DEVELOPMENT OF FIBRE RICH OAT-WHEAT FLOUR BLENDED BISCUITS USING MANGO PEEL

By

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J-15-M-417

Thesis submitted to Faculty of Postgraduate Studies

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FOOD SCIENCE AND TECHNOLOGY

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CERTIFICATE – I

This is to certify that the thesis entitled **"Development of fibre rich oat-wheat flour blended biscuits using mango peel"** submitted in partial fulfillment of the requirements for the degree of **Master of Science in Agriculture (Food Science and Technology)** to the Faculty of Post-Graduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, is a record of bonafide research carried out by **Ms. Ankita Choudhary**, Registration No. **J-15-M-417,** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma. It is further certified that such help and assistance received during the course of investigation have been duly acknowledged.

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CERTIFICATE – II

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ABSTRACT

Title of the Thesis/ Dissertation	:	**"Development of fibre rich oat-wheat flour blended biscuits using mango peel"**
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ABSTRACT

Baking industry has been increasingly engaged in production of fibre enriched biscuits with the aim to offer such product as a valuable constituent of proper nutrition and dietetic functional food intended for risky populations. Thereby, commercially available pure fibres or fibre-rich raw materials have been used for the enrichment of biscuits, prevalently pure fibres. In the present study, fibre rich oat-wheat flour blended biscuits using mango peel were prepared by using Wheat flour(WF), Oat flour(OF) and mango peel powder(MPP) of two cultivar viz. Chausa (CMPP) and Langra (LMPP) at different replacing levels in the ratios of T_1(100:0:0::WF:OF:MPP);T_2(0:100:0::WF:OF:MPP);T_3(50:42:8::WF:OF:CMPP);T_4(50:42:8::WF:OF:LMPP); T_5(50:40:10::WF:OF:CMPP);T_6(50:40:10::WF:OF:LMPP);T_7(50:38:12::WF:OF:CMPP);T_8(50:38:12::WF:OF:LMPP); T_9(50:36:14::WF:OF:CMPP); T_{10}(50:36:14::WF:OF:LMPP); T_{11}(50:34:16::WF:OF:CMPP) and T_{12}(50:34:16::WF:OF:LMPP). Chemical analysis of fresh mango peels, mango peel powders and wheat flour and oat flour were carried out. The result revealed that MPP had high contents of ash, fiber and polyphenols. The oat flour yielded higher contents of protein, fat, ash and crude fiber as compared to wheat flour sample. The processed product was stored at ambient conditions and subjected to chemical, microbial and sensory evaluations at an interval of one month for a period of three months.

The highest moisture content of 4.37 per cent was recorded in treatment T_{11}(50:34:16::WF:OF:CMPP) and lowest of 2.55 per cent in treatment T_1(100:0:0::WF:OF:MPP). Highest crude fiber content of 5.10 per cent was recorded in treatment T_{11}(50:34:16::WF:OF:CMPP) and lowest crude fiber content of 2.65 per cent was recorded in treatment T_1(100:0:0::WF:OF:MPP). The highest protein content of 8.77 per cent was recorded in treatment T_2(0:100:0::WF:OF:MPP) and the lowest of 6.99 was recorded in treatment T_{12}(50:34:16::WF:OF:LMPP) at 0 day storage. The highest crude fat content of 22.85 was recorded in treatment T_{11}(50:34:16::WF:OF:CMPP) and the lowest of 20.87 was recorded in treatment T_1(100:0:0::WF:OF:MPP). The treatment T_2(0:100:0::WF:OF:MPP) recorded the highest value of ash content of 2.42 per cent at initial day storage.The minimum and maximum carbohydrate content of 56.55 and 65.42 per cent was recorded in treatment T_2(0:100:0::WF:OF:MPP) and T_1(100:0:0::WF:OF:MPP), respectively. The highest total phenolic contentof 7.33 mgGAE/g was recorded in treatmentT_{11}(50:34:16::WF:OF:CMPP and lowest of 1.74 mgGAE/g was recorded in treatment T_1(100:0:0::WF:OF:MPP). The highest scavenging activity of 33.14 per cent was recorded in treatmentT_{11}(50:34:16::WF:OF:CMPP) and minimum value of 28.72 per cent was recorded in treatmentT_1(100:0:0::WF:OF:MPP).However, with the advancement of storage an increasing trend was observed in moisture content and carbohydrate. The decreasing trend was observed in crude fiber, crude protein, crude fat, ash, total phenolics and scavenging activity. No microbial count was observed at initial days. During 90days of storage the lowest microbial count was observed in treatment T_4(50:42:8::WF:OF:LMPP) and the highest in treatment T_1(100:0:0::WF:OF:MPP). On the basis of organoleptic evaluation among the blends, treatment T_5(50:40:10::WF:OF:CMPP)was adjudged best, scoring 7.47 for taste,7.51 for flavour and 7.29 for overall acceptability. Storage studies revealed that all the treatments could be kept for at least 90 days without affecting the quality attributes.

Key words: Biscuit, mango peel powder, oat, fiber

Signature of Major Advisor

Signature of Student

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LIST OF ABBREVIATIONS USED IN THIS MANUSCRIPT

***et al*.**	**et al (and others)**
°C	**Degree Celsius**
g	**gram**
mg	**milligram**
%	**per cent**
CRD	**Completely randomized design**
pp	**pages**
No.	**Number**
Fig.	**Figure**
C.D. (p=0.05)	**Critical difference at 5 per cent**
@	**at the rate of**
i.e.	**(that is)**
TPC	**Total plate count**
hrs	**hours**

Chapter-1

Introduction

CHAPTER-I

INTRODUCTION

Bakery industry in India is considered as one of the major food processing industry with an annual demand of over 2758 MT (Ministry of Food Processing Industries, 2013). India is known to be the second largest manufacturer of biscuits, first being USA.

