total plate count (-× 10^3 cfu/g)		Yeast and mold count (-× 10^3 cfu/g)	
		0 days	**90 days**	**0 days**	**90 days**
	Treatment				
T_0	Control	1.02	1.82	1.04	1.97
T_1	*Moringa* seed oil	1.01	2.31	1.05	1.98
T_2	Defatted *Moringa* seed flour	1.02	1.90	1.21	1.86
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	NS	0.03	NS	0.03
	Variety				
V_1	*Trimbak* (NIAW-301)	1.02	2.04	1.11	1.98
V_2	*Samadhan* (NIAW-1994)	1.01	1.98	1.10	1.89
	SE±	0.01	0.01	0.01	0.01
	CD@ 5%	NS	0.03	NS	0.03
	Packaging material				
P_1	LDPE	1.02	2.46	1.11	2.56
P_2	Laminated pouch	1.01	1.56	1.10	1.31
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	NS	0.03	0.03	0.03
	Interaction				
	T_0 V_1 P_1	1.03	2.30	1.05	2.66
	T_0 V_1 P_2	1.02	1.38	1.05	1.37
	T_0 V_2 P_1	1.01	2.28	1.05	2.58
	T_0 V_2 P_2	1.01	1.34	1.03	1.28
	T_1 V_1 P_1	1.02	2.78	1.05	2.83
	T_1 V_1 P_2	1.01	1.93	1.05	1.26
	T_1 V_2 P_1	1.02	2.68	1.06	2.67
	T_1 V_2 P_2	1.01	1.85	1.04	1.18
	T_2 V_1 P_1	1.03	2.38	1.23	2.38
	T_2 V_1 P_2	1.02	1.49	1.22	1.39
	T_2 V_2 P_1	1.02	2.35	1.20	2.27
	T_2 V_2 P_2	1.01	1.39	1.20	1.39
	SE±	0.01	0.01	0.01	0.02
	CD @ 5%	NS	0.04	NS	0.06

Each value represents the average of three determination. NS = Non-significant

4.8 Sensory Evaluation, Physical Properties, Chemical, Micronutrient Composition and Textural Characteristics of Cupcake

4.8.1 Sensory Evaluation

4.8.1.1 Sensory evaluation of *Moringa* seed oil cupcake

The result regarding sensory evaluation of cupcake prepared from *Trimbak* and *Samadhan* wheat flour with *Moringa* seed oil about colour and appearance, texture, flavour, taste and overall acceptability are presented in Table 4.45.

The differences for the sensory characteristics like colour and appearance, texture, flavour, taste and overall acceptability were statistically significant among all the treatments. The cupcake samples prepared with treatment T_5 (100 % MSO) were statisticaly significant different for overall acceptability parameter over all other treatments to the proportion of same variety (*Trimbak* and *Samadhan*).

Colour and appearance

The colour and appearance score of cupcakes from *Trimbak* and *Samadhan* wheat flour of control sample was 8.11 and 8.22 respectively. The optimized product prepared with treatment T_5 (100 % MSO) from *Trimbak* and *Samadhan* wheat flour had colour and appearance score 8.36 and 8.48 and showed mean colour and appearance score of treatment T_5 was 8.42. Treatment T_5 was statistically superior among all over treatment.

The value of colour and appearance of cupcake was increased with *Moringa* seed oil level increased. The combined effect of wheat variety and different level of *Moringa* seed oil showed mean colour appearance score 7.98.

Texture

The texture score of cupcakes from *Trimbak* and *Samadhan* wheat flour of control sample was 8.14 and 8.28, respectively. The optimized product prepared with treatment T_5 (100 % MSO) from *Trimbak* and *Samadhan* wheat flour had texture score 8.24 and 8.40 and showed mean texture score of treatment T_5 was 8.32. The combined effect of wheat variety and different level of *Moringa* seed oil showed mean texture score 7.87.

The incorporation of *Moringa* seed oil level increased in cupcake which effects on the texture of as its increase in sponginess. The combined effect of wheat variety and different level of *Moringa* seed oil showed mean texture score 7.87. Wiese and Duffrin, (2003) investigated sensory properties of plain shortened cake (PSC) using pawpaw fruit puree as a partial replacement for fat in the food formulation.

Table 4.45 Sensory evaluation of cupcake prepared with addition of different levels of *Moringa* seed oil

No.	Treatment	Colour and appearance			Texture			Flavour			Taste			Overall acceptability		
		V_1	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**
T_0	Control	8.11	8.22	8.17	8.14	8.28	8.21	8.00	8.24	8.12	8.15	8.26	8.21	8.10	8.25	8.18
T_1	20 % MSO	7.77	7.90	7.84	7.51	7.58	7.55	7.57	7.80	7.69	7.59	7.68	7.64	7.61	7.74	7.68
T_2	40 % MSO	7.79	7.90	7.85	7.65	7.63	7.64	7.75	7.90	7.83	7.65	7.71	7.68	7.71	7.81	7.76
T_3	60 % MSO	7.79	7.81	7.80	7.65	7.74	7.70	7.84	7.91	7.88	7.72	7.86	7.79	7.75	7.83	7.79
T_4	80 % MSO	7.80	7.83	7.82	7.77	7.82	7.80	7.85	7.94	7.90	7.82	7.89	7.86	7.81	7.87	7.84
T_5	**100 % MSO**	**8.36**	**8.48**	**8.42**	**8.24**	**8.40**	**8.32**	**8.30**	**8.52**	**8.41**	**8.30**	**8.40**	**8.35**	**8.30**	**8.45**	**8.38**
	Mean	7.94	8.02	7.98	7.83	7.91	7.87	7.89	8.05	7.97	7.87	7.97	7.92	7.88	7.99	7.94
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.002	0.005	0.020	0.001	0.002	0.009	0.005	0.014	0.059	0.001	0.004	0.015	0.001	0.003	0.015
	CD @ 5%	0.004	0.014	0.058	0.002	0.007	0.026	0.014	0.043	NS	0.004	0.011	NS	0.004	0.011	0.043

All values are mean of 10 replications. **V_1** = *Trimbak*, **V_2** = *Samadhan,* MSO = *Moringa* seed oil, NS = Non-significant. Maximum score out of 9.0.

The cakes were prepared by replacing about 25, 50 and 75 per cent of the fat with pawpaw fruit puree and were compared to a control using 100 % vegetable shortening. Arnab and Proshanta (2015) studied that the hardness of betel leaf oil cake was highest among all the cupcakes. Such hardness leads the new product towards a greater gumminess.

Flavour

The flavour score of cupcakes from *Trimbak* and *Samadhan* wheat flour of control sample was 8.00 and 8.24, respectively. The optimized product prepared with treatment T_5 (100 % MSO) from *Trimbak* and *Samadhan* wheat flour had flavour score 8.30 and 8.52 and showed mean flavour score value of treatment T_5 was 8.41.

The incorporation of *Moringa* seed oil level increased in cupcake which causes changes in flavour of cupcake. The combined effect of wheat variety and different level of *Moringa* seed oil showed mean flavour score 7.97.

Taste

The taste score of cupcakes from *Trimbak* and *Samadhan* wheat flour of control sample was significantly different had score 8.15 and 8.26, respectively. The optimized product T_5 (100 % MSO) from *Trimbak* and *Samadhan* wheat flour had taste score 8.30 and 8.400 and showed mean taste score value of treatment T_5 was 8.35. Treatment T_5 was statistically significant among all over treatment.

The *Moringa* seed oil level increased in cupcake which effects on taste of cupcake. The combined effect of wheat variety and different level of *Moringa* seed oil showed mean taste score 7.92. Radhika *et al.* (2020) studied that cupcake made from red palm olein received higher score (3.29) in sensory evaluation as compared to cupcakes containing palm olein (3.07).

Overall acceptability

The overall acceptability score of cupcakes from *Trimbak* and *Samadhan* wheat flour of control sample was 8.10 and 8.25, respectively. The optimized product treatment T_5 (100 % MSO) from *Trimbak* and *Samadhan* wheat flour had overall acceptability score 8.30 and 8.45.

The combined effect of wheat variety and different level of *Moringa* seed oil showed mean overall acceptability score 7.94. It could be observed that all the treatments were in acceptable range. Highest mean score for overall acceptability of biscuits were observed in treatment T_5 (8.38) which are at par with T_0 (8.18). Nasir *et al.* (2009)

extracted oil from maize germ, refined and used in cake recipe for value-addition. Cakes were successfully prepared with all levels of MGO fortification with high acceptability.

Kaur *et al.* (2014) prepared muffin samples by replacing bakery shortening with rice bran oil at 0, 25, 50, 75 and 100 per cent levels. Statistical analysis revealed that muffin making and organoleptic quality of muffins prepared after replacing fat by rice bran oil at 50 per cent level or greater varied significantly which is desirable from that of control. Arnab and Proshanta (2015) reported that sensory properties of cupcakes developed with incorporation of different amount of essential oil of betel leaf, i.e., 0.01, 0.005 and 0.001 per cent (v/w) of the flour. Developed cupcake (0.005 % oil) was the best for overall acceptability.

4.8.1.2 Sensory evaluation of defatted *Moringa* seed flour cupcake

On the basis of rheological properties of dough which indicated optimum level of defatted *Moringa* seed flour can be used for preparation of cupcake up to 5 per cent of acceptability quality. After increase in level of DMSF it gives bitter taste and hard texture of cupcake.

The differences for the sensory characteristics like colour and appearance, texture, flavour, taste and overall acceptability (Appendix II) were statistically significant among all treatments (Table 4.46). The cupcake sample prepared with treatment T_1 (5 % DMSF) were statistically superior for same variety (*Trimbak* and *Samadhan*).

Colour and appearance

The colour and appearance score of cupcakes from *Trimbak* and *Samadhan* wheat flour of control sample was 8.11 and 8.22, respectively. The optimized product prepared with treatment T_1 (5% DMSF) from *Trimbak* and *Samadhan* wheat flour had colour and appearance score 7.93 and 7.94 and showed mean colour and appearance score of treatment T_1 was 7.94.

The value of colour and appearance was decreased with increased incorporation of defatted *Moringa* seed flour. The combined effect of wheat variety and different level of defatted *Moringa* seed flour showed mean colour appearance score for cupcake 7.52. Atef *et al.* (2011) reported that all levels of substitution by raw and germinated bean flour the crust colours were in significant differences among samples and control.

Table 4.46 Sensory evaluation of cupcake prepared with addition of different levels of defatted *Moringa* seed flour

No.	Treatment	Colour and appearance			Texture			Flavour			Taste			Overall acceptability		
		V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_0	Control	8.11	8.22	8.17	8.14	8.28	8.21	8.00	8.24	8.12	8.15	8.26	8.21	8.10	8.25	8.18
T_1	**5 % DMSF**	**7.93**	**7.94**	**7.94**	**7.87**	**7.88**	**7.88**	**7.75**	**7.80**	**7.78**	**7.65**	**7.71**	**7.68**	**7.80**	**7.83**	**7.82**
T_2	10 % DMSF	7.74	7.76	7.75	7.63	7.43	7.53	7.62	7.65	7.64	7.45	7.52	7.49	7.61	7.65	7.63
T_3	15 % DMSF	7.48	7.51	7.50	7.52	7.57	7.55	7.32	7.43	7.38	7.20	7.29	7.25	7.38	7.45	7.42
T_4	20 % DMSF	7.00	7.22	7.11	7.10	7.23	7.17	6.50	6.66	6.58	6.40	6.50	6.45	6.75	6.90	6.83
T_5	25 % DMSF	6.62	6.65	6.64	6.50	6.57	6.54	6.12	6.21	6.17	6.00	6.30	6.15	6.31	6.43	6.37
	Mean	7.48	7.55	7.52	7.46	7.49	7.48	7.22	7.33	7.28	7.14	7.26	7.20	7.33	7.42	7.37
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.001	0.003	0.014	0.001	0.017	0.070	0.05	0.015	0.059	0.001	0.002	0.010	0.001	0.002	0.009
	CD @ 5%	0.003	0.010	0.041	NS	0.050	NS	0.014	0.042	NS	0.002	0.001	0.029	0.002	0.006	0.026

All values are mean of 10 replications. V_1 = *Trimbak*, V_2 = *Samadhan*, DMSF = Defatted *Moringa* seed flour, NS = Non-significant. Maximum score out of 9.0.

But above more than 50% substitution levels of raw and germinated cowpea the colour of cake had lower scores and significantly differed than the control sample.

Texture

The texture score of cupcakes from *Trimbak* and *Samadhan* wheat flour of control sample was 8.14 and 8.28, respectively. The optimized product prepared with treatment T_1 (5 % DMSF) from *Trimbak* and *Samadhan* wheat flour had texture score 7.87 and 7.88 and showed mean texture score of treatment T_1 was 7.88.

The incorporation of defatted *Moringa* seed flour level increased in cupcake which effects on the texture of cupcake. The combined effect of wheat variety and different level of defatted *Moringa* seed flour showed mean texture score 7.48. It was observed that addition of defatted seed flour during preparation of cupcake to decrease water absorption capacity of flour eventually resulted in hard texture of cupcake. Shameena *et al.* (2016) studied texture of 40 and 50 g virgin coconut oil (VCO) cake-based formulations was significantly different from other formulations including control with a mean score of 8.55 and 8.83, respectively.

Flavour

The flavour score of cupcakes from *Trimbak* and *Samadhan* wheat flour of control sample was 8.00 and 8.24, respectively. The cupcake samples prepared with treatment T_1 (5 % DMSF) from *Trimbak* and *Samadhan* wheat flour had flavour score 7.75 and 7.80 and showed mean flavour score value of treatment T_1 was 7.78.

The incorporation of defatted *Moringa* seed flour level increased in cupcake which causes changes in flavour of cupcake. The combined effect of wheat variety and different level of defatted *Moringa* seed flour showed mean flavour score for cupcake 7.28. Shameena *et al.* (2016) reported that muffins prepared by substituting refined wheat flour (RWF) with virgin coconut oil (VCO) cake (0-50 g/100 g flour blend). Muffins containing 40 g VCO cake/100 g flour blend obtained the maximum score for odour (7.85).

Taste

The taste score of cupcakes from *Trimbak* and *Samadhan* wheat flour of control sample was significantly different had higher score 8.15 and 8.26, respectively followed by treatment T_1 (5 % DMSF) from *Trimbak* and *Samadhan* wheat flour had taste score 7.65 and 7.71 and showed mean taste score value of treatment T_1 was 7.68.

The defatted *Moringa* seed flour level increased in biscuits which effects on taste of cupcake. The combined effect of wheat variety and different level of defatted *Moringa* seed flour showed mean taste score 7.20.

Overall acceptability

The overall acceptability score of cupcakes from *Trimbak* and *Samadhan* wheat flour of control sample was significantly superior had score 8.10 and 8.25 respectively. The treatment T_1 (5 % DMSF) from *Trimbak* and *Samadhan* wheat flour had overall acceptability score 7.80 and 7.83 and showed mean overall acceptability score value of treatment T_1 was 7.82 (Table 4.46).

The combined effect of wheat variety and different level of defatted *Moringa* seed flour showed mean overall acceptability score 7.37. Highest mean score for overall acceptability of cupcake were observed in treatment T_1 (7.82) which at par with T_0 (8.18). Kripa and Anita (2018) studied that the cupcakes were prepared by incorporating partially defatted peanut flour at different levels (10-20 %). Muffins with 15 per cent (S3 treatment) partially defatted peanut flour supplementation which was liked very much with overall acceptability of 7.66.

Chinma *et al.* (2014) investigated the effects of substituting germinated *Moringa* seed flour for wheat flour on the cake quality. The taste and overall acceptability of composite cakes up to 30 per cent germinated *Moringa* seed flour substitution were not significantly different from the whole wheat flour cake.

4.8.2 Physical Properties of Cupcake

4.8.2.1 Physical parameter of cupcake affected by wheat variety flour with the different level of *Moringa* seed oil

The significance of addition of *Moringa* seed oil (MSO) on physical parameter such as weight, volume, bulk density, spread volume and height were determined. The data about physical parameter of cupcake incorporated with different levels of *Moringa* seed oil is shown in Table 4.47.

Weight

The results obtained for weight of control cupcake sample from *Trimbak* and *Samadhan* wheat flour was 15.84 and 16.16 g. The addition of different levels of *Moringa* seed oil which effects on weight of cupcake. Weight of cupcake increased as level of MSO increased. Weight of acceptable product (T_5 100 per cent MSO) which can be obtained on basis of sensory parameter was 16.80 and 17.18 g respectively and mean weight showed 16.99 g.

The combined effect of wheat variety with different levels of *Moringa* seed oil (MSO) showed mean weight of cupcake 16.46 g. The induced in weight of cupcake after adding *Moringa* seed oil may be due to oil keep product moist.

Volume

The volume of control cupcake prepared from *Trimbak* and *Samadhan* wheat flour was 22.12 and 22.62 cm^3 respectively and showed mean volume of cupcake was 22.37 cm^3. The volume of optimized product 23.75 cm^3 (*Trimbak*) and 24.48 cm^3 (*Samadhan*) and the mean 24.12 cm^3. The combined effect of wheat variety and with different level of *Moringa* seed oil showed mean volume of cupcake was 22.47 cm^3.