Fruits and vegetables processing industry are generating million tons of agro industrial waste /byproducts per annum that not only creating a disposal problem but also aggravate the environmental pollution. Thus, their efficient, inexpensive and proper disposal is one of the fundamental pre-requisites for friendly ecosystem. Industrial residues especially fruits/vegetables peels are concentrated source of phytonutrients that have acquired core attention of the processors for their extraction and maximum recovery (Pinelo *et al*., 2006, Ajila *et al*., 2007).

Mango (*Mangifera indica* L.) is one of the most important fruits worldwide and is cultivated in more than 100 countries at both tropical and subtropical latitude, especially in Asia. The mango is indigenous to the Indian subcontinent and south-east Asia (Fowomola, 2010). Recognized for its attractive, delicious taste and exotic flavor, mango is a rich source of carotenoids and provides high contents of ascorbic acid, phenolic compounds and has been recognized as a 'king of the fruits'. Mango has its origin in India and approximately a thousand different types of mango fruits are produced in the country. The mango mainly constitutes pulp 33-70 % followed by kernel 7-24 % and peel 15-20 % of the fruit weight. Considering nutritional value, mango peel contains moisture, protein, ash, fiber and carbohydrates as 68.50, 2.05, 2.62, 5.40, and 26.5 per cent respectively and provides 453.92 Kj/100 g energy (Bede 2010; Ajila *et al*., 2007). Its peel is a promising source of phytonutrient such as polyphenols, carotenoids and Vitamin E&C. Interestingly, higher polyphenol contents are present in mango peel than that of pulp (Ajila *et al*., 2007).

Intake of dietary fiber and phytochemical such as polyphenols, carotenoids, tocopherols and ascorbic acid have been related to the maintenance of health and protection from diseases such as cancer, cardiovascular diseases and many other degenerative diseases. Dietary fiber incorporation prolong the shelf life, modify the

structural and physical characteristics of product such as texture, water and oil holding capacity as well as viscosity and sensory properties (Figuerola *et al*., 2005).

Oats (*Avena Sativa* L.) ranks sixth around the world cereals production statistics following wheat, maize, rice, barley and sorghum. The amount of oats used for human consumption has increased progressively, the fact health effects of oats benefits mainly on the dietary fibre and β-glucan content (Ahmad *et al*., 2014).The nutrition composition of oat per 100gm indicates carbohydrate 66g, dietary fiber 11g, fat 7 g, protein 17g, pantothenic acid (B_5) 1.3 mg, iron 5mg, magnesium 177g and β-glucan 54g. In addition to this it is also a rich source of amino acid, B vitamins and many minerals(Marquart and Coben, 2005)., Oats have numerous uses in food most commonly they are rolled or crushed into oatmeal or into fine oat flour. Though, oatmeal is chiefly eaten as porridge, but may also be consumed as raw and cookies.

Wheat (*Triticum aestivium* L.) is the major contributor of protein content of daily diet (Wahab *et al*., 2014). The chemical composition of wheat flour contains moisture 12.0, protein 10.0, fats 1.6, carbohydrate 72.6, fibre 1.3 and ash 1.4 g/100g respectively. In the recent years, an interest in the bakery products, with increased nutritional value, such as fibre enriched products has increased (Gomez *et al*., 2010). Biscuits are the most popularly consumed bakery items in the world. Some of the reasons for such wide popularity are their ready to eat nature, affordable cost, good nutritional quality, availability in different tastes and longer shelf life (Gandhi *et al*., 2001). Hassan *et al.* (2011) reported that the physio-chemical properties of the mango peel fiber rich powder make it a suitable by-product to be used in the preparations of a low calorie and high fiber food products, such as bakery products. Due to scientifically well documented health beneficial effects of dietary fibres and recommendations for an everyday intake on an average of 30 g by food (DRI 2005), the confectionery industry has been increasingly engaged in the production of fibre enriched biscuits with the aim to offer such a product as a valuable constituent of proper nutrition and dietetic functional food intended for risky populations.Keeping in view, present study was undertaken for the development of fiber rich oat-wheat flour blended biscuits using mango peel powders of two cultivars viz. Chausa and Langra at different levels to improve the nutraceutical properties of the developed product with the following objectives:

1. To analyze the chemical characteristics of raw material to be used.
2. To determine the effect of blending of oats on physico-chemical, microbial and sensory evaluation of developed product.
3. To estimate the shelf life and economics of the developed product.

Chapter-2

Review of Literature

CHAPTER-II

REVIEW OF LITERATURE

Biscuits are the most common bakery products preferred nearly by all levels of consumers. Different nutritionally rich ingredients can be incorporated in most of the bakery products for their diversity. Currently, the food sector has to deal with a high rate of food waste produced by industrial fruit processing of various products such as jams, wines, juices, ice cream, sweets, and others. Many researchers have used wheat bran, oat bran, rice bran, corn bran, whole grain rye, apple fibre, sugar beet fibre, carob fibre, psyllium husk fibre, flaxseed fibre, soy hull fibre etc. as a source of dietary fibre supplements in refined foods (Stojceska *et al*., 2008). This study for the preparation of fibre rich oat-wheat flour blended biscuit by incorporating mango peel powder will enhance the nutritional quality and improve the antioxidant properties of the biscuits. Therefore the available literature on the product development and storage related to other fibre enriched biscuit has been reviewed in this chapter.

2.1 Chemical characteristics of raw materials

Mango (*Mangifera indica* L.) is a popular fruit widely grown in tropical regions due to its sweet taste and high nutritive content (Kim *et al*., 2007). The mango mainly constitutes pulp 33-70% followed by kernel 7-24% and peel 15-20% of the total fruit weight. Considering nutritional value, mango peel contains moisture, protein, ash, fibre and carbohydrates as 68.50, 2.05, 2.62, 5.40 and 26.5% respectively and 453.92Kj/100g energy (Bede, 2010). Its peel is a promising source of phytonutrients such as polyphenol contents are present in mango peel than that of pulp (Ajila *et al*., 2007). Larrauri *et al.* (1996) studied the raw and ripe peels of Hayden variety of mango and observed higher TPC contents 70 mgGAE/ g in ripe peels as compared to 55 mg GAE/ g for raw peel. Arumugam and Manikandan (2011) evaluated the chemical composition of fruit wastes (pulp and peels) of Banana of Robusta variety and Mango of Alphonso variety, in order to explore their potential application in bio-ethanol production. It was observed that mango peel contains moisture content 59.98 per cent; crude protein 4.27 per cent and ash content 1.87 per cent respectively. Imran *et al*. (2013) reported moisture 68-71 per cent, protein 1.94-2.36 per cent, fat 2.11-2.31 per cent, fiber 4.53-5.47 per cent and ash 1.84-2.59 per

cent respectively in five different mango peels viz. chausa, anwar ratol, langra, dashehri and desi.

Ajila *et al.* (2007) reported values in mango peel powder of Badami and Raspuri varieties as moisture 10.5 per cent, fat content 2.2 per cent, total protein content as 3.6 per cent, total polyphenols 96.2 mg GAE/g MPP and free radical scavenging activity 79.6 µg MPP respectively. Ashoush and Gadallah (2011) reported that the mango peel powder of Zebda variety contains moisture 4.92 per cent, ash 3.88 per cent, fat 1.23 per cent, protein 3.6 per cent, crude fiber 9.33 per cent, total phenolics 19.06 mgGAE/g and scavenging activity as 93.89 per cent respectively. Aziz *et al***.** (2012) evaluated green and ripe mango var. Chokanan peel and pulp flours and reported that ripe peel flour contains moisture content, crude fiber, crude protein , crude fat and ash content were 6.2 per cent; 14.5 per cent; 1.8 per cent; 3.2 per cent and 3.2 per cent respectively. Baddi *et al.* (2015) reported the nutrient composition of mango peel powder of local mango variety as moisture 3.9 per cent protein 3.8 per cent, fat 2.61 per cent, crude fiber 8.9 per cent and ash as 3.29 g/ 100g respectively.

Refined wheat flour is the base ingredients in bakery products. Substitution of biscuits partially or completely with flours rich in nutrients or nutraceutical components enhance the nutritive quality of biscuits. Park *et al*. (1997) incorporated wheat fibre and psyllium husk fibre at 10 per cent level in preparation of bread. It was observed that fibre and antioxidant bread showed a 10 per cent reduction in loaf volume and slightly inferior crumb grain with an off- colour. However, crumb of fibre and antioxidant bread remained much softer than control and was well accepted for seven days of storage at room temperature. Rakha *et al*. (2010) characterised dietary fibre in rye products from a local supermarket. He reported that the soft breads generally had lower dietary fibre contents (8-18%) than had crisp breads (13-20%) due to high inclusion of wheat flour.

Oat (*Avena Sativa* L.) are rich source of dietary fiber but more importantly, oats are high in fiber, specifically, β- glucan, that has beneficial health effects. Sudha *et al*. (2007) studied the influence of fibre sources wheat, rice, oat and barley on rheological characteristics of biscuits. The samples ranged between 4-10 per cent ash content, total protein 12-14 per cent and dietary fibre content 20.5-49.5 per cent respectively. Highly acceptable biscuits could be obtained by incorporating 30 per

cent of oat bran and 20 per cent of barley bran. Vitali *et al*. (2009) studied the effect of incorporation of integral raw materials and dietary fibre on the selected nutritional and functional properties of biscuits and reported the total dietary fibre content ranged between 6.28 per cent in reference biscuit up to 14.48g/100g dry matter in biscuit containing oat fibre. El-Zainy *et al*. (2014) found that by incorporation of oat flour (20%) in bakery products increased the protective capacity against deleterious effects of oxidative stress.

2.2 Studies on fibre rich biscuits

Dietary fibre has found its pride place through the beneficial physiological actions. The recommended level of fibre in diet is 25-35g per day (Gorecka *et al*., 2000). However considering the regional variation, environmental effects, economical variations and food habits, the normal diet may provide fibre less than 15-20 g, which calls for the fibre rich foods. Several researchers have attempted the development of fibre rich products and their impact on functional properties.

Ranhotra *et al*. (1991) developed high fiber chocolate chip and oatmeal raisin cookies by substituting treated flour at 0, 50, 75 and 100 per cent levels with untreated wheat flour. The treated flour was prepared by exposing the flour to repeated autoclaving and cooling cycles. The total dietary fiber content in chocolate chip cookies increased from 1.50 per cent in control cookies to 3.50 per cent at 75 per cent treated flour incorporated cookies. However, in oat meal raisins cookies it ranged from 2.70 to 3.90 per cent.

Leelavathi and Rao (1993) developed high fibre rich biscuits, using wheat bran as a dietary fibre source. The dietary fibre content of these biscuits was about 7 times higher than the control biscuits. High fibre biscuits were wrapped in 10 gauge polypropylene pouches which had shelf life of about 90 days when stored at 27˚C and 60±2 per cent RH.

Arora and Camire (1994) used potato peels as a source of dietary fibre in muffins and cookies. It was found that potato peels reduced glycolalkaloid levels, which offer ability to prolong shelf life of the products with improved dietary fibre profile as compared to the control samples.