Bulk density

The bulk density was measured by the weight of cupcake to the volume of cupcake. The bulk density of control cupcake prepared from *Trimbak* and *Samadhan* wheat flour was 0.716 g/cm^3 and 714 g/cm^3 respectively. The bulk density of optimized product 0.707 g/cm^3 (*Trimbak*) and 0.702 g/cm^3 (*Samadhan*) and the mean 0.704 g/cm^3. The combined effect of wheat variety and with different level of *Moringa* seed oil (MSO) showed mean volume of cupcake was 0.733 g/cm^3. The treatment T_5 was statistically superior among all over treatment (Table 51).

Specific volume

The specific volume was measured by the volume of cupcake to the weight of cupcake. The specific volume of control cupcake prepared from *Trimbak* and *Samadhan* wheat flour was 1.396 cm^3/g and 1.399 cm^3/g respectively. The specific volume of optimized product 1.413 cm^3/g (*Trimbak*) and 1.425 cm^3/g (*Samadhan*) and the mean specific volume of optimized product 1.419 cm^3/g. The combined effect of wheat variety and with different level of *Moringa* seed oil showed mean specific volume of cupcake

Table 4.47 Physical parameter of cupcake affected by wheat variety flour with the different level of *Moringa* seed oil

No.	Treatment	Weight (g)			Volume (cm^3)			Bulk density (g/cm^3)			Specific volume (cm^3/g)			Height (cm)		
		V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_0	Control	15.84	16.16	16.00	22.12	22.62	22.37	0.716	0.714	0.715	1.396	1.399	1.397	3.24	3.31	3.28
T_1	20 % MSO	15.97	16.29	16.13	21.03	21.18	21.11	0.759	0.769	0.764	1.316	1.300	1.308	3.30	3.37	3.34
T_2	40 % MSO	16.11	16.54	16.33	21.52	21.59	21.56	0.748	0.766	0.757	1.335	1.305	1.320	3.34	3.42	3.38
T_3	60 % MSO	16.28	16.78	16.53	21.96	22.32	22.14	0.741	0.752	0.746	1.348	1.330	1.339	3.42	3.51	3.47
T_4	80 % MSO	16.56	17.00	16.78	23.37	23.65	23.51	0.708	0.719	0.713	1.411	1.391	1.401	3.50	3.58	3.54
T_5	100 % MSO	16.80	17.18	16.99	23.75	24.48	24.12	0.707	0.702	0.704	1.413	1.425	1.419	3.54	3.63	3.59
	Mean	16.26	16.66	16.46	22.29	22.64	22.47	0.729	0.737	0.733	1.369	1.358	1.364	3.39	3.47	3.43
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.002	0.005	0.021	0.002	0.007	0.026	0.0002	0.001	0.003	0.001	0.001	0.006	0.001	0.003	0.014
	CD @ 5%	0.005	0.015	0.060	0.006	0.19	0.076	0.001	0.002	0.007	0.001	0.004	0.017	0.003	0.010	NS

Each value represents the average of three determination. V_1 = *Trimbak* V_2 = *Samadhan*, MSO = *Moringa* seed oil, NS = Non-significant was 1.364 cm^3/g. The treatment T_0 was statistically superior among all over treatment. The specific volume is inversely proportional to weight.

Height

Height of control cupcake prepared from *Trimbak* and *Samadhan* wheat flour was 3.24 and 3.31 cm respectively and mean height of control cupcake was 3.28 cm. The T_5 was significantly different for height as compare overall treatments. The optimized product had height 3.54 cm (*Trimbak*) and 3.63 cm (*Samadhan*) and the mean height of cupcake was 3.59 cm. The combined effect of wheat variety and with different level of *Moringa* seed oil (MSO) showed cupcake mean height of 3.43 cm.

4.8.2.2 Physical parameter of cupcake affected by wheat variety flour with the different level of defatted *Moringa* seed flour

The data about physical parameter of biscuits incorporated with different levels of defatted *Moringa* seed flour (DMSF) is shown in Table 4.48. The significance of addition of defatted *Moringa* seed flour on physical properties such as weight, volume, bulk density, spread volume and height were determined.

Weight

The addition of different levels of defatted *Moringa* seed flour which effects on weight of cupcake. Weight of cupcake decreased a s level of DMSF increased. Weight of optimized product prepared from *Trimbak* and *Samadhan* (T_1 5 per cent DMSF) which can be obtained on basis of sensory parameter was 15.80 and 16.05 g respectively and mean weight showed 15.93 g.

The combined effect of wheat variety with different levels of defatted *Moringa* seed flour showed mean weight of cupcake 15.66 g. The reduction in weight of cupcake after adding defatted *Moringa* seed flour may be due to unable to water absorption of DMSF.

Volume

The volume of control cupcake prepared from *Trimbak* and *Samadhan* wheat flour was 22.12 and 22.62 cm^3 respectively and showed mean volume of cupcake was 22.37 cm^3. The volume of optimized product (5 % DMSF) 22.04 cm^3 (*Trimbak*) and 22.40 cm^3 (*Samadhan*) and the mean 22.22 cm^3. The combined effect of wheat variety and with different level of defatted *Moringa* seed flour showed mean volume of cupcake was 21.79 cm^3. Banks *et al.* (1997) observed that a significant decrease in baked volume of muffins made with de-oiled soy flour.

Table 4.48 Physical parameter of cupcake affected by wheat variety flour with the different level of defatted *Moringa* seed flour

No.	Treatment	Weight (g)			Volume (cm^3)			Bulk density (g/cm^3)			Specific volume (cm^3/g)			Height (cm)		
		V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_0	Control	15.84	16.16	16.00	22.12	22.62	22.37	0.716	0.714	0.715	1.396	1.399	1.398	3.24	3.31	3.28
T_1	5 % DMSF	15.80	16.05	15.93	22.04	22.4	22.22	0.717	0.716	0.716	1.394	1.395	1.395	2.90	3.28	3.09
T_2	10 % DMSF	15.72	15.88	15.80	21.87	22.13	22.00	0.719	0.717	0.718	1.391	1.393	1.392	2.93	3.11	3.02
T_3	15 % DMSF	15.56	15.69	15.63	21.60	21.82	21.71	0.720	0.719	0.720	1.388	1.390	1.389	2.79	2.88	2.84
T_4	20 % DMSF	15.38	15.45	15.42	21.33	21.45	21.39	0.721	0.720	0.721	1.386	1.388	1.387	2.65	2.76	2.71
T_5	25 % DMSF	15.16	15.28	15.22	20.98	21.15	21.07	0.723	0.722	0.723	1.383	1.384	1.384	2.48	2.62	2.55
	Mean	15.58	15.75	15.66	21.66	21.93	21.79	0.719	0.718	0.719	1.389	1.391	1.390	2.83	2.99	2.91
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.001	0.005	0.019	0.001	0.004	0.017	0.0001	0.0004	0.002	0.0001	0.0004	0.002	0.005	0.016	0.065
	CD @ 5%	0.005	0.013	0.054	0.004	0.012	0.049	NS	0.001	NS	NS	0.001	NS	0.015	0.047	NS

Each value represents the average of three determination. $\mathbf{V_1}$ = *Trimbak* $\mathbf{V_2}$ = *Samadhan*, DMSF = Defatted *Moringa* seed flour, NS = Non-significant

Bulk density

The bulk density of control cupcake prepared from *Trimbak* and *Samadhan* wheat flour was 0.716 and 0.714 g/cm^3 respectively. The bulk density of optimized product prepared from *Trimbak* and *Samadhan* was 0.717 and 0.716 g/cm^3. The combined effect of wheat variety and with different level of defatted *Moringa* seed flour (DMSF) showed mean volume of cupcake was 0.719 g/cm^3. The treatment T_5 was statistically superior for bulk density among all over treatment.

Specific volume

The specific volume of control cupcake prepared from *Trimbak* and *Samadhan* wheat flour was 1.396 and 1.399 cm^3/g, respectively. The specific volume of optimized product prepared from *Trimbak* and *Samadhan* was 1.394 and 1.395 cm^3/g. The combined effect of wheat variety and with different level of defatted *Moringa* seed flour (DMSF) showed mean volume of cupcake was 1.390 cm^3/g. The treatment T_0 was statistically superior among all over treatments. Results are in line with those observed by Yadav *et al.* (2013) who reported that specific volume of bread decreased significantly with incorporation of de-oiled peanut flour (Table 52).

Height

Height of control cupcake prepared from *Trimbak* and *Samadhan* wheat flour was 3.24 and 3.31 cm respectively and mean height of control cupcake was 3.28 cm. The T_0 was statistically significant for height as compare overall treatments. The optimized product had height 2.90 cm (*Trimbak*) and 3.28 cm (*Samadhan*) and the mean height of cupcake was 3.09cm. The combined effect of wheat variety and with different level of defatted *Moringa* seed flour showed cupcake mean height of 2.91 cm.

4.8.3 Chemical composition of cupcake

4.8.3.1 Chemical composition of cupcake incorporated with *Moringa* seed oil

Effects of different levels of *Moringa* seed oil on proximate composition of cupcake showed that with increase in MSO level in cupcake slightly affects on chemical composition of cupcake significantly (Table 4.49).

Moisture

The moisture content of cupcake prepared from *Trimbak* and *Samadhan* wheat flour for T_0 was 21.55 and 21.38 per cent respectively and showed mean moisture content of 21.47 per cent. There was a significant change in moisture.

Table 4.49 Proximate composition of cupcake affected by wheat variety with incorporation of *Moringa* seed oil

No.	Treatment	Moisture (%)			Protein (%)			Fat (%)			Crude fibre (%)			Ash (%)			Carbohydrate (%)		
		V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_0	Control	21.55	21.38	21.47	9.31	9.35	9.33	32.70	32.15	32.43	0.32	0.48	0.40	1.16	1.33	1.25	34.96	35.31	35.14
T_1	20 % MSO	21.07	20.87	20.97	9.65	9.71	9.68	32.85	32.33	32.59	0.29	0.41	0.35	1.28	1.47	1.38	34.86	34.46	34.66
T_2	40 % MSO	20.71	20.55	20.63	10.18	10.29	10.24	33.11	32.58	32.85	0.28	0.37	0.33	1.31	1.49	1.40	34.41	34.72	34.57
T_3	60 % MSO	20.45	20.27	20.36	10.45	10.61	10.53	33.28	32.72	33.00	0.23	0.38	0.31	1.35	1.54	1.45	34.24	34.48	34.36
T_4	80 % MSO	20.13	19.93	20.03	10.81	11.03	10.92	33.47	32.86	33.17	0.26	0.40	0.33	1.40	1.58	1.49	33.93	34.20	34.07
T_5	100 % MSO	19.79	19.58	19.69	11.41	11.68	11.55	33.62	32.98	33.30	0.28	0.42	0.35	1.44	1.63	1.54	33.46	33.71	33.59
	Mean	20.62	20.43	20.52	10.30	10.45	10.37	33.17	32.60	32.89	0.28	0.41	0.34	1.32	1.51	1.42	34.31	34.48	34.40
	Factor	**V**	**T**	**V ×T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.001	0.004	0.018	0.001	0.004	0.017	0.001	0.004	0.017	0.001	0.004	0.017	0.001	0.004	0.017	0.017	0.053	0.213
	CD @ 5%	0.004	0.013	NS	0.004	0.012	0.050	0.004	0.012	0.050	0.004	0.012	NS	0.004	0.012	NS	NS	0.153	NS

Each value represents the average of three determination. V_1 = *Trimbak*, V_2 = *Samadhan*, MSO = *Moringa* seed oil, NS = Non-significant

The moisture content of cupcake ranges from 19.79 to 21.55 per cent (*Trimbak*) and 19.58 to 21.38 per cent (*Samadhan*). The moisture content of cupcake ranges of mean from 19.69 to 21.47 per cent. The combined effect of wheat variety with different levels of *Moringa* seed oil showed mean moisture 20.52 per cent.

Protein

There was a significant change in protein content among the treatments. The protein content of cupcake from *Trimbak* and *Samadhan* wheat flour for T_0 was 9.31 and 9.35 per cent, respectively. T_5 showed statistically significant for protein content 11.41 per cent (*Trimbak*) and 11.68 per cent (*Samadhan*) (Table 4.49).

The combined effect of wheat variety and different levels of *Moringa* seed oil showed mean protein content of 10.37 per cent. Similar finding were also reported by Khaled *et al.* (2017).

Fat

There were significant changes among the treatments. The fat content for T_0 was 32.70 per cent (*Trimbak*), 32.15 per cent (*Samadhan*) and showed mean fat content of 32.43 per cent. The fat content of cupcake ranges from 32.70 to 33.62 per cent (*Trimbak*), 32.15 to 32.98 per cent (*Samadhan*) and fat content of cupcake ranges of mean from 32.43 to 33.30 per cent.

The combined effects of wheat variety and different levels of *Moringa* seed oil showed mean fat content of 32.89 per cent.

Crude fibre

The crude fibre content of cupcake from *Trimbak* and *Samadhan* wheat flour for treatment T_0 was 0.32 and 0.48 per cent and showed mean value 0.40 per cent.

The fibre content of cupcake ranges from 0.23 to 0.32 per cent (*Trimbak*) and 0.37 to 0.48 per cent (*Samadhan*). The Fibre content of cupcake ranges of mean from 0.31 to 0.40 per cent. The combined effect of wheat variety and different levels of *Moringa* seed oil showed mean crude fibre 0.34 per cent. The present findings are in conformity with reported results of Sharoon *et al.* (2014).

Ash

Ash content of cupcake from *Trimbak* and *Samadhan* wheat flour for treatment T_0 was 1.16 and 1.33 per cent and showed mean ash content of 1.25 per cent.

The ash content of cupcake ranges from 1.16 to 1.44 per cent (*Trimbak*) and 1.33 to 1.63 per cent (*Samadhan*). The ash content of cupcake ranges of mean from 1.25 to 1.54 per cent. The combined effect of wheat variety and different levels of *Moringa* seed oil showed mean ash content of 1.42 per cent.

Carbohydrate

The carbohydrate content of cupcake from *Trimbak* and *Samadhan* wheat flour for treatment T_0 was 34.96 and 35.31 per cent and showed mean carbohydrate content 35.14 per cent.

There was significantly different in carbohydrate content among the treatments. The carbohydrate content of cupcake ranged from 33.46 to 34.96 per cent (*Trimbak*) and 33.71 to 35.31 per cent (*Samadhan*). The carbohydrate content of cupcake ranged of mean from 33.59 to 35.14 per cent. The combined effect of wheat variety and different levels of *Moringa* seed oil showed mean carbohydrate of 34.40 per cent.

4.8.3.2 Chemical composition of cupcake incorporated with defatted *Moringa* seed flour

Effects of different levels of defatted *Moringa* seed flour (DMSF) on proximate composition of cupcake. The results obtained in this investigation the proximate composition of cupcake like moisture, fat, protein, crude fibre, ash and carbohydrate are presented in Table 4.50. The observation for moisture, fat, protein, crude fibre, ash and carbohydrate of cupcake showed statistically significant difference among the variety and treatments.

Moisture

The moisture content cupcake prepared from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 21.55 and 21.38 per cent respectively and showed the mean moisture content of 21.47 per cent (Table 4.50). There was significant changes in moisture content T_0 is significantly superior than all over treatments.

The moisture content of cupcake decreased with incremental addition of level of defatted *Moringa* seed flour. The moisture content of optimized product T_1 was 21.23 per cent (*Trimbak*) and 20.89 per cent (*Samadhan*) and observed the mean moisture content of 21.06 per cent. The combined effect of wheat variety and different levels of defatted *Moringa* seed flour recorded mean moisture content of 20.58 per cent. Islamiyat *et al.* (2019) reported *Moringa* seed powder addition significantly decreased moisture (22.90–20.01 %) in bread.

Table 4.50 Proximate composition of cupcake affected by wheat variety with incorporation of defatted *Moringa* seed flour

No.	Treatment	Moisture (%)			Protein (%)			Fat (%)			Crude fibre (%)			Ash (%)			Carbohydrate (%)		
		V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_0	Control	21.55	21.38	21.47	9.31	9.35	9.33	32.70	32.15	32.43	0.32	0.48	0.40	1.16	1.33	1.25	34.96	35.31	35.14
T_1	5 % DMSF	21.23	20.89	21.06	10.43	10.58	10.51	31.68	31.22	31.45	0.80	0.92	0.86	1.52	1.68	1.60	34.34	34.71	34.52
T_2	10 % DMSF	20.85	20.51	20.68	12.09	12.21	12.15	31.32	30.74	31.03	1.29	1.40	1.35	1.89	2.03	1.96	32.56	33.11	32.84
T_3	15 % DMSF	20.62	20.19	20.41	13.32	13.53	13.43	30.62	30.07	30.35	1.75	1.87	1.81	2.25	2.37	2.31	31.44	31.97	31.71
T_4	20 % DMSF	20.34	19.81	20.08	14.60	15.07	14.84	30.16	29.81	29.99	2.22	2.36	2.29	2.61	2.75	2.68	30.06	30.20	30.13
T_5	25 % DMSF	20.04	19.53	19.79	16.21	16.66	16.44	29.54	29.13	29.34	2.74	2.85	2.80	2.91	3.10	3.00	28.57	28.73	28.65
	Mean	20.77	20.39	20.58	12.66	12.90	12.78	31.00	30.52	30.76	1.52	1.65	1.58	2.06	2.21	2.13	31.99	32.34	32.16
	Factor	**V**	**T**	**V ×T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.001	0.004	0.017	0.001	0.004	0.017	0.001	0.004	0.018	0.001	0.004	0.018	0.001	0.004	0.019	0.001	0.004	0.019
	CD @ 5%	0.004	0.012	0.051	0.004	0.012	0.048	0.004	0.013	0.052	0.004	0.013	NS	0.004	0.013	NS	0.004	0.014	0.056

Each value represents the average of three determination. V_1 = *Trimbak*, V_2 = *Samadhan*, DMSF = Defatted *Moringa* seed flour, NS = Non-significant

Protein

The protein content of cupcake from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 9.31 and 9.35 per cent respectively and observed the mean protein content of 9.33 per cent. There was increased in protein content as defatted *Moringa* seed flour level increased.