Yahya (2004) developed low fat, mung bean and chickpea (25% each) cookies with 40 per cent sago flour as a fat replacer. The cookies exhibited higher dietary fiber (5.38%) and trypsin inhibitor activity (3.76%) but low protein digestibility (70.16%).

Larrea *et al*. (2005) studied the functional properties of extruded orange pulp and its effect on the quality of cookies and reported that the biscuits made with 5,15 and 25g/100g extruded orange pulp were good alimentary fibre sources.

Arshad *et al*. (2007) replaced wheat germ flour with defatted wheat germ flour at 0 to 25 per cent levels. The cookies containing 15 per cent defatted germ flour was highly acceptable. At this level of substitution, cookies exhibited higher protein (14.02%) and crude fiber (3.01%) contents than the control wheat biscuits (11.80 and 2.33% for proteins and crude fiber, respectively.

Ajila *et al*. (2008) developed soft dough biscuits using different levels (5-20%) of Mango peel powder (MPP). It was reported that total dietary fiber increased from 6.5% to 20.7% at incorporation of 20 per cent MPP. The acceptable biscuits with mango flavour were obtained at 10 per cent MPP

Mridula and Gupta (2008) developed high fiber biscuits by substituting bajra flour at 10 to 50 per cent in wheat flour fortified with 5 per cent defatted soy flour. It was reported that with increase proportion of bajra flour, the thickness and spread ratio of biscuit decreased. This was attributed to high fiber and low dough strength of bajra flour blends. Bajra flour biscuits recorded high crude fiber (1.08%), fat (24.16%) and ash (1.41%) than the control biscuits (0.36, 22.10 and 1.15% of crude fiber, fat and ash respectively). However, protein content of bajra biscuits was less (6.53%) than control biscuits (7.11%).

Chaudhary and Awasthi (2009) developed high fiber biscuits with parboiled rice bran (PRB) at 15 to 35 per cent levels. Sensory scores of 30 per cent PRB incorporated biscuits were >7.0 for colour, flavour, texture and overall acceptability. Biscuit with 30 per cent PRB contained protein (7.31%), fat (20.30%), crude fiber (3.20) total dietary fiber (11.81%) which were higher than control biscuits.

Shariff *et al*. (2009) developed high fiber and mineral enriched cookies by supplementing defatted rice bran in wheat flour at 0 to 50 per cent level. It was reported that cookies with rice bran (20%) were highly acceptable. Beyond 20 per

cent, sensory scores for all sensory attributes decreased significantly. The dietary fiber was found maximum 11.01 per cent in (50% DFRB) as compared to 2.56 per cent in control cookies.

Jisha *et al*. (2010) studied nutritional and textural studies on dietary fiber-enriched muffins and biscuits from cassava-based composite flours. High dietary fiber content of 2.77-3.44 per cent and 3.20-3.40 per cent, was obtained in muffins and biscuits made from cassava-bran blends.

Gorecka *et al*. (2010) used two sorts of raspberry powder crumbled and non-crumbled as a source of potential fibre for cookies enrichment. The preparations were used as replacement of flour at the level of 25 and 50 per cent. Among the cookies tested, the largest amount of dietary fibre was to be found in cookies with 50 per cent of the non crumbled raspberry powder.

Kohajdova *et al*. (2011) studied the effect of the commercial apple fibre powder on the baking and sensory properties of cookies Addition of apple fibre powder significantly altered rheological parameters of dough by increasing water absorption, dough development and dough stability, however mixing tolerance index was reduced. It revealed that apple fibre powder addition resulted in notable decreasing lightness and addition of redness of cookies.

Turksoy *et al*. (2011) analyzed the effect of black carrot fiber addition on the composition and quality characteristics of cookies. Fiber from BC powder was incorporated into flour at different levels (0,5, 10 and 15%). When the BC powder was incorporated at the rate of 15 per cent, it increased the total dietary fiber contents from 0.93 to 3.72 per cent. The black carrot fiber also increased the polyphenol content and antioxidant activity of the cookies and these values, respectively, increased 5 and 5.5 times greater at the level of 15 per cent.

Kumar and Kumar (2011) dried carrot pomace and incorporated its powder as a source of fibre in fine wheat flour at different proportions (0-9%). It was observed that moisture varied from 4.03 to 4.79 per cent. The average L*, a*, b* values ranged from 51.535 to 61.206, 11.205 to 15.595, 31.65 to 35.27 with average values of 55.3275, 13.84625 and 34.18375 respectively. The hardness ranged from 41.047 to 116N with an average value of 81.499N. It was further observed that moisture

content, hardness and L*, a* values increased with increase in proportion of carrot powder in cookies.

Abdeldaiem and Hoda (2012) incorporated irradiated mango peel dietary fibre into beef burger at different levels (3, 6, 9 and 12 %) and reported that, mango peel dietary fiber samples contained high amounts of extractable polyphenols and soluble dietary fiber especially irradiated sample at dose level of 3kGy.

Nagi *et al*. (2012) studied the effect of storage period and packaging on the shelf life of cereal bran incorporated biscuits using full fat and defatted cereal bran with flour to produce nutrtitive biscuits. On the basis of quality 20 per cent was selected best. The product remained in high acceptable range upto 3 months. It was concluded that cereal bran(full fat and defatted) i.e., wheat, rice, corn, barley and oats as a source of dietary fibre and can be added without adversely affecting the physiochemical and sensory quality of biscuits.

Aslam *et al*. (2014) utilized mango waste materials (peel and kernel), both in powder form to enhance dietary fibre content and antioxidants properties of biscuits. The crude fibre were improved from 0.22 -16.79 % by addition of mango peel and kernel powder.

2.3 Storage studies

2.3.1 Moisture

Mc Kechnie (1983) reported that oats have an excellent moisture retention property that keeps bread fresher for longer period.

Leelavathi and Rao (1993) developed high fibre rich biscuits, using wheat bran as a dietary fibre source and reported that high moisture pickup of biscuit containing bran during storage was due to its greater hygroscopicity in wheat bran.

Goyale and Gujral (1993) studied the keeping qualities of biscuits produced from malted and raw wheat Bengal gram (4:1) with or without 7.50g colocassia leaf powder. The biscuits were packed in low density polyethylene packets, kept at accelerated conditions (37˚C and 90 % RH) and at room temperature for one month. The study revealed that the moisture content ranged between 4.22 and 4.54 per cent.

Under accelerated conditions, biscuits became soggy after 14 days; but were crisp at ambient.

Hemalatha *et al*. (2006) evaluated little millet biscuits for storage quality. The study indicated that the biscuits packed in metalized polyester polyethylene laminated pouches stored for 120 days under ambient conditions exhibited increased acidity and moisture content. The millet (30.00%) incorporated cookies through recorded higher moisture (4.04%) than the control cookies (3.82%), the levels were within the critical levels at the end of storage.

Nagi *et al*. (2012) studied the effect of storage and packaging on the shelf life of cereal bran incorporated biscuits and found that the mean moisture of biscuits at the beginning of storage was 2.33 per cent which increased significantly to 4.09 per cent as the storage period approached three months.

Aslam *et al*. (2014) concluded that by incorporating mango peel powder, biscuits showed significant changes during storage. The minimum moisture was observed at 0 day with 2.30 per cent and highest moisture content 2.36 per cent was recorded at 30^{th} day of storage.

Divyashree *et al*. (2016) developed buckwheat-Chia seeds fortified biscuits and reported increase in moisture content from 2.64 per cent to 2.81 per cent at the end of 60 days. The increase in moisture content might be due to the hygroscopic nature of biscuits, storage environment (temperature, relative humidity) and the nature of packaging material used.

2.3.2 Crude fiber

Leelavathi and Rao (1993) studied the development of high fibre biscuit using wheat bran. The study indicated that flour could be substituted with raw wheat bran up to 30 per cent level, as a source of dietary fibre. The dietary fibre content of these biscuit was about 7 times higher than that of the control biscuits. High fibre biscuits wrapped in 100 gauge polypropylene pouches had a shelf life of about 90 days when stored at 27(±2˚C) and 60(±2 per cent) relative humidity(RH).

Pasha *et al*. (2002) prepared cookies by replacing sucrose with dietetic sweeteners fructose, sorbitol and mannitol. The chemical analysis revealed that the crude fibre content decreased from 0.13-0.08 during 60 days of storage.

Sujirtha and Mahendran (2015) blended defatted coconut flour as a source of protein and dietary fibre with wheat flour at different levels(0,10,20,30,40 and 50%) to prepare nutritive biscuits. Fiber content of biscuits ranged from 8.26 to 12 per cent when defatted flour was incorporated from 0 to 50 per cent. Fiber content of stored biscuits decreased significantly during the storage period of 14 weeks.

2.3.3 Crude protein

Pasha *et al*. (2002) studied the effect of dietetic sweeteners on the quality of cookies and reported decrease in protein content from 6.52 to 6.41 during 60 days of storage.

Aslam *et al*. (2014) studied the utilisation of waste material (peel, kernel) to enhance dietary fiber content and antioxidant properties of biscuit and reported decrease in crude protein content from 7.60 to 7.48 during 30 days of storage.

2.3.4 Crude Fat

Kumar *et al*. (2014) prepared biscuits with commercially available fat (CF) and oryzanol fortified fat (OFF) and analysed its stability during storage of 120 days. The crude fat content of control biscuits (12.2 %) and oryzanol fortified biscuits (12.5 %) indicated that there was a very small change in crude fat content at the various relative humidity conditions. The variance analysis of fat content showed that there was no significant difference ($p>0.05$) in the fat content during storage at different relative humidities.

Sujirtha and Mahendran *et al*. (2015) studied the influence of storage conditions on the quality characteristics of wheat-defatted coconut flour biscuits and reported decrease in fat throughout the storage period. Reduction was due to the oxidation of unsaturated fatty acids with atmospheric oxygen and moisture uptake.

Chugh *et al*. (2016) developed low fat biscuits containing protein based fat replacer (Simpleese) and reported that during three months of storage, low fat biscuit

was found more oxidative stable due to their less increase in free fatty acid value and peroxide value and was found more acceptable than control biscuit.

2.3.5 Ash

Pasha *et al*. (2002) studied the effect of dietetic sweeteners on the quality of cookies and reported a decrease in ash content (0.53- 0.36) in the 60 days of storage.

Sharif *et al*. (2005) extracted oil from rice industrial waste and studied its effect on physico-chemical characteristics of cookies and found that storage has non-significant effect on ash content of biscuits. At 0 day, the mean ash content for all the treatment was 0.74 per cent which decreased non-significantly to 0.64 after 45 days of storage.

Aslam *et al*. (2014) developed biscuits by using mango peel powder and mango kernel powder and reported that there were non-significant changes in ash content (0.981-0.943) during 30 days of storage.

Sujirtha and Mahendran *et al*. (2015) reported that the ash in all treatments had very little changes throughout the storage. In other words, ash content decreased significantly ($p<0.05$) throughout 14 weeks of storage.

2.3.6 Total phenolic content

Magda *et al*. (2008) evaluated Mandarin and navel orange peels as natural sources of antioxidant in biscuits at three levels of supplementation (5, 10 and 15%) reported that the mandarin orange peel had higher total polyphenol content (780 mg/100gm) as compared to navel orange peels which had 670 mg/100gm. The addition of navel orange and mandarin peel powder increased the shelf life of biscuits as compared to the control.