The protein content of optimized product T_1 was 10.43 per cent (*Trimbak*) and 10.58 per cent (*Samadhan*) and recorded mean protein content in cupcake was 10.51 per cent. The combined effect of wheat variety and different levels of defatted *Moringa* seed flour found the mean protein content of 12.78 per cent. Mirsaeedghazi *et al.* (2008) reported that increase of protein in dough causes greater consistency of dough. The interactions (including physical and chemical forces) among protein molecules play key role on the rheological properties (Shiau and Yeh, 2001). Ogunsina *et al.* (2011) reported replacing wheat flour with 10 per cent debittered *Moringa* seed in bread with had more protein. Results are comparable with those reported by Yadav *et al.* (2013) who observed the increase in protein content upon incorporation of de-oiled peanut meal into bread.

Fat

The fat content of cupcake from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 32.70 and 32.15 per cent respectively and the results of mean fat content of 32.43 per cent. There was decreased in fat content with increased the levels of defatted *Moringa* seed flour.

The treatment T_0 was statistically higher for fat content followed by T_1 and at par with T_2. The fat content of optimized product T_1 was 31.68 per cent (*Trimbak*) and 31.22 per cent (*Samadhan*) and resulted the mean fat content of 31.45 per cent. The combined effect of wheat variety and different levels of defatted *Moringa* seed flour showed mean fat content of 30.76 per cent (Table 4.50).

Crude fibre

The crude fibre content of cupcake prepared from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 0.32 and 0.48 per cent and showed mean crude fibre content of 0.40 per cent. The crude fibre content of cupcake increased as the level of defatted *Moringa* seed flour increased.

The crude fibre content of optimized product T_1 was 0.80 per cent (*Trimbak*) and 0.92 per cent (*Samadhan*) and observed the mean crude fibre content of 0.86 per cent.

The combined effect of wheat variety and different level of defatted *Moringa* seed flour showed crude fibre content of 1.58 per cent. Chinma *et al.* (2014) investigated the effects of substituting germinated *Moringa* seed flour for wheat flour increased crude fiber contents of cakes from 0.71 to 2.52 per cent. Mahmoud *et al.* (2018) evaluation of cakes containing Treated *Moringa* Seed powder (TMOS) would increase crude fiber content (0.68-1.65 %).

Ash

The ash content of cupcake prepared from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 1.16 and 1.33 per cent and showed mean ash content of 1.25 per cent. The ash content of cupcake increased as increment the level of defatted *Moringa* seed flour.

The ash content of optimized product T_1 was 1.52 per cent (*Trimbak*) and 1.68 per cent (*Samadhan*) and observed the mean ash content of 1.60 per cent. The combined effect of wheat variety and different level of defatted *Moringa* seed flour showed ash content of 2.13 per cent. Mahmoud *et al.* (2018) evaluation of cakes containing Treated *Moringa* Seed powder (TMOS) would increase total ash (1.06-1.97 %),

Carbohydrate

The carbohydrate content of cupcake prepared from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 34.96 and 35.31 per cent and showed mean carbohydrate content of 35.14 per cent. The carbohydrate content of cupcake decreased as the level of defatted *Moringa* seed flour increased.

The carbohydrate content of optimized product T_1 was 34.34 per cent (*Trimbak*) and 34.71 per cent (*Samadhan*) and observed the mean carbohydrate content of 34.52 per cent. The combined effect of wheat variety and different level of defatted *Moringa* seed flour showed carbohydrate content of 32.16 per cent. Chinma *et al.* (2014) reported substitution of the germinated *Moringa* flours for wheat flour carbohydrate content decreased from 65.40 to 51.08 per cent. Islamiyat *et al.* (2019) reported that *moringa* seed powder addition decreased carbohydrates content (57.68-46.73 %) of bread.

4.8.4 Mineral Composition of Cupcake

4.8.4.1 Mineral composition of cupcake incorporated with *Moringa* seed oil

It was observed from Table 4.51 that with increased the level of *Moringa* seed oil (MSO) in biscuits, does not affects mineral composition of biscuits. The slight non-significant change in calcium, phosphorus, iron and zinc was observed.

Calcium

Calcium content of cupcake from *Trimbak* and *Samadhan* wheat flour in ranged from 79.74 to 79.81 mg/100g and 88.27 to 88.30 mg/100g, respectively. The mean calcium content in ranged from 84.01 to 84.06 mg/100g. The combined effect of wheat variety and different level of *Moringa* seed oil showed mean calcium content in cupcake of 84.03 mg/100g (Table 4.51).

Phosphorus

Phosphorus content of cupcake from *Trimbak* and *Samadhan* wheat flour in ranged from 172.20 to 172.30 mg/100g and 179.54 to 180.50 mg/100g, respectively. The mean phosphorus content in biscuits ranged from 175.87 to 176.40 mg/100g. The combined effect of wheat variety and different level of *Moringa* seed oil showed mean phosphorus content of 176.16 mg/100g.

Iron

There was slight significant change in iron content. Iron content of cupcake from *Trimbak* and *Samadhan* wheat flour in ranged from 5.38 to 5.46 mg/100g and 4.21 to 4.27 mg/100g, respectively. The mean iron content in cupcake ranged from 4.80 to 4.87 mg/100g. The combined effect of wheat variety and different level of *Moringa* seed oil showed mean iron content of 4.83 mg/100g.

Zinc

Zinc content of cupcake from *Trimbak* and *Samadhan* wheat flour in ranged from 1.17 to 1.23 mg/100g and 1.42 to 1.45 mg/100g, respectively. The mean zinc content of cupcake in ranged from 1.30 to 1.34 mg/100g. The combined effect of wheat variety and different level of *Moringa* seed oil showed mean zinc content of 1.31 mg/100g.

Table 4.51 Mineral content of cupcake affected by wheat variety with incorporation of *Moringa* seed oil

No.	Treatment	Calcium (mg/100 g)			Phosphorus (mg/100 g)			Iron (mg/100 g)			Zinc (mg/100 g)		
		V_1	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**
T_0	Control	79.81	88.30	84.06	172.30	180.50	176.40	5.46	4.27	4.87	1.23	1.45	1.34
T_1	20 % MSO	79.79	88.29	84.04	172.26	180.44	176.35	5.43	4.26	4.85	1.21	1.44	1.33
T_2	40 % MSO	79.76	88.28	84.02	172.23	180.29	176.26	5.40	4.24	4.82	1.19	1.43	1.31
T_3	60 % MSO	79.75	88.27	84.01	172.20	179.54	175.87	5.38	4.21	4.80	1.19	1.42	1.31
T_4	80 % MSO	79.74	88.29	84.02	172.24	179.81	176.03	5.39	4.23	4.81	1.17	1.42	1.30
T_5	100 % MSO	79.75	88.29	84.02	172.25	179.87	176.06	5.40	4.25	4.83	1.18	1.44	1.31
	Mean	79.77	88.29	84.03	172.25	180.08	176.16	5.41	4.24	4.83	1.20	143	131
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.001	0.003	0.012	0.001	0.004	0.016	0.001	0.004	0.016	0.001	0.003	0.012
	CD @ 5%	0.003	0.009	NS	0.004	0.012	0.048	0.003	0.011	NS	0.003	0.009	NS

Each value represents the average of three determination. **V_1 =** *Trimbak*, **V_2 =** *Samadhan*, MSO = *Moringa* seed oil, NS = Non-significant

4.8.4.2 Mineral composition of cupcake incorporated with defatted *Moringa* seed flour

The cupcake were prepared from *Trimbak* and *Samadhan* wheat flour with addition of different levels of defatted *Moringa* seed flour and evaluated for calcium, phosphorus, iron and zinc. The results (Table 4.52) obtained for calcium, phosphorus, iron and zinc of cupcake prepared with addition of defatted *Moringa* seed flour showed significant difference for calcium, phosphorus, iron and zinc among all treatments and non-significant among the interaction of variety and treatments.

Calcium

The calcium content of cupcake prepared from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 79.81 and 88.30 mg/100g, respectively and showed the mean calcium content of 84.05 mg/100g. The calcium content in cupcake ranged from 79.81 to 137.89 mg/100g (*Trimbak*) and 88.30 to 144.28 mg/100g (*Samadhan*) and the mean calcium content of cupcake ranged from 84.05 to 141.08 mg/100g (Table 4.52).

Increased calcium content was observed with increase in concentration of defatted *Moringa* seed flour. The calcium content of optimized product treatment T_1 was 91.41 mg/100 g (*Trimbak*) and 99.48 mg/100 g (*Samadhan*) and observed mean calcium content of cupcake was 95.45 mg/100g.

The combined effect of wheat variety and different level of defatted *Moringa* seed flour (DMSF) showed mean calcium content of 112.56 mg/100 g. Chinma *et al.* (2014) reported that substitution of the germinated *Moringa* flours for wheat flour increased calcium content 48.29 to 54.56 mg/100g. Muhammad *et al.* (2016) reported that 16 per cent of defatted sesame meal on mineral composition of bread were found calcium (91.72 mg/100g).

Phosphorus

The phosphorus content of cupcake prepared from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 172.30 and 180.50 mg/100g, respectively and showed the mean phosphorus content of 176.40 mg/100 g. Treatment T_5 was statistically superior in phosphorus content over all other treatments.

The data revealed that phosphorus content in cupcake ranged from 172.30 to 196.72 mg/100 g (*Trimbak*) and 180.50 to 202.87 mg/100 g (*Samadhan*) and the mean phosphorus content of cupcake ranged from 176.40 to 199.80 mg/100g. The phosphorus content of optimized product treatment T_1 was 177.18 mg/100g (*Trimbak*) and 184.97 mg/100g (*Samadhan*) and observed mean phosphorus content of cupcake was 181.08 mg/100g (Table 4.52).

The combined effect of wheat variety and different level of defatted *Moringa* seed flour showed mean phosphorus content of 188.36 mg/100 g. Islamiyat *et al.* (2019) reported that *Moringa* seed powder addition significantly increased the mineral contents phosphorus.

Iron

The iron content of cupcake prepared from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 5.46 and 4.27 mg/100 g, respectively and showed the mean value iron content of 4.87 mg/100 g. Iron content in cupcake prepared with treatment T_5 was significantly higher than over all other treatments.

It was observed that iron content of cupcake ranged from 5.46 to 8.47 mg/100 g (*Trimbak*) and 4.27 to 7.58 mg/100 g (*Samadhan*) whereas the ranged of mean iron content of cupcake from 4.87 to 8.02 mg/100 g. The iron content of optimized product treatment T_1 was 6.06 mg/100 g (*Trimbak*) and 4.93 mg/100 g (*Samadhan*) and observed mean iron content of cupcake was 5.50 mg/100 g (Table 4.52).

The combined effect of wheat variety and different level of defatted *Moringa* seed flour showed mean iron content of cupcake 6.44 mg/100 g. Chinma *et al.* (2014) reported substitution of the germinated *Moringa* flours for wheat flour increased iron content 2.95 to 7.88 mg/100 g. Islamiyat *et al.* (2019) reported that *Moringa* seed powder addition significantly increased the mineral contents iron.

Zinc

The zinc content of cupcake prepared from *Trimbak* and *Samadhan* wheat flour without defatted *Moringa* seed flour was 1.23 and 1.45 mg/100 g respectively. Zinc content of cupcake ranged from 1.23 to 1.98 mg/100 g (*Trimbak*) and 1.45 to 2.15 mg/100 g (*Samadhan*) whereas the data observed ranged of mean zinc content from 1.34 to 2.06 mg/100 g. The zinc content of optimized product treatment T_1 was 1.30 mg/100g (*Trimbak*) and 1.58 mg/100 g (*Samadhan*) and observed mean zinc content of cupcake was 1.44 mg/100g (Table 4.52).

Table 4.52 Mineral content of cupcake affected by wheat variety with incorporation of defatted *Moringa* seed flour

No.	Treatment	Calcium (mg/100 g)			Phosphorus (mg/100 g)			Iron (mg/100 g)			Zinc (mg/100 g)		
		V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_0	Control	79.81	88.30	84.05	172.30	180.50	176.40	5.46	4.27	4.87	1.23	1.45	1.34
T_1	5 % DMSF	91.41	99.48	95.45	177.18	184.97	181.08	6.06	4.93	5.50	1.30	1.58	1.44
T_2	10 % DMSF	103.03	110.61	106.82	182.07	189.45	185.76	6.66	5.59	6.13	1.53	1.73	1.63
T_3	15 % DMSF	114.66	121.89	118.28	186.95	193.92	190.44	7.27	6.25	6.76	1.68	1.86	1.77
T_4	20 % DMSF	126.29	133.05	129.67	195.04	198.40	196.72	7.87	6.91	7.39	1.83	2.01	1.92
T_5	25 % DMSF	137.89	144.28	141.08	196.72	202.87	199.80	8.47	7.58	8.02	1.98	2.15	2.06
	Mean	108.85	116.27	112.56	185.04	191.69	188.36	6.96	5.92	6.44	1.59	1.80	1.69
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.258	0.774	3.098	0.404	1.212	4.848	0.014	0.044	0.177	0.0038	0.011	0.046
	CD @ 5%	0.740	2.221	NS	1.158	3.476	NS	0.042	0.127	NS	0.011	0.033	NS

Each value represents the average of three determination. V_1 = *Trimbak* V_2 = *Samadhan*, DMSF = Defatted *Moringa* seed flour, NS = Non-significant

The combined effect of wheat variety and different level of defatted *Moringa* seed flour cupcake showed mean zinc content of 1.69 mg/100g. Chinma *et al.* (2014) reported substitution of the germinated *Moringa* flours for wheat flour increased zinc content 0.86 to 1.44 mg/100 g.

4.8.5 Textural Characteristics of Cupcake

Springiness signifies that the product retained its original shape once compressed. In general, both, springiness and cohesiveness could be indicative of an increase in bond formation within the three-dimensional protein network in cakes. Springiness of cupcake provide information about texture. Present investigation showed very good structure of cupcake with *Moringa* seed oil and defatted *Moringa* seed flour.

4.8.5.1 Springiness of cupcake affected by wheat variety flour with the different level of *Moringa* seed oil

Results showed that springiness of cupcake prepared from *Trimbak* and *Samadhan* wheat flour with *Moringa* seed oil was presented in Table 4.53 and Fig. 4.56-4.67.

The springiness of cupcake prepared from *Trimbak* and *Samadhan* wheat flour for control T_0 was 1.50 and 1.56 mm, respectively and mean of springiness for control was 1.53 mm. The springiness of cupcake increased as the level of *Moringa* seed oil increased. Oil keep product moist. Basically, captures the gases that are released from the interaction of baking powder and baking soda and slow down the gluten formation to keep cupcake tender and fluffy. T_5 was statistically significant for springiness among all over treatments (Table 4.53).

Springiness signifies that the product retained its original shape once compressed and the ranges for cupcakes were 1.50 to 1.85 mm (*Trimbak*) and 1.56 to 2.78 mm (*Samadhan*). The combined effect of wheat flour and different level of *Moringa* seed oil (MSO) showed mean value for springiness was 1.93 mm. Yadav *et al.,* (2013) observed the similar results.

Kaur *et al.* (2014) reported that the replace bakery shortening with refined rice bran oil in the preparation of muffins. The force required to compress the muffins was minimum (176.56 g) in case of muffins prepared by replacing bakery shorting with rice bran oil at 100 % replacement level and maximum in control (186.26 g) muffins prepared with 100 % bakery shortening.

Table 4.53 Springiness of cupcake affected by wheat variety flour with the different level of *Moringa* seed oil

No.	Treatment	V_1	V_2	Mean
T_0	Control	1.50	1.56	1.53
T_1	20 % MSO	1.63	1.80	1.72
T_2	40 % MSO	1.85	2.14	2.00
T_3	60 % MSO	1.79	2.40	2.10
T_4	80 % MSO	1.79	2.43	2.11
T_5	100 % MSO	1.54	2.78	2.16
	Mean	1.68	2.19	1.93
	Factor	**V**	**T**	**V × T**
	SE±	0.002	0.005	0.020
	CD @ 5%	0.005	0.014	0.056

All results are mean of three replications. V_1 = *Trimbak* V_2 = *Samadhan*, MSO = *Moringa* seed oil

4.8.5.2 Springiness of cupcake affected by wheat variety flour with the different level of defatted *Moringa* seed flour

Results revealed that the springiness of cupcake prepared from *Trimbak* and *Samadhan* wheat flour with defatted *Moringa* seed flour in Table 4.54 and Fig. 4.68 - 4.77. The springiness of cupcake prepared from *Trimbak* and *Samadhan* wheat flour for control T_0 was 1.50 and 1.56 mm respectively and mean of springiness for control was 1.53 mm. The springiness of cupcake decreased as the level of defatted *Moringa* seed flour (DMSF) increased. T_1 was statistically significant for springiness among all over treatments (Table 4.54).

Springiness signifies that the product retained its original shape once compressed and the ranges for cupcakes were 1.40 to 1.63 mm (*Trimbak*) and 1.42 to 2.66 mm (*Samadhan*). The combined effect of wheat flour and different level of defatted *Moringa* seed flour showed mean value for springiness was 1.74 mm.