Ashoush and Gadallah (2011) reported increase in the phenolic content from 3.84 to 24.37 mg/g in biscuits incorporated at different levels of mango peel powder (5,10,15 and 20%) and mango kernel powder (20,30,40 and 50%)

Oral *et al*. (2014) studied the effect of certain polyphenols and extract on furans and acrylamide in model system and total furans during storage. The polyphenols and extracts were used in biscuit formulation and acrylamide formation

was observed. All phenolic compounds and plant extracts decreased in the range of 30.8-85% in the model system except for oleuropein, and all of them decreased in the range of 10.3-19.2% in biscuit.

2.3.7 Scavenging activity

Nanditha *et al*. (2008) studied the influence of natural antioxidants and their carry-through property in biscuit processing. Among the five different natural antioxidants viz. hexane (G-1) and chloroform (G-2) extracts of Garcinia, Peltophorum ferrugineum flower extract (FE), turmeric powder (C-1) and curcumin (C-2), used in biscuit preparation in the place of synthetic ones, and carry-through properties were evaluated during processing and storage, hexane extract from Garcinia (G-1) was found to be more suitable for biscuit making and retains antioxidant activity of 36.31% after baking; storage loss was found to be 46.25%.

Gupta *et al*. (2011) prepared cookies by incorporating 10, 20, 30 and 40 per cent barley flour into wheat flour and evaluated the same for their total antioxidant capacity and reported that with the incorporation of barley flour the antioxidant property was increased and hence increased functional properties of the cookies as compared to the control.

Sharma and Gujral (2014) studied the antioxidant properties of cookies prepared from the blended flours of wheat and barley in the ratios of 100:0, 75:25, 50:50, 25:75 and 0:100 and reported that as the level of barley flour increased, increased the antioxidant activity from 8.8 to 17 per cent in the blend. Baking further increased the antioxidant activity upto 22.3 per cent.

2.4 Microbial growth

Hozova *et al*. (1997) studied the microbiological, nutritional and sensory aspects of amaranth biscuits and crackers and reported an increase of 2.1 x 10^2 cfu/g to 1.3 x10^6 cfu/g in the amount of aerobic mesophilic bacteria in the biscuit during three months of storage.

Nagi *et al*. (2012) observed that the total plate count on nutrient agar medium was found nil for fresh biscuits before storage of different cereal bran biscuits under ambient conditions. Oat bran biscuits had least bacterial count (11.15 x 10^2 cfu g^{-1})

whereas rice bran biscuits had maximum bacterial count (21.68 x 10^2 cfu g^{-1}). Storage period showed significant effect on the microbial quality of biscuits. The count increased 1.98 x 10^2 cfu g^{-1} to 62.92 x 10^2 cfu g^{-1}) after three months of storage.

Desayi (2012) studied the microbial load of mushroom fortified biscuits as influenced by different treatments at 15 days and 30 days after storage and reported that there was significant increase in the total plate count of biscuits during storage of 30 days. Least bacterial population 0.7 x 10^2 and 1.1 x 10^2 cfu per gram was observed in bakery recipe along with fortification of 10 per cent mushroom powder + 0.2 per cent vanilla flavour at 15 days and 30 days after storage, respectively. The highest bacterial population was observed in control 2.0 x 10^2 and 2.4 x 10^2 cfu per gram at 15 days and 30 days after storage, respectively.

Banusha and Vasantharuba (2014) reported that bacterial count was found as 6.8×10^2 cfu/g and 2.3×10^2 cfu/g for wheat flour biscuit (WB) and composite biscuit (CB) after 1 month of storage period. After 2 months of storage period, bacterial count was found to be 9.6×10^2 cfu/g and 3.6×10^2 cfu/g for WB and CB respectively. This safe limit was satisfied by both WB and CB samples up to 2 months of storage period.

2.5 Sensory Evaluation

Hooda and Jood (2005) studied the organoleptic and nutrition evaluation of wheat biscuit supplemented with untreated and treated fenugreek flour. The sensory results showed that a maximum of 10% fenugreek flour can be incorporated to prepare acceptable quality biscuits. These biscuits can be safely stored in polypropylene bags upto 1 month without altering their organoleptic properties

Raju *et al*. (2007) studied the storage quality of whey protein incorporated cookies (0.00 to 30.00 %), stored at ambient condition for 60 days, packed in metalized polypropylene. In 60 days storage period, sensory scores decreased gradually.

Ajila *et al*. (2008) incorporated mango peel powder in soft dough biscuits at different levels (5, 10, 15 and 20%). Acceptable biscuits with mango flavour were obtained by incorporating 10 per cent mango peel powder.

Nassar *et al*. (2008) studied the effect of citrus by- products on chemical, rheological and organoleptic characteristics of biscuits. Sensory evaluation of biscuit revealed that, biscuit with 5 and 15 per cent orange pulp- and peel had the highest level of acceptance for all sensory characteristics.

Banureka and Mahendran (2009) evaluated the quality characteristics of protein enriched biscuits which could be used as protein supplemented cereal snack food. Organoleptic evaluation indicated that there were no significant ($p<0.05$) differences between the control treatment and 10% soy flour supplemented biscuits in the organoleptic attributes of taste, texture and flavour but differences were significant in colour and overall acceptability. From the overall acceptance rating, 10% soybean flour incorporated biscuit obtained the highest preference compared to other combinations.

Ashoush and Gadallah (2011) utilized mango peel powders (MPP) and Mango kernel powders (MKP) as source of phytochemical in biscuit. Sensory evaluation studies showed that the surface colour and appearance of biscuits containing up to 10 per cent of MPP and 40 per cent of MKP were acceptable as those of control biscuits.