Shameena *et al.* (2016) reported that with increasing the level of VCO cake increased the lower springiness values. Springiness of the muffins was also adversely affected by the addition of VCO cake. Lower springiness values obtained for VCO cake-based formulations (0.82, 0.77, 0.72, 0.59 and 0.43 in 10, 20, 30, 40 and 50 g VCO cake-based formulations, respectively) in comparison with the control (0.88).

Table 4.54 Springiness of cupcake affected by wheat variety flour with the different level of defatted *Moringa* seed flour

No.	Treatment	V_1	V_2	Mean
T_0	Control	1.50	1.56	1.53
T_1	5 % DMSF	1.63	2.66	2.15
T_2	10 % DMSF	1.48	2.58	2.03
T_3	15 % DMSF	1.48	1.96	1.72
T_4	20 % DMSF	1.40	1.83	1.62
T_5	25 % DMSF	1.40	1.42	1.41
	Mean	1.48	2.00	1.74
	Factor	**V**	**T**	**V × T**
	SE±	0.002	0.005	0.020
	CD @ 5%	0.005	0.015	0.058

All results are mean of three replications. V_1 = *Trimbak* V_2 = *Samadhan*, DMSF = Defatted *Moringa* seed flour

4.9 Storage Quality of Cupcake

The control cupcake and standardized cupcake from *Trimbak* and *Samadhan* wheat flour, containing 100 per cent *Moringa* seed oil (MSO) and 5 per cent defatted *Moringa* seed flour were packed in LDPE and laminated pouch and stored at ambient temperature for 6 days. The cupcake was evaluated for their sensory and proximate qualities. The results of quality evaluation of biscuits obtained during storage are presented under following captions (Table 4.55-4.59).

4.9.1 Effects of Packaging Material on Changes in Sensory Quality of *Moringa* Seed Oil and Defatted *Moringa* Seed Flour Cupcake During Storage

The cupcakes were evaluated for their sensory qualities at an interval of every 3 days. The results of mean scores for different sensory attributes such as colour and appearance, texture, flavour, taste and overall acceptability of cupcake are presented as referred below (4.55-4.59).

4.9.1.1 Changes in colour and appearance

Score for colour and appearance of *Moringa* seed oil and defatted seed flour cupcake prepared from *Trimbak* and *Samadhan* wheat flour as influenced by storage period and

Table 4.55. Effect of packaging material on changes in colour and appearance of *Moringa* seed oil and defatted seed flour cupcake during storage

No.	Treatment	0 Days	3 Days	6 Days
	Treatment			
T_0	Control	8.16	7.98	7.85
T_1	*Moringa* seed oil	8.41	8.28	8.10
T_2	Defatted *Moringa* seed flour	7.93	7.81	7.67
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Variety			
V_1	*Trimbak* (NIAW-301)	8.12	7.97	7.82
V_2	*Samadhan* (NIAW-1994)	8.21	8.08	7.92
	SE±	0.01	0.01	0.01
	CD @ 5%	NS	0.03	0.03
	Packaging material			
P_1	LDPE	8.16	8.01	7.85
P_2	Laminated pouch	8.17	8.03	7.90
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Interaction			
	$T_0 V_1 P_1$	8.12	7.88	7.78
	$T_0 V_1 P_2$	8.10	7.91	7.84
	$T_0 V_2 P_1$	8.21	8.05	7.89
	$T_0 V_2 P_2$	8.23	8.07	7.92
	$T_1 V_1 P_1$	8.36	8.21	8.02
	$T_1 V_1 P_2$	8.35	8.22	8.07
	$T_1 V_2 P_1$	8.47	8.34	8.14
	$T_1 V_2 P_2$	8.49	8.36	8.17
	$T_2 V_1 P_1$	7.91	7.78	7.62
	$T_2 V_1 P_2$	7.93	7.80	7.65
	$T_2 V_2 P_1$	7.94	7.82	7.69
	$T_2 V_2 P_2$	7.94	7.84	7.74
	SE±	0.01	0.01	0.01
	CD @ 5%	0.04	NS	0.04

Each value represents the average of three determination. NS = Non-significant

packaging material are presented in Table 4.55. A gradual decrease in mean score for colour and appearance of control (*Trimbak*) from 8.12 to 7.78 in LDPE and 8.10 to 7.84 in laminated pouch whereas control (*Samadhan*) from 8.21 to 7.89 in LDPE and 8.23 to 7.92 in laminated pouch was observed for 6th days of storage. The all-interaction effects showed statistically significant among the treatments and packaging material.

The cupcake sample prepared from *Trimbak* wheat flour with MSO showed colour and appearance from 8.36 to 8.02 in LDPE and 8.35 to 8.07 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed colour and appearance from 8.47 to 8.14 in LDPE and 8.49 to 8.17 in laminated pouch. The sample prepared from *Trimbak* wheat flour with DMSF showed colour and appearance from 7.91 to 7.62 in LDPE and 7.93 to 7.65 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed colour and appearance from 7.94 to 7.69 in LDPE and 7.94 to 7.74 in laminated pouch.

The aluminum laminated pouch packed cupcakes showed minimum decrease in appearance due to its higher barrier to moisture. Anu *et al.* (2008) reported similar results after replacing maida with blanched bajra flour and green gram flours at 20:70:10 per cent level respectively in banana enriched sponge cake.

4.9.1.2 Changes in texture

Texture score for *Moringa* seed oil and defatted seed flour cupcake prepared from *Trimbak* and *Samadhan* wheat flour as influenced by storage period and packaging material are presented in Table 4.56. A gradual decrease in mean score for texture of control (*Trimbak*) from 8.13 to 7.73 in LDPE and 8.14 to 7.77 in laminated pouch whereas control (*Samadhan*) from 8.28 to 7.93 in LDPE and 8.29 to 7.94 in laminated pouch was observed for 6th days of storage. The all-interaction effects showed statistically significant among the treatments and packaging material.

The cupcake sample prepared from *Trimbak* wheat flour with MSO showed texture from 8.24 to 7.43 in LDPE and 8.22 to 7.47 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed texture from 8.37 to 7.45 in LDPE and 8.43 to 7.52 in laminated pouch. The sample prepared from *Trimbak* wheat flour with DMSF showed texture from 7.87 to 7.38 in LDPE and 7.88 to 7.40 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed texture from 7.88 to 7.38 in LDPE and 7.88 to 7.44 in laminated pouch.

Table 4.56 Effect of packaging material on changes in texture of *Moringa* seed oil and defatted seed flour cupcake during storage

No.	Factor	0 Days	3 Days	6 Days
	Treatment			
T_0	Control	8.21	8.04	7.84
T_1	*Moringa* seed oil	8.30	7.81	7.47
T_2	Defatted *Moringa* seed flour	7.88	7.65	7.40
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Variety			
V_1	*Trimbak* (NIAW-301)	8.07	7.79	7.53
V_2	*Samadhan* (NIAW-1994)	8.19	7.88	7.61
	SE±	0.01	0.01	0.01
	CD @ 5%	NS	NS	0.03
	Packaging material			
P_1	LDPE	8.13	7.83	7.55
P_2	Laminated pouch	8.13	7.84	7.59
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Interaction			
	T_0 V_1 P_1	8.13	7.95	7.73
	T_0 V_1 P_2	8.14	7.95	7.77
	T_0 V_2 P_1	8.28	8.13	7.93
	T_0 V_2 P_2	8.29	8.15	7.94
	T_1 V_1 P_1	8.24	7.80	7.43
	T_1 V_1 P_2	8.17	7.76	7.47
	T_1 V_2 P_1	8.37	7.81	7.45
	T_1 V_2 P_2	8.43	7.87	7.52
	T_2 V_1 P_1	7.87	7.62	7.38
	T_2 V_1 P_2	7.88	7.65	7.40
	T_2 V_2 P_1	7.88	7.66	7.38
	T_2 V_2 P_2	7.88	7.68	7.44
	SE±	0.02	0.01	0.01
	CD @ 5%	0.06	0.04	0.03

Each value represents the average of three determination. NS = Non-significant

Decreased in texture was observed by changes in level of treatments significantly changes values due to corresponding packaging material whereas nonsignificant reduction was found among wheat variety. The sample packed in laminated pouch showed maximum texture followed by LDPE package on the 6th day of storage (Table 60).

There was gradual decrease in texture score due to hard texture resulting from loss of moisture during storage. Many factors including moisture content affect the firmness of cake. It is generally accepted that water binding capacity of flour accounts for much of the loss of cake moisture during storage.

Gupta and Singh, (2005) also reported changes in texture of biscuits containing quality protein maize, when packed in polyethylene bags and stored at ambient conditions. Sahoo (2010) reported similar sensory score of cake sample prepared with wheat (malted) and finger millet flour (50:50) as that of control.

4.9.1.3 Changes in flavour

Score for flavour of *Moringa* seed oil and defatted seed flour cupcake prepared from *Trimbak* and *Samadhan* wheat flour as influenced by storage period and packaging material are presented in Table 4.57. Decrease in mean score for flavour of control (*Trimbak*) from 8.00 to 7.64 in LDPE and 8.02 to 7.69 in laminated pouch whereas control (*Samadhan*) from 8.24 to 7.91 in LDPE and 8.25 to 7.97 in laminated pouch was observed for 6th days of storage. The all-interaction effects showed among the treatment and packaging material are significant.

The cupcake sample prepared from *Trimbak* wheat flour with MSO showed flavour from 8.30 to 7.49 in LDPE and 8.31 to 7.62 in laminated pouch. The cupcake prepared from *Samadhan* wheat flour with MSO showed flavour from 8.52 to 7.72 in LDPE and 8.53 to 7.76 in laminated pouch. The cupcake prepared from *Trimbak* wheat flour with DMSF showed flavour from 7.75 to 7.45 in LDPE and 7.77 to 7.50 in laminated pouch. The cupcake prepared from *Samadhan* wheat flour with DMSF showed flavour from 7.80 to 7.51 in LDPE and 7.82 to 7.53 in laminated pouch. Decreased in flavour was observed by changes in level of treatment significantly changes values due to corresponding packaging material (Table 4.57).

Sample packed in aluminium laminated pouch showed maximum score for flavour followed by LDPE packages on the 6th day of storage. The flavouring compounds

Table 4.57 Effect of packaging material on changes in flavour of *Moringa* seed oil and defatted seed flour cupcake during storage

No.	Factor	0 Days	3 Days	6 Days
	Treatment			
T_0	Control	8.13	7.96	7.80
T_1	*Moringa* seed oil	8.42	7.78	7.65
T_2	Defatted *Moringa* seed flour	7.78	7.65	7.50
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Variety			
V_1	*Trimbak* (NIAW-301)	8.02	7.71	7.56
V_2	*Samadhan* (NIAW-1994)	8.19	7.88	7.73
	SE±	0.01	0.01	0.01
	CD @ 5%	NS	0.03	0.03
	Packaging material			
P_1	LDPE	8.10	7.77	7.62
P_2	Laminated pouch	8.12	7.82	7.68
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Interaction			
	$T_0 V_1 P_1$	8.00	7.82	7.64
	$T_0 V_1 P_2$	8.02	7.84	7.69
	$T_0 V_2 P_1$	8.24	8.06	7.91
	$T_0 V_2 P_2$	8.25	8.12	7.97
	$T_1 V_1 P_1$	8.30	7.65	7.49
	$T_1 V_1 P_2$	8.31	7.75	7.62
	$T_1 V_2 P_1$	8.52	7.84	7.72
	$T_1 V_2 P_2$	8.53	7.89	7.76
	$T_2 V_1 P_1$	7.75	7.61	7.45
	$T_2 V_1 P_2$	7.77	7.64	7.50
	$T_2 V_2 P_1$	7.80	7.66	7.51
	$T_2 V_2 P_2$	7.82	7.70	7.53
	SE±	0.02	0.01	0.01
	CD @ 5%	NS	0.04	0.04

Each value represents the average of three determination. NS = Non-significant

might be lost at higher rate during storage that lowered the flavour score. The decrease in flavour of cupcakes might be due to the fat oxidation. Gupta and Singh (2005) reported reduced flavour score of maize fortified biscuits during storage. The results obtained in the present investigation are similar to earlier reports. Gund (2019) reported that changes in flavor of multigrain cupcake during 6th day of storage

4.9.1.4 Changes in taste

Score for taste of *Moringa* seed oil and defatted seed flour cupcake prepared from *Trimbak* and *Samadhan* wheat flour as influenced by storage period and packaging material are presented in Table 4.58. A gradual decrease in mean score for taste of control (*Trimbak*) from 8.14 to 7.80 in LDPE and 8.16 to 7.83 in laminated pouch whereas control (*Samadhan*) from 8.26 to 7.88 in LDPE and 8.25 to 7.95 in laminated pouch was observed for 6th days of storage. The all-interaction effects showed statistically significant difference among the treatments and packaging material.

The cupcake prepared from *Trimbak* wheat flour with MSO showed taste from 8.30 to 7.82 in LDPE and 8.31 to 7.89 in laminated pouch. The cupcake prepared from *Samadhan* wheat flour with MSO showed taste from 8.40 to 7.91 in LDPE and 8.40 to 7.94 in laminated pouch. The cupcake prepared from *Trimbak* wheat flour with DMSF showed taste from 7.64 to 7.32 in LDPE and 7.65 to 7.36 in laminated pouch. The cupcake prepared from *Samadhan* wheat flour with DMSF showed taste from 7.70 to 7.50 in LDPE and 7.72 to 7.54 in laminated pouch. Decreased in taste was observed by changes in level of treatment significantly changes values due to corresponding packaging material. The sample packed in laminated pouch showed maximum taste followed by LDPE package on the 6th day of storage (Table 4.58).

Gund (2019) reported scores for taste of multigrain cupcake as influenced by storage period and packaging material.

4.9.1.5 Changes in overall acceptability

Score for overall acceptability of *Moringa* seed oil (MSO) and defatted seed flour (DMSF) cupcake prepared from *Trimbak* and *Samadhan* wheat flour as influenced by storage period and packaging material are presented in Table 4.59. A gradual decrease in mean score for overall acceptability of control (*Trimbak*) from 8.11 to 7.65 in LDPE and 8.11 to 7.67 in laminated pouch whereas control (*Samadhan*) from 8.25 to 7.81 in LDPE and 8.26 to 7.87 in

Table 4.58 Effect of packaging material on changes in taste of *Moringa* seed oil and defatted seed flour cupcake during storage

No.	Factor	0 Days	3 Days	6 Days
	Treatment			
T_0	Control	8.21	8.07	7.86
T_1	*Moringa* seed oil	8.35	8.17	7.89
T_2	Defatted *Moringa* seed flour	7.67	7.57	7.43
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Variety			
V_1	*Trimbak* (NIAW-301)	8.03	7.88	7.67
V_2	*Samadhan* (NIAW-1994)	8.12	8.00	7.79
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Packaging material			
P_1	LDPE	8.07	7.92	7.70
P_2	Laminated pouch	8.09	7.95	7.75
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Interaction			
	T_0 V_1 P_1	8.14	8.02	7.80
	T_0 V_1 P_2	8.16	8.05	7.83
	T_0 V_2 P_1	8.26	8.11	7.88
	T_0 V_2 P_2	8.25	8.12	7.95
	T_1 V_1 P_1	8.30	8.10	7.82
	T_1 V_1 P_2	8.31	8.13	7.89
	T_1 V_2 P_1	8.40	8.22	7.91
	T_1 V_2 P_2	8.40	8.25	7.94
	T_2 V_1 P_1	7.64	7.49	7.32
	T_2 V_1 P_2	7.65	7.50	7.36
	T_2 V_2 P_1	7.70	7.61	7.50
	T_2 V_2 P_2	7.72	7.68	7.54
	SE±	0.01	0.01	0.01
	CD @ 5%	0.04	0.04	0.04

Each value represents the average of three determination. NS = Non-significant

Table 4.59 Effect of packaging material on changes in overall acceptability of *Moringa* seed oil and defatted seed flour cupcake during storage

No.	Factor	0 Days	3 Days	6 Days
	Treatment			
T_0	Control	8.18	7.95	7.75
T_1	*Moringa* seed oil	8.39	8.20	7.90
T_2	Defatted *Moringa* seed flour	7.81	7.65	7.48
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Variety			
V_1	*Trimbak* (NIAW-301)	8.08	7.87	7.65
V_2	*Samadhan* (NIAW-1994)	8.18	7.99	7.77
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Packaging material			
P_1	LDPE	8.13	7.91	7.70
P_2	Laminated pouch	8.13	7.96	7.73
	SE±	0.01	0.01	0.01
	CD @ 5%	NS	0.03	0.03
	Interaction			
	T_0 V_1 P_1	8.11	7.80	7.65
	T_0 V_1 P_2	8.11	7.86	7.67
	T_0 V_2 P_1	8.25	8.06	7.81
	T_0 V_2 P_2	8.26	8.08	7.87
	T_1 V_1 P_1	8.32	8.15	7.85
	T_1 V_1 P_2	8.33	8.18	7.89
	T_1 V_2 P_1	8.46	8.21	7.92
	T_1 V_2 P_2	8.47	8.28	7.94
	T_2 V_1 P_1	7.80	7.61	7.40
	T_2 V_1 P_2	7.81	7.62	7.48
	T_2 V_2 P_1	7.81	7.64	7.52
	T_2 V_2 P_2	7.83	7.72	7.64
	SE±	0.01	0.02	0.02
	CD @ 5%	NS	0.06	0.06

Each value represents the average of three determination. NS = Non-significant

laminated pouch was observed for 90th days of storage. The all-interaction effects showed statistically significant difference among the treatment and packaging material (Table 4.59). The sample prepared from *Trimbak* wheat flour with MSO showed overall acceptability from 8.32 to 7.85 in LDPE and 8.33 to 7.89 in laminated pouch. The cupcake prepared from *Samadhan* wheat flour with MSO showed overall acceptability from 8.46 to 7.92 in LDPE and 8.47 to 7.94 in laminated pouch. The cupcake prepared from *Trimbak* wheat flour with DMSF showed overall acceptability from 7.80 to 7.40 in LDPE and 7.81 to 7.48 in laminated pouch. The cupcake prepared from *Samadhan* wheat flour with DMSF showed overall acceptability from 7.81 to 7.52 in LDPE and 7.83 to 7.64 in laminated pouch (Table 4.59).