Chappalwar *et al*. (2013) made cookies with oats and finger millet based composite flour. The sensory score revealed that replacement of oat and finger millet flour has significant effect on almost all characteristics of the cookies. The product was regularly evaluated for its sensory quality at every 15 days of interval. It was concluded that oat and finger millet flour can be replaced up to 30% and 40% without any change in physical, chemical and organoleptic attributes of cookies.

Chapter-3

Materials and Methods

CHAPTER-III

MATERIALS AND METHODS

The present study entitled "Development of fibre rich oat-wheat flour blended biscuits using mango peel" was carried out in the Division of Food Science and Technology, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, during 2016-17. This chapter contains relevant information pertaining to research design and methodologies used for conducting the present study.

3.1 Raw material

Wheat flour, oat flour, mango peel powder, sugar, vegetable fat, sodium bicarbonate and skimmed milk powder were used for the development of fibre rich biscuits.

3.1.1 Collection of raw materials

Two mango cultivars viz. Chausa and Langra of good quality were procured from Narwal Mandi, Jammu and transported to Division of Food Science and Technology, SKUAST-J for processing. Wheat flour, oat flour and other ingredients were purchased from local market, Jammu.

3.2 Mango peel powder

The peel was removed by sharp knife. The fresh peel thus obtained was analysed. The peels were spread in trays and dried in hot air oven at 60-65˚C for 18 hrs to a moisture content around 10 %. The dried peels were powdered using a hammer mill and sieved through a 150mm sieve and packed in air tight polypropylene jar and stored in cool and dry place.

3.3 Fibre rich biscuits

Wheat flour, oat flour and mango peel powder were blended together in different ratios as per treatment given in the below table

Treatments	Wheat flour (g)	Oat flour (g)	Mango peel powder (g)	Cultivars
T_1	100	0	0	-
T_2	0	100	0	-
T_3	50	42	8	Chausa
T_4	50	42	8	Langra
T_5	50	40	10	Chausa
T_6	50	40	10	Langra
T_7	50	38	12	Chausa
T_8	50	38	12	Langra
T_9	50	36	14	Chausa
T_{10}	50	36	14	Langra
T_{11}	50	34	16	Chausa
T_{12}	50	34	16	Langra

3.3.1 Development of biscuits

Biscuits were prepared by using wheat flour, oat flour and mango peel powder at different ratios with other basic ingredients of biscuits like vegetable fat, sugar, baking powder, skimmed milk powder, dextrose, sodium chloride and water. The powdered sugar and fat were creamed with a flat beater for 3 min. Sodium chloride was dissolved in water and added. Skimmed milk powder was made into a suspension in the water and transferred to the cream. The contents were mixed and sieved flour was added to the cream and kneaded to form dough. Dough was sheeted to a thickness of 3.5 mm, cut using a circular mould (51 mm diameter) and baked at 205°C for 10 minutes on a greased tray. After baking, biscuits were cooled to room temperature and were wrapped tightly with laminated pouches for a period of 90 days at ambient temperatures.