It could be observed that overall acceptability decreases progressively during storage in all the packaging materials. Data from Table 4.59 showed that cupcakes packed in aluminum laminated pouch and low density polyethylene (LDPE) exhibited minimum decrease in overall acceptability during 6th days of storage.

Anu *et al.* (2008) reported same results after replacing maida with blanched bajra flour and green gram flours at 20:70:10 per cent level respectively in banana enriched multigrain cake.

4.9.2 Effects of Packaging Material on Changes in Chemical Composition of *Moringa* Seed Oil and Defatted Seed Flour Cupcake During Storage

4.9.2.1 Changes in moisture

Data obtained from Table 4.60 that the moisture decreased for control (*Trimbak*) from 21.53 to 21.45 in LDPE and 21.55 to 21.49 in laminated pouch whereas control (*Samadhan*) from 21.38 to 21.25 in LDPE and 21.38 to 21.30 in laminated pouch was observed for 6 days of storage.

The cupcake prepared from *Trimbak* wheat flour with MSO showed decreased in moisture content from 19.79 to 19.70 in LDPE and 19.77 to 19.71 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed moisture content decreased from 19.58 to 19.43 in LDPE and 19.59 to 19.53 in laminated pouch.

The sample prepared from *Trimbak* wheat flour with DMSF showed decreased in moisture content from 21.32 to 21.24 in LDPE and 21.33 to 21.27 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed moisture decreased from 20.89 to 20.75 in LDPE and 20.87 to 21.81 in laminated pouch. Decrease in moisture content was observed by changes in level of treatments significantly changes

Table 4.60 Effect of packaging material on changes in moisture (%) of *Moringa* seed oil and defatted seed flour cupcake during storage

No.	Factor	0 Days	3 Days	6 Days
	Treatment			
T_0	Control	21.43	21.40	21.37
T_1	*Moringa* seed oil	20.45	20.41	20.37
T_2	Defatted *Moringa* seed flour	20.33	20.28	20.24
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Variety			
V_1	*Trimbak* (NIAW-301)	20.88	20.85	20.81
V_2	*Samadhan* (NIAW-1994)	20.60	20.57	20.51
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.04
	Packaging material			
P_1	LDPE	20.75	20.70	20.64
P_2	Laminated pouch	20.73	20.72	20.68
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Interaction			
	$T_0\ V_1\ P_1$	21.53	21.50	21.45
	$T_0\ V_1\ P_2$	21.55	21.53	21.49
	$T_0\ V_2\ P_1$	21.38	21.36	21.30
	$T_0\ V_2\ P_2$	21.38	21.36	21.25
	$T_1\ V_1\ P_1$	19.79	19.74	19.70
	$T_1\ V_1\ P_2$	19.77	19.74	19.71
	$T_1\ V_2\ P_1$	19.58	19.49	19.43
	$T_1\ V_2\ P_2$	19.59	19.56	19.53
	$T_2\ V_1\ P_1$	21.32	21.29	21.24
	$T_2\ V_1\ P_2$	21.33	21.30	21.27
	$T_2\ V_2\ P_1$	20.89	20.82	20.75
	$T_2\ V_2\ P_2$	20.87	20.83	20.81
	SE±	0.01	0.01	0.01
	CD @ 5%	0.04	0.04	0.04

Each value represents the average of three determination. NS = Non-significant

moisture values due to corresponding packaging material. The sample packed in LDPE showed maximum moisture loss followed by laminated pouch on 6th day of storage. This may be due to higher WVTR and GTR of LDPE than laminated pouch.

A decrease in moisture content of millet based multigrain cake during storage period were reported by Kwaw *et al.* (2013) and Anu *et al.* (2008) reported same results in bajra enriched banana cake.

4.9.2.2 Changes in protein

The result revealed from Table 4.61 that the protein decreased for control (*Trimbak*) from 9.32 to 9.25 in LDPE and 9.31 to 9.26 in laminated pouch whereas control (*Samadhan*) from 9.35 to 9.27 in LDPE and 9.35 to 9.29 in laminated pouch was observed for 90 days of storage.

The cupcake prepared from *Trimbak* wheat flour with MSO showed decreased in protein content from 11.41 to 11.31 in LDPE and 11.43 to 11.36 in laminated pouch. The cupcake prepared from *Samadhan* wheat flour with MSO showed protein content decreased from 11.68 to 11.53 in LDPE and 11.67 to 11.60 in laminated pouch.

The cupcake sample prepared from *Trimbak* wheat flour with DMSF showed decreased in protein content from 10.44 to 10.35 in LDPE and 10.42 to 10.37 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed protein decreased from 10.56 to 10.51 in LDPE and 10.58 to 10.53 in laminated pouch. Decrease in protein content was observed by changes in level of treatments significantly due to change in protein content due to corresponding packaging material and wheat variety. The sample packed in laminated pouch showed maximum protein followed by LDPE on 6th day of storage.

Biradar *et al.* (2020) investigated that the optimum level of little millet flour with wheat flour for the preparation of quality cookies. Protein decreased in ambient temperature during storage period of 3 month. Jemziya and Mahendran (2018) reported that according to DMRTprotein content of cookies decreased significantly throughout storage period.

4.9.2.3 Changes in fat

It was obtained from Table 4.62 that the fat decreased for control (*Trimbak*) from 32.69 to 32.63 in LDPE and 32.70 to 32.64. In laminated pouch whereas control (*Samadhan*) from 32.15 to 32.04 in LDPE and 32.13 to 32.06 in laminated pouch was

Table 4.61 Effect of packaging material on changes in protein (%) of *Moringa* seed oil and defatted seed flour cupcake during storage

No.	Factor	0 Days	3 Days	6 Days
	Treatment			
T_0	Control	9.33	9.30	9.27
T_1	*Moringa* seed oil	11.55	11.50	11.48
T_2	Defatted *Moringa* seed flour	10.50	10.48	10.44
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Variety			
V_1	*Trimbak* (NIAW-301)	10.39	10.36	10.31
V_2	*Samadhan* (NIAW-1994)	10.53	10.49	10.47
	SE±	0.01	0.01	0.01
	CD @ 5%	NS	0.03	NS
	Packaging material			
P_1	LDPE	10.46	10.41	10.39
P_2	Laminated pouch	10.46	10.44	10.41
	SE±	0.01	0.01	0.01
	CD @ 5%	NS	0.03	0.03
	Interaction			
	$T_0 V_1 P_1$	9.32	9.28	9.25
	$T_0 V_1 P_2$	9.31	9.29	9.26
	$T_0 V_2 P_1$	9.35	9.31	9.27
	$T_0 V_2 P_2$	9.35	9.32	9.29
	$T_1 V_1 P_1$	11.41	11.34	11.31
	$T_1 V_1 P_2$	11.43	11.43	11.36
	$T_1 V_2 P_1$	11.68	11.58	11.53
	$T_1 V_2 P_2$	11.67	11.64	11.60
	$T_2 V_1 P_1$	10.44	10.40	10.35
	$T_2 V_1 P_2$	10.42	10.40	10.37
	$T_2 V_2 P_1$	10.56	10.53	10.51
	$T_2 V_2 P_2$	10.58	10.56	10.53
	SE±	0.01	0.01	0.01
	CD @ 5%	0.04	0.04	0.04

Each value represents the average of three determination. NS = Non-significant

Table 4.62 Effect of packaging material on changes in fat (%) of *Moringa* seed oil and defatted seed flour cupcake during storage

No.	Factor	0 Days	3 Days	6 Days
	Treatment			
T_0	Control	32.42	32.38	32.34
T_1	*Moringa* seed oil	33.29	33.24	33.20
T_2	Defatted *Moringa* seed flour	31.45	31.40	31.37
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Variety			
V_1	*Trimbak* (NIAW-301)	32.66	32.62	32.58
V_2	*Samadhan* (NIAW-1994)	32.11	32.06	32.03
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Packaging material			
P_1	LDPE	32.39	32.34	32.29
P_2	Laminated pouch	32.38	32.34	32.31
	SE±	0.01	0.01	0.01
	CD @ 5%	NS	NS	0.03
	Interaction			
	$T_0 V_1 P_1$	32.69	32.67	32.63
	$T_0 V_1 P_2$	32.70	32.68	32.64
	$T_0 V_2 P_1$	32.15	32.08	32.04
	$T_0 V_2 P_2$	32.13	32.09	32.06
	$T_1 V_1 P_1$	33.62	33.52	33.47
	$T_1 V_1 P_2$	33.61	33.57	33.54
	$T_1 V_2 P_1$	32.98	32.95	32.90
	$T_1 V_2 P_2$	32.97	32.94	32.91
	$T_2 V_1 P_1$	31.68	31.63	31.59
	$T_2 V_1 P_2$	31.69	31.64	31.61
	$T_2 V_2 P_1$	31.23	31.16	31.11
	$T_2 V_2 P_2$	31.21	31.18	31.14
	SE±	0.01	0.01	0.02
	CD @ 5%	NS	NS	NS

Each value represents the average of three determination. NS = Non-significant

observed for 6 days of storage. The sample prepared from *Trimbak* wheat flour with MSO showed decreased in fat content from 33.62 to 33.47 in LDPE and 33.61 to 33.54 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed fat content decreased from 32.98 to 32.90 in LDPE and 32.97 to 32.91 in laminated pouch.

The sample prepared from *Trimbak* wheat flour with DMSF showed decreased in fat content from 31.68 to 31.59 in LDPE and 31.69 to 31.61 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed fat decreased from 31.23 to 31.11 in LDPE and 31.21 to 31.14 in laminated pouch. Decrease in fat content was observed by changes in level of treatments significantly wheat variety whereas nonsignificant among packaging material. The interaction effect showed nonsignificant.

The decline in fat content throughout storage might be due to moisture uptake by biscuits from the surrounding air and breakdown of fats to different compound. Abdul *et al.* (2010) reported fat content of linseed cookies at 0 days was 24.18 per cent which decreased thereafter to 24.00 per cent after 45 days of storage.

Gund (2019) reported decrease in fat was ranged from 32.43 to 32.34 per cent at 6^{th} days of storage in cupcake.

4.9.2.4 Changes in crude fibre

The results on change in crude fibre of biscuits as influenced by storage are presented in Table 4.63. It was observed that the crude fibre decreased for control (*Trimbak*) from 0.32 to 0.26 in LDPE and 0.31 to 0.27 in laminated pouch whereas control (*Samadhan*) from 0.48 to 0.41 in LDPE and 0.47 to 0.42 in laminated pouch was observed for 6 days of storage.

The cupcake prepared from *Trimbak* wheat flour with MSO showed decreased in crude fibre content from 0.28 to 0.23 in LDPE and 0.27 to 0.25 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed crude fibre content decreased from 0.42 to 0.36 in LDPE and 0.42 to 0.37 in laminated pouch (Table 4.63).

The sample prepared from *Trimbak* wheat flour with DMSF showed decreased in crude fibre content from 0.80 to 0.72 in LDPE and 0.81 to 0.74 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed crude fibre increased from 0.92 to 0.80 in LDPE and 0.92 to 0.88 in laminated pouch. Significant decrease in crude fibre content was observed for treatments whereas nonsignificant among packaging material and wheat variety.

Table 4.63 Effect of packaging material on changes in crude fibre (%) of *Moringa* seed oil and defatted seed flour cupcake during storage

No.	Factor	0 Days	3 Days	6 Days
	Treatment			
T_0	Control	0.39	0.36	0.34
T_1	*Moringa* seed oil	0.35	0.32	0.30
T_2	Defatted *Moringa* seed flour	0.86	0.83	0.78
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Variety			
V_1	*Trimbak* (NIAW-301)	0.46	0.43	0.41
V_2	*Samadhan* (NIAW-1994)	0.61	0.57	0.54
	SE±	0.01	0.01	0.01
	CD @ 5%	NS	NS	0.03
	Packaging material			
P_1	LDPE	0.54	0.50	0.47
P_2	Laminated pouch	0.53	0.50	0.48
	SE±	0.01	0.01	0.01
	CD @ 5%	NS	NS	NS
	Interaction			
	$T_0 V_1 P_1$	0.32	0.29	0.26
	$T_0 V_1 P_2$	0.31	0.29	0.27
	$T_0 V_2 P_1$	0.48	0.45	0.41
	$T_0 V_2 P_2$	0.47	0.45	0.42
	$T_1 V_1 P_1$	0.28	0.25	0.23
	$T_1 V_1 P_2$	0.27	0.26	0.25
	$T_1 V_2 P_1$	0.42	0.39	0.36
	$T_1 V_2 P_2$	0.42	0.40	0.37
	$T_2 V_1 P_1$	0.80	0.75	0.72
	$T_2 V_1 P_2$	0.81	0.77	0.74
	$T_2 V_2 P_1$	0.92	0.87	0.80
	$T_2 V_2 P_2$	0.92	0.91	0.88
	SE±	0.01	0.01	0.01
	CD @ 5%	NS	0.04	0.04

Each value represents the average of three determination. NS = Non-significant

The sample packed in LDPE showed slight lower crude fibre followed by laminated pouch on 6th day of storage.

Abdul *et al.* (2010) reported that crude fibre of linseed cookies at 0 days were 1.26 per cent which decreased thereafter 1.06 per cent after 45 days of storage. Gund (2019) reported crude fibre content of multigrain cake at 0 day was 1.28 per cent which decreased thereafter to 1.22 per cent at 6th days of storage.

4.9.2.5 Changes in ash

The results on changes in ash of biscuits as influenced by storage and packaging material are presented in Table 4.64. It was found that the ash decreased for control (*Trimbak*) from 1.17 to 1.08 in LDPE and 1.16 to 1.10 in laminated pouch whereas control (*Samadhan*) from 1.31 to 1.20 in LDPE and 1.33 to 1.26 in laminated pouch was observed for 6 days of storage.

The sample prepared from *Trimbak* wheat flour with MSO showed decreased in ash content from 1.44 to 1.35 in LDPE and 1.43 to 1.37 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed ash content decreased from 1.63 to 1.56 in LDPE and 1.64 to 1.59 in laminated pouch.

The sample prepared from *Trimbak* wheat flour with DMSF showed decreased in ash content from 1.52 to 1.44 in LDPE and 1.52 to 1.46 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed ash decreased from 1.68 to 1.53 in LDPE and 1.67 to 1.58 in laminated pouch. Decrease in ash content was observed by chenges in level of treatments significantly changes ash values due to corresponding wheat variety whereas nonsignificant among packaging material. The sample packed in LDPE showed slight lower ash followed by laminated pouch on 6th day of storage.

A gradual decrease in ash content of cookies was reported by (Sharif *et al.,* 2009) either due to atmosphere or packaging material. Gund (2019) reported ash content of multigrain cupcake at 0 day was 1.44 per cent which decreased thereafter to 1.37 per cent at 6th days of storage.

4.9.2.6 Changes in carbohydrate

The results observed changes in carbohydrates of cupcake as influenced by storage are presented in Table 4.65. The carbohydrate decreased for control (*Trimbak*) from 34.96 to 34.82 in LDPE and 34.96 to 34.87 in laminated pouch whereas control (*Samadhan*) from

Table 4.64 Effect of packaging material on changes in ash (%) of *Moringa* seed oil and defatted seed flour cupcake during storage

No.	Factor	0 Days	3 Days	6 Days
	Treatment			
T_0	Control	1.24	1.20	1.17
T_1	*Moringa* seed oil	1.54	1.51	1.45
T_2	Defatted *Moringa* seed flour	1.60	1.54	1.49
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Variety			
V_1	*Trimbak* (NIAW-301)	1.38	1.34	1.29
V_2	*Samadhan* (NIAW-1994)	1.54	1.49	1.45
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Packaging material			
P_1	LDPE	1.46	1.42	1.36
P_2	Laminated pouch	1.46	1.41	1.37
	SE±	0.01	0.01	0.01
	CD @ 5%	NS	NS	NS
	Interaction			
	$T_0 V_1 P_1$	1.17	1.13	1.08
	$T_0 V_1 P_2$	1.16	1.14	1.10
	$T_0 V_2 P_1$	1.31	1.25	1.20
	$T_0 V_2 P_2$	1.33	1.30	1.26
	$T_1 V_1 P_1$	1.44	1.41	1.35
	$T_1 V_1 P_2$	1.43	1.41	1.37
	$T_1 V_2 P_1$	1.63	1.60	1.56
	$T_1 V_2 P_2$	1.64	1.62	1.59
	$T_2 V_1 P_1$	1.52	1.49	1.44
	$T_2 V_1 P_2$	1.52	1.50	1.46
	$T_2 V_2 P_1$	1.68	1.60	1.53
	$T_2 V_2 P_2$	1.67	1.63	1.58
	SE±	0.01	0.01	0.02
	CD @ 5%	0.04	0.04	0.04

Each value represents the average of three determination. NS = Non-significant

Table 4.65 Effect of packaging material on changes in carbohydrate (%) of *Moringa* seed oil and defatted seed flour cupcake during storage

No.	Factor	0 Days	3 Days	6 Days
	Treatment			
T_0	Control	35.13	35.07	35.04
T_1	*Moringa* seed oil	33.58	33.55	33.49
T_2	Defatted *Moringa* seed flour	34.51	34.44	34.35
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Variety			
V_1	*Trimbak* (NIAW-301)	34.25	34.16	34.07
V_2	*Samadhan* (NIAW-1994)	34.57	34.53	34.48
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Packaging material			
P_1	LDPE	34.42	34.30	34.19
P_2	Laminated pouch	34.40	34.33	34.21
	SE±	0.01	0.01	0.01
	CD @ 5%	NS	NS	NS
	Interaction			
	$T_0 V_1 P_1$	34.96	34.88	34.82
	$T_0 V_1 P_2$	34.96	34.92	34.87
	$T_0 V_2 P_1$	35.31	35.27	35.24
	$T_0 V_2 P_2$	35.31	35.29	35.26
	$T_1 V_1 P_1$	33.46	33.40	33.36
	$T_1 V_1 P_2$	33.45	33.42	33.38
	$T_1 V_2 P_1$	33.71	33.69	33.60
	$T_1 V_2 P_2$	33.70	33.68	33.64
	$T_2 V_1 P_1$	34.34	34.28	34.22
	$T_2 V_1 P_2$	34.33	34.32	34.28
	$T_2 V_2 P_1$	34.70	34.65	34.59
	$T_2 V_2 P_2$	34.68	34.64	34.61
	SE±	0.01	0.01	0.02
	CD @ 5%	0.04	0.04	0.06

Each value represents the average of three determination. NS = Non-significant

35.31 to 35.24 in LDPE and 35.31 to 35.26 in laminated pouch was observed for 6 days of storage. The cupcake sample prepared from *Trimbak* wheat flour with MSO showed decreased in carbohydrate content from 33.46 to 33.36 in LDPE and 33.45 to 33.38 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed carbohydrate content decreased from 33.71 to 33.60 in LDPE and 33.70 to 33.64 in laminated pouch.

The cupcake sample prepared from *Trimbak* wheat flour with DMSF showed decreased in carbohydrate content from 34.34 to 34.22 in LDPE and 34.33 to 34.28 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed carbohydrate decreased from 34.70 to 34.59 in LDPE and 34.68 to 34.61 in laminated pouch. Decrease in carbohydrate content was observed by change in level of treatments significantly changes values of carbohydrate due to corresponding wheat variety whereas nonsignificant among packaging material. The sample packed in laminated pouch showed maximum carbohydrate followed by LDPE on 6th day of storage.

Sharoon *et al.* (2014) reported decreased in carbohydrates content during storage in biscuits prepared from composite flour during storage period of 45 days. The decrease in carbohydrate content of cookies prepared from red palm oil and rice bran oil during storage has also been reported by Butt *et al.* (2004) and Sharif *et al.* (2005).

4.9.3 Effects of Packaging Material on Changes in Mineral Composition of *Moringa* Seed Oil and Defatted Seed Flour Cupcake During Storage

The results on change in minerals content such as calcium, phosphorus, iron and zinc of cupcake as influenced by storage and packaging material are presented in Table 4.66 to 4.69.

4.9.3.1 Changes in calcium

It was observed from Table 4.66 that the calcium decreased for control (*Trimbak*) from 79.79 to 79.70 in LDPE and 79.82 to 79.72 in laminated pouch whereas control (*Samadhan*) from 88.30 to 88.21 in LDPE and 88.28 to 88.22 in laminated pouch was observed for 6 days of storage.

The cupcake prepared from *Trimbak* wheat flour with MSO showed decreased in calcium content from 79.75 to 79.68 in LDPE and 79.73 to 79.69 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed calcium content decreased from 88.28 to 88.23 in LDPE and 88.30 to 88.23 in laminated pouch.

Table 4.66. Effect of packaging material on changes in calcium (mg/100g) of *Moringa* seed oil and defatted seed flour cupcake during storage

No.	Treatment	0 Days	3 Days	6 Days
	Treatment			
T_0	Control	84.05	84.01	83.96
T_1	*Moringa* seed oil	84.01	83.97	83.96
T_2	Defatted *Moringa* seed flour	95.44	95.41	95.37
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Variety			
V_1	*Trimbak* (NIAW-301)	83.65	83.61	83.57
V_2	*Samadhan* (NIAW-1994)	92.02	91.99	91.95
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Packaging material			
P_1	LDPE	87.83	87.80	87.76
P_2	Laminated pouch	87.84	87.80	87.77
	SE±	0.01	0.01	0.01
	CD @ 5%	NS	NS	NS
	Interaction			
	$T_0 V_1 P_1$	79.79	79.74	79.70
	$T_0 V_1 P_2$	79.82	79.76	79.72
	$T_0 V_2 P_1$	88.30	88.29	88.21
	$T_0 V_2 P_2$	88.28	88.25	88.22
	$T_1 V_1 P_1$	79.75	79.71	79.68
	$T_1 V_1 P_2$	79.73	79.69	79.69
	$T_1 V_2 P_1$	88.28	88.24	88.23
	$T_1 V_2 P_2$	88.30	88.26	88.23
	$T_2 V_1 P_1$	91.41	91.36	91.32
	$T_2 V_1 P_2$	91.41	91.38	91.34
	$T_2 V_2 P_1$	99.47	99.45	99.41
	$T_2 V_2 P_2$	99.49	99.47	99.42
	SE±	0.01	0.01	0.02
	CD @ 5%	0.04	0.04	NS

Each value represents the average of three determination. NS = Non-significant

The cupcake prepared from *Trimbak* wheat flour with DMSF showed decreased in calcium content from 91.41 to 91.32 in LDPE and 91.41 to 91.34 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed calcium decreased from 99.47 to 99.41 in LDPE and 99.49 to 99.42 in laminated pouch. (Table 4.66). Significant decrease in calcium content was observed for treatments and packaging material whereas nonsignificant among wheat variety. The interaction effect was significant among the different factor.

Gund (2019) reported the changes in calcium content as influenced by storage period and packaging material at ambient temperature was calcium content of multigrain cake at 0 day were 128.00 mg/100g which decreased thereafter to 120.25mg/100g at 6th days of storage.

4.9.3.2 Changes in phosphorus

The data obtained from Table 4.67 that the phosphorus decreased for control (*Trimbak*) from 172.30 to 172.20 in LDPE and 172.31 to 172.22 in laminated pouch whereas control (*Samadhan*) from 180.50 to 180.39 in LDPE and 180.50 to 180.43 in laminated pouch was observed for 6 days of storage.

The sample prepared from *Trimbak* wheat flour with MSO showed decreased in phosphorus content from 172.26 to 172.18 in LDPE and 172.26 to 172.20 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed phosphorus content decreased from 177.84 to 179.76 in LDPE and 179.83 to 179.77 in laminated pouch (Table 4.67).

The sample prepared from *Trimbak* wheat flour with DMSF showed decreased in phosphorus content from 177.18 to 177.10 in LDPE and 177.20 to 177.11 in laminated pouch. The sample prepared from *Samadhan* wheat flour with DMSF showed phosphorus decreased from 202.87 to 202.79 in LDPE and 202.86 to 202.80 in laminated pouch. Decrease in phosphorus content was observed by change in level of treatments significantly changes values of phosphorus content due to corresponding wheat variety and non significant among packaging material.

Deshmukh (2017) reported by gradual decrease in phosphorus content of cookies were stored in LDPE, HDPE and laminated pouch during storage period of 6th month.

Table 4.67. Effect of packaging material on changes in phosphorus (mg/100 g) of *Moringa* seed oil and defatted seed flour cupcake during storage

No.	Factor	0 Days	3 Days	6 Days
	Treatment			
T_0	Control	176.40	176.35	176.31
T_1	*Moringa* seed oil	175.55	176.01	175.98
T_2	Defatted *Moringa* seed flour	190.03	189.99	189.95
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Variety			
V_1	*Trimbak* (NIAW-301)	173.92	173.88	173.83
V_2	*Samadhan* (NIAW-1994)	187.40	187.69	187.66
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Packaging material			
P_1	LDPE	180.83	180.78	180.74
P_2	Laminated pouch	180.83	180.79	180.75
	SE±	0.01	0.01	0.01
	CD @ 5%	NS	NS	NS
	Interaction			
	T_0 V_1 P_1	172.30	172.26	172.20
	T_0 V_1 P_2	172.31	172.27	172.22
	T_0 V_2 P_1	180.50	180.42	180.39
	T_0 V_2 P_2	180.50	180.48	180.43
	T_1 V_1 P_1	172.26	172.21	172.18
	T_1 V_1 P_2	172.26	172.24	172.20
	T_1 V_2 P_1	177.84	179.80	179.76
	T_1 V_2 P_2	179.83	179.79	179.77
	T_2 V_1 P_1	177.18	177.14	177.10
	T_2 V_1 P_2	177.20	177.16	177.11
	T_2 V_2 P_1	202.87	202.84	202.79
	T_2 V_2 P_2	202.86	202.83	202.80
	SE±	0.02	0.01	0.01
	CD @ 5%	0.06	0.04	NS

Each value represents the average of three determination. NS = Non-significant

4.9.3.3 Iron

It was observed from Table 4.68 that the iron decrease for control (*Trimbak*) from 5.42 to 5.35 in LDPE and 5.46 to 5.41 in laminated pouch whereas control (*Samadhan*) from 4.28 to 4.20 in LDPE and 4.27 to 4.22 in laminated pouch was observed for 6 days of storage.

The cupcake prepared from *Trimbak* wheat flour with MSO showed decrease in iron content from 5.39 to 5.32 in LDPE and 5.41 to 5.34 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO showed iron content decreased from 4.26 to 4.18 in LDPE and 4.27 to 4.19 in laminated pouch (Table 4.68).

The cupcake prepared from *Trimbak* wheat flour with DMSF showed decrease in iron content from 6.06 to 5.97 in LDPE and 6.04 to 5.97 in laminated pouch. The cupcake prepared from *Samadhan* wheat flour with DMSF showed decrease in iron from 4.93 to 4.87 in LDPE and 4.94 to 4.88 in laminated pouch. Decrease in iron content was observedby change in level of treatments significantly due to corresponding packaging material whereas nonsignificant among wheat variety. The interaction effect was significant among different factors.

Gradual decreases in iron content of cookies were reported by Wade (1988) and Sharif *et al.* (2009) either due to atmosphere or packaging material. Biradar *et al.* (2020) reported iron decreased in ambient temperature during storage period of 3 month due to increase in moisture was more rapid in the samples stored in PP than LDPE during the storage period.

4.9.3.4 Zinc

The result revealed from Table 4.69 that the zinc decreased for control (*Trimbak*) from 1.23 to 1.16 in LDPE and from 1.24 to 1.18 in laminated pouch whereas control (*Samadhan*) from 1.45 to 1.30 in LDPE and 1.45 to 1.41 in laminated pouch was observed for 6 days of storage.

The cupcake prepared from *Trimbak* wheat flour with MSO showed decrease in zinc content from 1.18 to 1.10 in LDPE and 1.18 to 1.11 in laminated pouch. The cupcake prepared from *Samadhan* wheat flour with MSO showed zinc content decreased from 1.44 to 1.34 in LDPE and 1.43 to 1.37 in laminated pouch (Table 4.69).

The cupcake prepared from *Trimbak* wheat flour with DMSF showed decrease in zinc content from 1.30 to 1.24 in LDPE and 1.30 to 1.25 in laminated pouch.

Table 4.68. Effect of packaging material on changes in iron (mg/100 g) of *Moringa* seed oil and defatted seed flour cupcake during storage

No.	Factor	0 Days	3 Days	6 Days
	Treatment			
T_0	Control	4.86	4.82	4.80
T_1	*Moringa* seed oil	4.83	4.79	4.76
T_2	Defatted *Moringa* seed flour	5.49	5.46	5.42
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Variety			
V_1	*Trimbak* (NIAW-301)	5.63	5.59	5.56
V_2	*Samadhan* (NIAW-1994)	4.49	4.46	4.42
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Packaging material			
P_1	LDPE	5.06	5.02	4.98
P_2	Laminated pouch	5.06	5.02	5.00
	SE±	0.01	0.01	0.01
	CD @ 5%	NS	NS	0.03
	Interaction			
	T_0 V_1 P_1	5.42	5.39	5.35
	T_0 V_1 P_2	5.46	5.41	5.41
	T_0 V_2 P_1	4.28	4.25	4.20
	T_0 V_2 P_2	4.27	4.25	4.22
	T_1 V_1 P_1	5.39	5.34	5.32
	T_1 V_1 P_2	5.41	5.36	5.34
	T_1 V_2 P_1	4.26	4.23	4.18
	T_1 V_2 P_2	4.27	4.22	4.19
	T_2 V_1 P_1	6.06	6.03	5.97
	T_2 V_1 P_2	6.04	6.00	5.97
	T_2 V_2 P_1	4.93	4.89	4.87
	T_2 V_2 P_2	4.94	4.91	4.88
	SE±	0.01	0.01	0.01
	CD @ 5%	0.04	0.04	NS

Each value represents the average of three determination. NS = Non-significant

Table 4.69. Effect of packaging material on changes in zinc (mg/100 g) of *Moringa* seed oil and defatted seed flour cupcake during storage

No.	Factor	0 Days	3 Days	6 Days
	Treatment			
T_0	Control	1.34	1.29	1.25
T_1	*Moringa* seed oil	1.31	1.27	1.23
T_2	Defatted *Moringa* seed flour	1.44	1.41	1.37
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Variety			
V_1	*Trimbak* (NIAW-301)	1.24	1.21	1.17
V_2	*Samadhan* (NIAW-1994)	1.49	1.44	1.40
	SE±	0.01	0.01	0.01
	CD @ 5%	0.03	0.03	0.03
	Packaging material			
P_1	LDPE	1.36	1.33	1.28
P_2	Laminated pouch	1.36	1.32	1.29
	SE±	0.01	0.01	0.01
	CD @ 5%	NS	NS	NS
	Interaction			
	$T_0 V_1 P_1$	1.23	1.20	1.16
	$T_0 V_1 P_2$	1.24	1.21	1.18
	$T_0 V_2 P_1$	1.45	1.36	1.30
	$T_0 V_2 P_2$	1.45	1.41	1.41
	$T_1 V_1 P_1$	1.18	1.14	1.10
	$T_1 V_1 P_2$	1.18	1.15	1.11
	$T_1 V_2 P_1$	1.44	1.40	1.34
	$T_1 V_2 P_2$	1.43	1.39	1.37
	$T_2 V_1 P_1$	1.30	1.27	1.24
	$T_2 V_1 P_2$	1.30	1.28	1.25
	$T_2 V_2 P_1$	1.58	1.54	1.49
	$T_2 V_2 P_2$	1.58	1.55	1.52
	SE±	0.01	0.01	0.01
	CD @ 5%	NS	0.04	0.04

Each value represents the average of three determination. NS = Non-significant

The cupcake prepared from *Samadhan* wheat flour with DMSF showed zinc content decrease from 1.58 to 1.49 in LDPE and 1.58 to 1.52 in laminated pouch. Significant decrease in zinc content was observed for treatments and wheat variety whereas nonsignificant among packaging material. Deshmukh (2017) reported decrease in zinc content in cookies during 180th day of storage.

4.9.4 Effect of Storage Period and Packaging Material on Changes in Microbial Quality of *Moringa* Seed Oil and Defatted Seed Flour Cupcake

The control cupcake and standardized cupcake from *Trimbak* and *Samadhan* wheat flour, containing 100 per cent *Moringa* seed oil (MSO) and 5 per cent defatted *Moringa* seed flour (DMSF) were packed in LDPE and laminated pouch and stored at ambient temperature for 6 days. The cupcakes were evaluated for microbial quality on 0 day and 6 days of storage. The microbial quality was studied for Total Plate Count (TPC) and Yeast and Mould Count. It was determined by using serial dilution pour plate method. The number of colonies appearing on dilution plates were counted, averaged and reported as cells per gram (cfu/gm) of the sample.

4.9.4.1 Total plate count

The results for total plate count of cupcake obtained in present investigation as influenced by packaging material and storage period are presented in Table 4.70. It was observed that the total plate count gradually increased for control (*Trimbak*) from 1.06 to 2.31 in LDPE and 1.05 to 2.30 in laminated pouch whereas control (*Samadhan*) from 1.04 to 2.32 in LDPE and 1.03 to 2.25 in laminated pouch was observed for 6 days of storage.

The cupcake prepared from *Trimbak* wheat flour with MSO showed increased in total plate count was observed from 1.04 to 2.31 in LDPE an d 1.03 to 2.28 in laminated pouch. The cupcake prepared from *Samadhan* wheat flour with MSO observed total plate count increased from 1.04 to 2.28 in LDPE and 1.02 to 2.24 in laminated pouch.

The cupcake prepared from *Trimbak* wheat flour with DMSF observed increased in total plate count from 1.04 to 2.38 in LDPE and 1.03 to 2.35 in laminated pouch. The cupcake prepared from *Samadhan* wheat flour with DMSF observed total plate count increased from 1.03 to 2.29 in LDPE and 1.03 to 2.25 in laminated pouch. Samples packed in LDPE showed higher plate count value followed by laminated pouch on 6th day of storage. This might be due to higher WVTR and GTR of LDPE then laminated pouch.

Nagi *et al.* (2012) stated that the packaging material had non-significant effect on the microbial quality of cupcake, however, growth was observed more in cupcake packed in HDPE than the laminate packed cupcake.

4.9.4.2 Yeast and mould count

The results for yeast and mould count of cupcake obtained in present investigation as influenced by packaging material and storage period are presented in Table 4.70. It was observed that yeast and mould count gradually increased for control (*Trimbak*) from 1.06 to 2.39 in LDPE and 1.06 to 2.33 in laminated pouch whereas control (*Samadhan*) from 1.05 to 2.37 in LDPE and 1.04 to 2.29 in laminated pouch was observed for 6 days of storage.

The cupcake prepared from *Trimbak* wheat flour with MSO showed increased in yeast and mould count was observed from 1.07 to 2.39 in LDPE and 1.05 to 2.34 in laminated pouch. The sample prepared from *Samadhan* wheat flour with MSO observed yeast and mould count increased from 1.04 to 2.33 in LDPE and 1.02 to 2.27 in laminated pouch.

The cupcake prepared from *Trimbak* wheat flour with DMSF observed increased in yeast and mould count from 1.05 to 2.33 in LDPE and 1.05 to 2.29 in laminated pouch. The cupcake prepared from *Samadhan* wheat flour with DMSF observed yeast and mould increased from 1.06 to 2.36 in LDPE and 1.04 to 2.27 in laminated pouch. Cupcake packed in LDPE showed higher yeast and mould value followed by laminated pouch on 6^{th} day of storage. This might be due to higher WVTR and GTR of LDPE then laminated pouch (Table 74).

Berwal *et al.* (2013) investigated that the yeast and mould growth was only detected after 60^{th} day of storage and had very less growth 3 to 9 cfu/g in CMM incorporated cookies throughout the storage period.

Deshmukh (2017) studied that the yeast and mould count gradually increased during storage period. The sample packed in LDPE showed higher yeast and mould count than the HDPE and aluminium foil packages on the 180^{th} of the storage.

Table 4.70 Effect of storage period and packaging material on changes in microbial quality of *Moringa* seed oil and defatted seed flour cupcake

No.	Factor	Total plate count (-×10^3 cfu/g)		Yeast and mold count (-×10^3 cfu/g)	
	Treatment	**0 days**	**6 days**	**0 days**	**6 days**
T_0	Control	1.04	2.29	1.05	2.34
T_1	*Moringa* seed oil	1.03	2.28	1.04	2.33
T_2	Defatted *Moringa* seed flour	1.03	2.32	1.05	2.31
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	NS	0.03	NS	0.03
	Variety				
V_1	*Trimbak* (NIAW-301)	1.04	2.32	1.06	2.34
V_2	*Samadhan* (NIAW-1994)	1.03	2.27	1.04	2.31
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	NS	0.03	NS	0.03
	Packaging material				
P_1	LDPE	1.04	2.31	1.05	2.36
P_2	Laminated pouch	1.03	2.28	1.04	2.30
	SE±	0.01	0.01	0.01	0.01
	CD @ 5%	NS	0.03	NS	0.03
	Interaction				
	T_0 V_1 P_1	1.06	2.31	1.06	2.39
	T_0 V_1 P_2	1.05	2.30	1.06	2.33
	T_0 V_2 P_1	1.04	2.32	1.05	2.37
	T_0 V_2 P_2	1.03	2.25	1.04	2.29
	T_1 V_1 P_1	1.04	2.31	1.07	2.39
	T_1 V_1 P_2	1.03	2.28	1.05	2.34
	T_1 V_2 P_1	1.04	2.28	1.04	2.33
	T_1 V_2 P_2	1.02	2.24	1.02	2.27
	T_2 V_1 P_1	1.04	2.38	1.05	2.33
	T_2 V_1 P_2	1.03	2.35	1.05	2.29
	T_2 V_2 P_1	1.03	2.29	1.06	2.36
	T_2 V_2 P_2	1.03	2.25	1.04	2.27
	SE±	0.02	0.02	0.01	0.02
	CD @ 5%	NS	NS	NS	NS

Each value represents the average of three determination. NS = Non-significant

4.10 Economics of Biscuits and Cupcake

4.10.1 Economics of biscuits production

Cost of production of whole wheat flour biscuits given in Table 4.71, *Moringa* seed oil biscuits are given in Table 4.72 and that of defatted seed flour biscuits given in Table 4.73. This cost workout on the basis of cost of raw materials, chemicals to be added, labour charges at prevailing rates of experimental period. The total cost production for 1 kg of whole wheat flour biscuits was Rs. 137.01, production cost of 1 kg of *Moringa* seed oil biscuits Rs. 184.05 and the production cost of 1 kg defatted *Moringa* seed flour biscuits was Rs. 192.61. The cost did not include rent and transport charges, sales commission, local tax, interest on capital, depreciation on equipment etc.

Table 4.71 Cost of biscuits production of whole wheat flour (control)

Sr. No.	Item	Quantity	Rate	Total cost (Rs)
1	Wheat flour	100 g	Rs 32 /kg	3.20
2	Sugar	50 g	Rs 40 /kg	2.00
3	Vanaspati fat	50 g	Rs 140 /kg	7.00
4	Sodium bicarbonate	0.5 g	Rs 12 /50g	0.12
5	Ammonium bicarbonate	0.5 g	Rs 25 /50g	0.25
6	Salt	0.2 g	Rs 17 /kg	0.003
7	Total			12.57
8	10 % fluctuation in price			1.25
9	Energy: labour, electricity, equipment, packaging material and miscellaneous	40 % Overhead cost		5.02
10	Total weight of biscuits produced	165 g		18.84
11	Cost of producing 1 kg of biscuit			114.18
12	20 % profit margin			22.83
13	Selling price of biscuits (Rs/kg)			137.01

Table 4.72 Cost of biscuits production by using *Moringa* seed oil

Sr. No.	Item	Quantity	Rate	Total cost (Rs)
1	Wheat flour	100 g	Rs 32 /kg	3.20
2	Sugar	50 g	Rs 40 /kg	2.00
3	Vanaspati fat	30 g	Rs 140 /kg	4.20
4	*Moringa* seed oil	20 g	Rs 432 /kg	8.64
5	Sodium bicarbonate	0.5 g	Rs 12 /50g	0.12
6	Ammonium bicarbonate	0.5 g	Rs 25 /50g	0.25
7	Salt	0.2 g	Rs 17 /kg	0.003
8	Total			18.41
9	10 % fluctuation in price			1.84
10	Energy: labour, electricity, equipment, packaging material and miscellaneous	40 % Overhead cost		7.36
11	Total weight of biscuits produced	180 g		27.61
12	Cost of producing 1 kg of biscuit			153.38
13	20 % profit margin			30.67
14	Selling price of biscuits (Rs/kg)			184.05

Table 4.73 Cost of biscuits production by using defatted *Moringa* seed flour

Sr. No.	Item	Quantity	Rate	Total cost (Rs)
1	Wheat flour	90 g	Rs 32 /kg	2.88
2	Sugar	50 g	Rs 40 /kg	2.00
3	Vanaspati fat	50 g	Rs 140 /kg	7.00
4	Defatted *Moringa* seed flour	10 g	Rs 648 /kg	6.48
5	Sodium bicarbonate	0.5 g	Rs 12 /50g	0.12
6	Ammonium bicarbonate	0.5 g	Rs 25 /50g	0.25
7	Salt	0.2 g	Rs 17 /kg	0.003
8	Total			18.73
9	10 % fluctuation in price			1.87
10	Energy: labour, electricity, equipment, packaging material and miscellaneous	40 % Overhead cost		7.49
11	Total weight of biscuits produced	175 g		28.09
12	Cost of producing 1 kg of biscuit			160.51
13	20 % profit margin			32.10
14	Selling price of biscuits (Rs/kg)			192.61

4.10.2 Economics of Cupcake Production

Cost of production of whole wheat flour cupcake given in Table 4.74, *Moringa* seed oil cupcake was given in Table 4.75 and that of defatted seed flour cupcake given in Table 4.76. This cost workout on the basis of cost of raw materials, chemicals to be added, labour charges at prevailing rates of experimental period. The total cost production for 1 kg of whole wheat flour cupcake was Rs. 146.14, production cost of 1 kg of *Moringa* seed oil cupcake Rs. 269.04 and the production cost of 1 kg defatted *Moringa* seed flour cupcake was Rs. 171.01 The cost did not include rent and transport charges, sales commission, local tax, interest on capital, depreciation on equipment etc.

Table 4.74 Cost of cupcake production of whole wheat flour (control)

Sr. No.	Item	Quantity	Cost	Total cost (Rs)
1	Wheat flour	100 g	Rs 32 /kg	3.20
3	Sugar	85 g	Rs 40 /kg	3.40
4	Vanaspati fat	65 g	Rs 140 /kg	9.10
5	Sodium bicarbonate	2 g	Rs 12 /50 g	0.48
6	Baking powder	2 g	Rs 40 /200 g	0.40
7	Egg	45 g	Rs 6 /No	6.00
	Total			22.58
9.	10% fluctuation in prize			2.25
10.	Energy: labour, electricity, equipment, packaging material and miscellaneous	40 % Overhead cost		9.03
11.	Total weight of cupcake produced	278 g		33.86
12.	Cost of producing 1 kg of cupcake			121.79
13.	20% profit margin			24.35
14.	Selling price of (Rs/kg)			146.14

Table 4.75 Cost of cupcake production by using *Moringa* seed oil

Sr. No.	Item	Quantity	Cost (Rs/kg)	Total cost (Rs)
1	Wheat flour	100 g	Rs 32 /kg	3.20
2	Sugar	85 g	Rs 40 /kg	3.40
3	MSO	65 g	Rs 432 /kg	28.08
4	Sodium bicarbonate	2 g	Rs 12 /50g	0.48
5	Baking powder	2 g	Rs 40 /200 g	0.40
6	Egg	45 g	Rs 6 /No	6.00
7	Total			41.56
8	10% fluctuation in prize			4.15
9	Energy: labour, electricity, equipment, packaging material and miscellaneous	40 % Overhead cost		16.62
10	Total weight of cupcake produced	278 g		62.33
11	Cost of producing 1 kg of cupcake			224.20
12	20% profit margin			44.84
13	Selling price of (Rs/kg)			269.04

Table 4.76 Cost of cupcake production by using defatted *Moringa* seed flour

Sr. No.	Item	Quantity	Cost (Rs/kg)	Total cost (Rs)
1	Wheat flour	95 g	Rs 32 /kg	3.04
2	Defatted *Moringa* seed flour	5 g	Rs 648 /kg	3.24
3	Sugar	85 g	Rs 40 /kg	3.40
4	Fat	65 g	Rs 140 /kg	9.10
5	Sodium bicarbonate	2 g	Rs 12 /50g	0.48
6	Baking powder	2 g	Rs 40 /200 g	0.40
7	Egg	45 g	Rs 6 /No	6.00
8	Total			25.66
9	10 % fluctuation in prize			2.56
10	Energy: labour, electricity, equipment, packaging material and miscellaneous	40 % Overhead cost		10.26
11	Total weight of cupcake produced	270 g		38.48
12	Cost of producing 1 kg of cupcake			142.51
13	20% profit margin			28.50
14	Selling price of (Rs/kg)			171.01

5. SUMMARY AND CONCLUSION

5.1 Summary

Keeping in view the wide ranges of food choices available with people, it is essential that, choices be diversified as well as nutritious. Hence with the emphasizing the objective of diversification, the present research work on "Studies on characterization and value addition of *Moringa* seed oil and defatted flour in different bakery products" was undertaken to explore the possibility of utilization of the underutilized but highly nutrient dense *Moringa* seed in bakery products by using wheat flour *Trimbak* and *Samadhan*. The oil was extracted from seed and defatted seed flour was characterized. The oil as rich source of oleic acid and defatted seed flour as a rich source of protein, minerals and dietary fibre was utilized in bakery products such as biscuits and cupcake. The prepared products were analysed for nutritional composition. The changes during storage of biscuits and cupcake were also studied.

The results obtained during present investigation are summarized as follow:

5.1.1 Proximate Composition of Wheat Flour, Raw *Moringa* Seed Flour and Defatted *Moringa* Seed Flour

The result showed that the protein content of wheat varieties *Trimbak* and *Samadhan* flours was 12.76 and 12.06 per cent, respectively. Crude fibre content of wheat varieties *Trimbak* and *Samadhan* flours was 1.8 and 0.9 per cent, respectively. The raw *Moringa* seed contained protein 28.62 per cent, fat 34.36 per cent, crude fibre 6.75 per cent and ash 4.06 per cent. The protein, fat, crude fibre, carbohydrate and ash content of defatted *Moringa* seed flour was 45.08, 2.02, 10.20, 29.18 and 8.42 per cent respectively. The mineral content such as calcium, phosphorus, iron and zinc of raw *Moringa* seed flour were 358.75, 602.08, 8.75 and 5.31 mg/100 g, respectively whereas in defatted seed flour these were 416.39, 270.31, 17.5 and 8.24 mg/100 g, respectively.

5.1.2 Physical Properties of *Moringa* Seed

The physical properties of *Moringa* seed showed the colour whitish while length 8.372 mm, width 7.658 mm, thickness 6.962 mm whereas bulk density of *Moringa* seed were found to be low. The bulk density of *Moringa* seed was 0.480 (g/cm^3).

5.1.3 Physicochemical Properties of *Moringa* Seed Oil

The physical properties of *Moringa* seed oil has colour value such as L* value (44.535), a* value (0.633) and b* value (32.642). The oil has 44.838 (mPa.s) viscosity

30°C. Specific gravity of oil was 0.908. Chemical properties of oil showed saponification value (180.13 mg KOH/g), Iodine value (68.20 g of I_2 absorbed /100g), Ester value (175.49), Acid value (4.64 mg KOH/g) and Peroxide value (1.61 mg KOH/g).

5.1.4 Fatty Acid Profile of *Moringa* Seed Oil

The fatty acid profile analysis of *Moringa* seed oil showed the presence of major fatty acids such as oleic acid (75.152 %), palmitic acid (5.797 %), stearic acid (5.496 %), behenic acid (5.323 %), arachidic acid (3.330 %), Cis,11-eicosenaoate acid (1.949 %), palmitoleic acid (1.096 %), Cis-13,16- docosadienoic acid (0.868 %), linoleic acid (0.498 %), myristic acid (0.114 %), linolenic acid (0.112 %), erucic acid (0.105 %), butyric acid (0.093 %) and heptadeconoic acid (0.067 %). The overview of fatty acid composition of *Moringa oleifera* seed oil showed that it contained 16.89% of TSFA and 83.11 % TUFA. The unsaturated fatty acid contains 78.197 % MUFA and 4.913 % (PUFA). The trans fatty acids in *Moringa oleifera* seed oil was less than 0.01%. The ratio of TSFA to TUFA was 0.2032 %.

5.1.5 Amylographic Characteristics

Beginning of gelatinization temperature was affected by the increased addition of defatted *Moringa* seed flour. The character of beginning gelatinization decreased significantly as the defatted *Moringa* seed flour percentage increased. It was observed that there was inverse relation of beginning gelatinization temperature and levels of defatted *Moringa* seed flour. The decrease in beginning of gelatinization with increase in defatted *Moringa* seed flour up to 25 per cent may be attributed to dilution of starch and gluten of wheat flour. The higher gelatinization temperature was recorded for $T_{1.}$ The gelatinization temperature was slightly higher for wheat flour *Samadhan* among all treatment as compared to wheat flour from *Trimbak*. The gelatinization maximum was decreased as defatted *Moringa* seed flour per cent increased might be due to reduction in hydrogen bond between starch and gluten. Control of two variety had the higher gelatinization maximum as compared to 25 per cent replacement of defatted *Moringa* seed flour. On comparing both the varieties of wheat, *Samadhan* had the high beginning of gelatinization temperature. It was also observed that gelatinization temperature and gelatinization maximum was higher in *Samadhan*.

5.1.6 Farinographic Characteristics

The farinographic study revealed that there was inverse relation between the water absorption and the level of defatted *Moringa* seed flour in dough. Control treatment of two varieties had the lower water absorption compared to other treatments. *Samadhan* variety showed higher water absorption than *Trimbak*. There was inverse relation between dough development time. Dough development time decreased up to treatment T_3 and increased at T_4 and T_5. Dough stability which indicates dough strength, was decreased with increasing defatted *Moringa* seed flour from 0 to 15 per cent and increased from 20 to 25 per cent.

Results indicated that the degree of softening increased with increased incorporation of defatted *Moringa* seed flour. Hence, this indicated that there was significantly adverse effect of the addition of defatted *Moringa* seed flour on bakery products. The average degree of softening of different levels of defatted *Moringa* seed flour dough was 118.17 FU.

Farinograph quality number decreased up to 15 per cent level of defatted *Moringa* seed flour and increased at 20 to 25 per cent. The mean value farinograph quality number by addition of defatted *Moringa* seed flour was 50.00.

On comparing both variety of wheat, *Samadhan* had the lower water absorption and dough development time, whereas highest farinograph quality number. It was also observed that *Samadhan* had better farinographic characteristics than *Trimbak*.

5.1.7 Extensographic Characteristics

It was further observed in the extensographic study that as the concentration of defatted *Moringa* seed flour increased the energy required to stretch the dough i.e. area under the curve decreased. Time analysis showed that the energy gradually increased with proofing time 30 to 90 min.

Resistance to extensibility had the inverse relation with level of defatted *Moringa* seed flour. It is decreased with the increase in defatted Moringa seed flour incorporation. Hence it can be concluded that gluten gets diluted on the addition of defatted *Moringa* seed flour therefore bakery products produced with higher level of defatted *Moringa* seed flour had weak strength. Time analysis showed that resistance to extension gradually increased with increase in proofing time from 30 to 90 min.

Extensibility was highest in treatment T_1 and decreased with addition of defatted *Moringa* seed flour. The dough extensibility increased at first whereas it decreased during further proofing. The defatted seed flour caused similar changes in the extensographic characteristics.

Maximum was significantly influenced by addition of defatted *Moringa oleifera* seed flour in wheat flour. The value of maximum (BU) went on decreasing with the incremental addition of defatted *Moringa* seed flour. Time analysis showed that resistance to extension gradually increased with increase in proofing time from 30 to 90 min.

It was observed during the study that ratio number was significantly influenced by addition of defatted *Moringa* seed flour in wheat flour. Addition of defatted *Moringa* seed flour caused changes in the ratio number. Time analysis showed that the ratio number gradually decreased with increasing proving time from 30 to 60 min but increased from 60 to 90 min similar trends was observed for ratio number max.

On comparing both the varieties of wheat, *Samadhan* had the better extensographic characteristics than *Trimbak*.

5.1.8 Sensory Evaluation of Biscuits

The biscuits samples prepared with treatment T_2 (40 % MSO) were statistically superior for overall acceptability parameter over all other treatments to the proportion of same variety (*Trimbak* and *Samadhan*). The biscuits samples prepared with treatment T_2 (10 % DMSF) were statistically superior for all sensory parameter over all other treatments. It was revealed that 10 per cent addition of DMSF helped in improved acceptability of biscuits.

5.1.9 Proximate Composition of Biscuits

The increased in MSO level in biscuits does not affect chemical composition of biscuits significantly. There was a non significant change in moisture, protein, crude fibre and ash content but significantly changes in fat and carbohydrate.

The increased in DMSF level in biscuits effects on chemical composition of biscuits significantly. The moisture content of biscuits increased with incremental addition of level of defatted *Moringa* seed flour. The moisture content of optimized product T_2 was 3.95 per cent (*Trimbak*) and 3.72 per cent (*Samadhan*) and observed the mean moisture content of 3.84 per cent. The protein content of optimized product T_2 (10

% DMSF) was 10.94 per cent (*Trimbak*) and 10.40 per cent (*Samadhan*) and recorded mean protein content in biscuits was 10.67 per cent. The fat content of optimized product T_2 was 24.37 per cent (*Trimbak*) and 24.29 per cent (*Samadhan*) with the mean fat content of 24.33 per cent. The crude fibre content of optimized product T_2 was 2.01 per cent (*Trimbak*) and 1.77 per cent (*Samadhan*) and observed the mean crude fibre content of 1.89 per cent. The ash content in treatment T_5 was highest 2.90 per cent (*Trimbak*) and 2.95 per cent (*Samadhan*). Increased calcium content was observed with increase in concentration of defatted *Moringa* seed flour. The calcium content in biscuits ranged from 35.29 to 130.47 mg/100 g (*Trimbak*) and 32.13 to 128.10 mg/100 g (*Samadhan*) and the mean calcium content of biscuits ranged from 33.71 to 129.28 mg/100 g. The results revealed that phosphorus content in biscuits ranged from 343.26 to 371.04 mg/100 g (*Trimbak*) and 326.03 to 342.35 mg/100 g (*Samadhan*) and the mean phosphorus content of biscuits ranged from 334.65 to 356.70 mg/100 g. The iron content of biscuits ranged from 4.33 to 7.61 mg/100 g (*Trimbak*) and 2.71 to 6.28 mg/100 g (*Samadhan*) whereas the range of mean iron content of biscuits from 3.52 to 6.95 mg/100 g. Zinc content of biscuits ranged from 1.96 to 2.52 mg/100 g (*Trimbak*) and 2.13 to 2.59 mg/100 g (*Samadhan*) whereas the results observed range of mean zinc content from 2.05 to 2.56 mg/100 g.

5.1.10 Textural properties of biscuits

The crushing force, cutting force and penetration force of *Moringa* seed oil incorporated biscuits ranged from 35.48 to 48.71 N (*Trimbak*) and 37.14 to 50.04 N (*Samadhan*), 31.91 to 54.19 N (*Trimbak*) and 30.21 to 57.27 N (*Samadhan*) and 10.02 to 22.48 N (*Trimbak*) and 10.06 to 22.71 N (*Samadhan*).

The crushing force, cutting force and penetration force of defatted *Moringa* seed flour incorporated biscuits ranged from 39.27 to 101.08 N (*Trimbak*) and 40.47 to 105.63 N (*Samadhan*), 40.58 to 72.58 N (*Trimbak*) and 42.63 to 74.94 N (*Samadhan*) and 20.74 to 41.63 N (*Trimbak*) and 20.92 to 42.54 N (*Samadhan*).

5.1.11 Storage study of biscuits

The moisture increased for *Trimbak* wheat flour with MSO from 3.62 to 3.69 and for *Samadhan* wheat flour with MSO from 3.35 to 3.44 in laminated pouch. The moisture increased for *Trimbak* wheat flour with DMSF from 3.92 to 4.08 and for *Samadhan* wheat flour with DMSF from 3.75 to 3.83 in laminated pouch. The protein decreased for

Trimbak wheat flour with MSO from 7.24 to 7.12 and for *Samadhan* wheat flour with MSO from 6.64 to 6.57 in laminated pouch. The protein decreased for *Trimbak* wheat flour with DMSF from 10.95 to 10.85 and for *Samadhan* wheat flour with DMSF from 10.42 to 10.28 in laminated pouch. The carbohydrate decreased for *Trimbak* wheat flour with MSO from 60.06 to 59.83 and for *Samadhan* wheat flour with MSO from 61.59 to 61.26 in laminated pouch. The carbohydrate decreased for *Trimbak* wheat flour with DMSF from 24.32 to 24.17 and for *Samadhan* wheat flour with DMSF from 24.24 to 24.12 in laminated pouch. The crude fibre decreased for *Trimbak* wheat flour with MSO from 1.13 to 1.02 and for *Samadhan* wheat flour with MSO from 0.87 to 0.76 in laminated pouch. The crude fibre decreased for *Trimbak* wheat flour with DMSF from 1.96 to 1.87 and for *Samadhan* wheat flour with DMSF from 1.71 to 1.60 in laminated pouch. Sample packed in LDPE showed higher fatty acids than laminated pouch on 90th day of storage. Significant increase in peroxide value was observed. Sample packed in LDPE showed higher peroxide value followed by aluminum laminated pouch on 90th day of storage. Samples packed in LDPE showed higher yeast and mould count followed by laminated pouch on 90th day of storage. Samples packed in LDPE showed higher total plate count value than laminated pouch on the 90th day of storage.

5.1.12 Cost Production of Biscuits

The cost production of control (whole wheat flour) biscuit was Rs. 137.01/kg and production cost of *Moringa* seed oil biscuit (T_2) was Rs. 184.05/kg and production cost of defatted *Moringa* seed flour biscuit (T_2) was Rs. 192.61/kg.

5.1.13 Sensory Evaluation of Cupcake

The cupcake samples prepared with treatment T_5 (100 % MSO) were statistically superior for overall acceptability parameter over all other treatments to the proportion of same variety (*Trimbak* and *Samadhan*). Results revealed that 100 % addition of MSO improve the texture and acceptability of cupcake. It was revealed that 5 % addition of DMSF helped in improved acceptability of cupcake. The cupcake samples prepared with treatment T_1 (5 % DMSF) were statistically superior for all sensory parameter over all other treatments.

5.1.14 Proximate Composition of Cupcake

The increased in MSO level in cupcake effects on chemical composition of cupcake significantly. The moisture content of cupcake ranged from 19.79 to 21.55 per cent (*Trimbak*) and 20.43 to 21.38 per cent *Samadhan*), protein 9.31 to 11.41 per cent (*Trimbak*) and 9.35 to 11.68 per cent (*Samadhan*), fat 32.70 to 33.62 per cent, carbohydrate 33.46 to 34.96 per cent (*Trimbak*) and 33.71 to 35.31 per cent (*Samadhan*), crude fibre 0.23 to 0.32 per cent (*Trimbak*) and 0.37 to 0.48 per cent (*Samadhan*) and ash 1.16 to 1.44 per cent (*Trimbak*) and 1.33 to 1.63 per cent. It was observed that with increased the level of *Moringa* seed oil in biscuits, does not affects mineral composition of biscuits. The slight non-significant change in calcium, phosphorus, iron and zinc was observed.

Effects of different levels of defatted *Moringa* seed flour on proximate composition of cupcake. The moisture content of optimized product T_1 was 21.07 per cent (*Trimbak*) and 2.87 per cent (*Samadhan*) and observed the mean moisture content of 9.65 per cent. There was increased in protein, crude fibre and ash content as defatted *Moringa* seed flour level increased. The protein content of optimized product T_1 was 10.43 per cent (*Trimbak*) and 10.58 per cent (*Samadhan*) and recorded mean protein content in cupcake was 10.51 per cent. The crude fibre content of optimized product T_1 was 0.80 per cent (*Trimbak*) and 0.92 per cent (*Samadhan*) and observed the mean crude fibre content of 0.86 per cent. The ash content of optimized product T_1 was 1.52 per cent (*Trimbak*) and 1.68 per cent (*Samadhan*) and observed the mean ash content of 1.60 per cent. The carbohydrate content of optimized product T_1 was 34.34 per cent (*Trimbak*) and 34.71 per cent (*Samadhan*) and observed the mean carbohydrate content of 34.52 per cent. The results obtained for calcium, phosphorus, iron and zinc of cupcake prepared with addition of defatted *Moringa* seed flour showed significant difference for calcium, phosphorus, iron and zinc among all treatments and non-significant among the interaction of variety and treatments. The calcium content in cupcake ranged from 79.81 to 137.89 mg/100 g (*Trimbak*) and 88.30 to 144.28 mg/100 g (*Samadhan*) and the mean calcium content of cupcake ranged from 84.05 to 141.08 mg/100 g. Phosphorus content in cupcake ranged from 172.30 to 196.72 mg/100 g (*Trimbak*) and 180.50 to 202.87 mg/100 g (*Samadhan*) and the mean phosphorus content of cupcake ranged from 176.40 to 199.80 mg/100 g. The iron content of cupcake ranged from 5.46 to 8.47 mg/100 g (*Trimbak*) and 4.27 to 7.58 mg/100 g (*Samadhan*) whereas the ranged of mean iron content of cupcake from 4.87 to 8.02 mg/100 g. Zinc content of cupcake ranged from

1.23 to 1.98 mg/100 g (*Trimbak*) and 1.45 to 2.15 mg/100 g (*Samadhan*) whereas the data observed ranged of mean zinc content from 1.34 to 2.06 mg/100 g.

5.1.15 Textural Properties of Cupcake

Springiness signifies that the product retained its original shape once compressed and the ranges for cupcakes were 1.50 to 1.85 mm (*Trimbak*) and 1.56 to 2.78 mm (*Samadhan*). The combined effect of wheat flour and different level of *Moringa* seed oil (MSO) showed mean value for springiness was 1.93 mm.

Springiness signifies that the product retained its original shape once compressed and the ranges for cupcakes were 1.40 to 1.63 mm (*Trimbak*) and 1.42 to 2.66 mm (*Samadhan*). The combined effect of wheat flour and different level of defatted *Moringa* seed flour showed mean value for springiness was 1.74 mm.

5.1.16 Storage Study of Cupcake

The moisture decreased for *Trimbak* wheat flour with MSO from 19.77 to 19.71 and for *Samadhan* wheat flour with MSO from 19.59 to 19.53 in laminated pouch. The moisture decreased for *Trimbak* wheat flour with DMSF from 21.33 to 21.27and for *Samadhan* wheat flour with DMSF from 20.87 to 21.81 in laminated pouch. Cupcake prepared from *Trimbak* wheat flour with MSO showed decreased in protein content from 11.43 to 11.36 and for *Samadhan* wheat flour with MSO showed protein content decreased 11.67 to 11.60 in laminated pouch. The cupcake sample prepared from *Trimbak* wheat flour with DMSF showed decreased in protein content from 10.42 to 10.37 and for *Samadhan* wheat flour with DMSF showed protein decreased from 10.58 to 10.53 in laminated pouch. Significant decrease in fat content was observed for treatments whereas nonsignificant among wheat variety. The interaction effect showed nonsignificant. The cupcake prepared from *Trimbak* wheat flour with MSO showed decreased in crude fibre content 0.27 to 0.25 and for *Samadhan* wheat flour with MSO showed crude fibre content decreased from 0 0.42 to 0.37 in laminated pouch. The sample prepared from *Trimbak* wheat flour with DMSF showed decreased in crude fibre content from 0.81 to 0.74 and for *Samadhan* wheat flour with DMSF showed crude fibre decreased from 0.92 to 0.88 in laminated pouch. The sample prepared from *Trimbak* wheat flour with MSO showed decreased in ash content from 1.43 to 1.37 and for *Samadhan* wheat flour with MSO showed ash content decreased from 1.64 to 1.59 in laminated pouch. The sample prepared from *Trimbak* wheat flour with DMSF showed decreased in ash content from 1.52 to 1.46 for *Samadhan* wheat flour with DMSF showed ash decreased from 1.67 to 1.58 in laminated pouch. The cupcake sample prepared from *Trimbak* wheat flour with MSO showed decreased in carbohydrate content from 33.45 to 33.38 and for *Samadhan* decreased from 33.70 to 33.64 in laminated pouch. The cupcake sample prepared from *Trimbak* wheat flour with DMSF showed decreased in carbohydrate content from 34.33 to 34.28 and for *Samadhan* decreased from 34.68 to 34.61 in laminated pouch.

5.1.17 Cost of Production of Cupcake

The cost of production for 1 kg of control (whole wheat flour) cupcake was Rs. 146.14 and production cost of *Moringa* seed oil cupcake **(T_5)** was Rs. 269.04 and production cost of defatted *Moringa* seed flour cupcake **(T_1)** was Rs. 171.01. Whereas the cost of one cupcake of control was Rs. 2.35 and cost of one cupcake of MSO cupcake was Rs. 4.56 and cost of one cupcake of DMSF cupcake was Rs. 2.55

5.2 Conclusions

The oil extracted from *Moringa* seed is rich source of monounsaturated fatty acid as oleic acid which is today lacking in diet and the deficiency disease are increasing therefore it can be used in diet which has great potential for nutritional enrichment as similar to that found in olive oil. The defatted *Moringa* seed flour is by product of *Moringa* seed flour after extraction of oil are good source of protein, mineral and dietary fibre explored as a novel source of fibre, proteins in bakery products where whole wheat flour (Var. *Trimbak* and *Samadhan*) is used. Biscuits and cupcake prepared from *Trimbak* (NIAW-301) and *Samadhan* (NIAW-1994) had very good organoleptic score and both were suitable for biscuits and cupcake making. Defatted *Moringa* seed flour has nutritional potential which enable it to be used in formulations and fortifications in food is the economical way.

It is concluded that *Moringa* seed can be explored or utilized in the preparation of biscuits and cupcake. The best acceptable product can be developed using *Moringa* seed oil and defatted *Moringa* seed flour with ingredients at house hold level and commercial scale however it needs further pilot plant trials.

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*Originals are not seen.

APPENDIX-I

SCORE CARD FOR SENSORY EVALUATION OF BISCUITS AND CUPCAKE BY USING WHEAT FLOUR (*Trimbak* and *Samadhan*) WITH VALUE ADDITION OF *MORINGA* SEED OIL

9-Point Hedonic Scale

Name of evaluator: -..Designation: ....

Name of Product: ....

Date: ....

Treatments	Colour and Appearance	Texture	Flavour	Taste	Overall Acceptability
T_0					
T_1					
T_2					
T_3					
T_4					
T_5					

Quality grade distribution	Score
1. Like extremely	9
2. Like very much	8
3. Like moderately	7
4. Like slightly	6
5. Neither like nor dislike	5
6. Dislike slightly	4
7. Dislike moderately	3
8. Dislike very much	2
9. Dislike extremely	1

Remarks: **Signature**

APPENDIX-II

SCORE CARD FOR SENSORY EVALUATION OF BISCUITS AND CUPCAKE BY USING WHEAT FLOUR (*Trimbak* and *Samadhan*) WITH VALUE ADDITION OF DEFATTED *MORINGA* SEED POWDER

9-Point Hedonic Scale

Name of evaluator: -.. Designation: ....

Name of Product: ....

Date: ....

Treatments	Colour and Appearance	Texture	Flavour	Taste	Overall Acceptability
T_0					
T_1					
T_2					
T_3					
T_4					
T_5					

Quality grade distribution	Score
1. Like extremely	9
2. Like very much	8
3. Like moderately	7
4. Like slightly	6
5. Neither like nor dislike	5
6. Dislike slightly	4
7. Dislike moderately	3
8. Dislike very much	2
9. Dislike extremely	1

Remarks: **Signature**

8. VITAE

Miss. MUSALE SHUBHADA VIJAYKUMAR

A Candidate for the degree of

DOCTOR OF PHILOSOPHY

in

FOOD TECHNOLOGY

2021

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