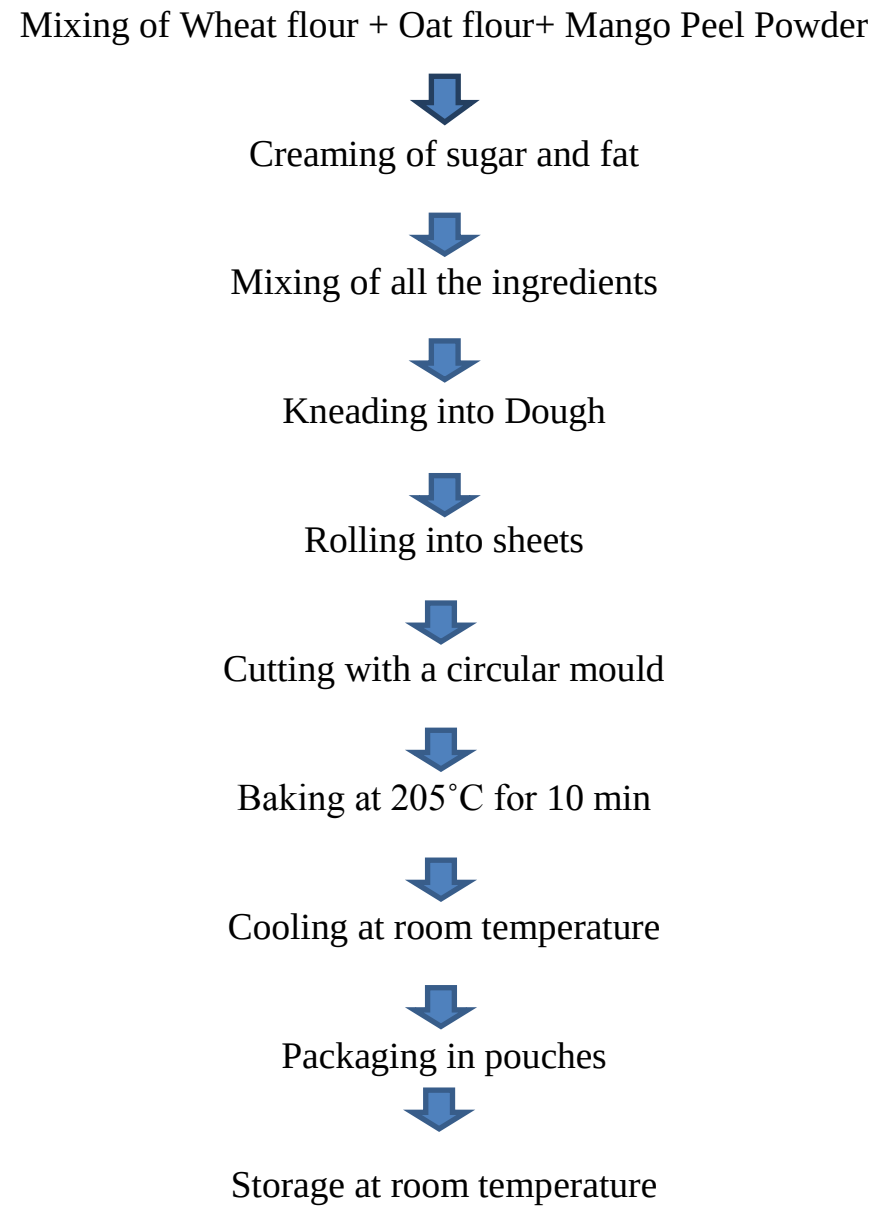


Fig. 1: Flow chart for the preparation of fibre rich biscuits

The samples were evaluated for physico-chemical, microbial and sensory parameters during 90 days of storage at an interval of 30 days.

3.4 Physical parameters of biscuits

Diameter and thickness of biscuits were measured using vernier caliper. Spread ratio was calculated according to AACC method (1999) by dividing the average value of diameter by the average value of thickness of biscuits.

3.5 Chemical parameters

3.5.1 Moisture content

Moisture content was estimated by drying 10 g sample in pre-weighed aluminium moisture boxes in hot air oven at 130±1˚C for 1 hour till constant weight. Dried samples were cooled down to room temperature by keeping the boxes in desiccator prior to weighing (AOAC,2002) and the difference in weight was expressed as per cent moisture content and was calculated as per the given formula:

$$\text{Moisture Content (\%)} = \frac{\text{Loss in weight (g)}}{\text{Weight of sample (g)}} \times 100$$

3.5.2 Crude fiber

2g fat free dried sample was taken in a beaker to which 200ml of 1.25 per cent sulphuric acid was added. Beaker along with contents was placed on hot plate and boiled for 30 minutes. After boiling, the contents of the beaker were filtered through Whatman filter paper no.4. The filter paper was then transferred in a beaker containing 200 ml of 1.25 per cent sodium hydroxide. The contents weighed again were allowed to digest for 30 minutes then filtered and washed again with hot water and alcohol thrice till free of alkali. The residue was then transferred in pre-weighed silica crucibles followed by drying in hot air oven at 100˚ C. The crucibles were then kept in muffle furnace and ignited for 30 minutes at 600±15˚C followed by cooling and weighing. The loss in weight after ignition represents the crude fiber (AOAC, 2002) and was calculated as follows:

$$\text{Crude fiber (\%)} = \frac{\text{Loss in weight on ignition (g)}}{\text{Weight of sample (g)}} \times 100$$

3.5.3 Crude protein

Crude protein was estimated by micro-Kjeldahl method, using the factor 6.25 for converting nitrogen content into crude protein (Sadasivam and Manickam, 2008). Weighed sample of 2g was digested with concentrated sulphuric acid (2ml) and 2g of catalyst mixture (K_2SO_4, $CuSO_4$ and SeO_2) in long neck Kjeldahl flask for 2 hours till free from carbon. The contents were cooled and transferred to 100ml volumetric flask and volume was made to 100ml with distilled water. Measured aliquot was distilled with 40 per cent sodium hydroxide and liberated ammonia was collected through a condenser in a flask containing 10 ml 4 per cent boric acid solution and a few drops of mixed methyl red and bromocresol green indicator (AOAC, 2002) and was titrated against standardized 0.1 N sulphuric acid and protein content was calculated using the equation given below. A blank sample was also run along with the sample.

$$N(\%) = \frac{\text{Titre value x 0.00014 x Volume made}}{\text{Aliquot taken (g) x weight of sample (g)}} \times 100$$

Crude Protein = N (%) x 6.25

3.5.4 Crude fat

5g of dried sample was extracted with petroleum ether at 120˚C in Soxhlet extraction apparatus for 6 hours. The ether extract was filtered in pre-weighed beakers. Petroleum ether was completely evaporated from the beakers and the increase in weight of beaker represented the fat content (AOAC, 2002) and was calculated as below:

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

3.5.5 Total Carbohydrate

Amount of carbohydrate was calculated by difference method as subtracting the total sum of moisture content, crude protein, crude fat, ash and crude fibre from 100 (AOAC,2002)

3.5.6 Ash

Ash was determined gravimetrically by taking 5 g of sample in pre-weighed silica crucibles followed by incineration over hot plate under open atmosphere to

make it smoke free and ashing in muffle furnace at 600˚C for 4 hours. The crucibles were allowed to cool down. The crucibles, along with the ash were taken out, kept in desiccator and weighed till constant weight. The difference between the weight of empty silica crucible and with ash was the amount of total ash (AOAC, 2002). The per cent ash was calculated using the following formula:

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

3.5.7 Total phenolics

Total phenolic content of the extracts was determined colorimetrically, using the Folin-Ciocalteu method, as described by (Singelton *et al.*, 1999). Aliquots of 0.5 ml of the extract were added to 0.5 ml of Folin-Ciocalteu reagent, followed by addition of 0.5 ml of an aqueous 7.5% solution of sodium carbonate. The mixture was stirred and allowed to stand for 30 min. The absorbance at 765nm was measured by using UV 1601 spectrophotometer (Shimadzu). A blank sample consisting of distilled water and reagents was used as a reference. The results were expressed as milligrams of gallic acid equivalents per gram powder (mg GAE/g powder) by reference to the gallic acid calibration curve using the following equation:

$Y= 0.0158+ 0.0917X \qquad r^2= 0.99$

3.5.8 Scavenging Activity

The antioxidant activity was determined by DPPH (2,2,-diphenyl-1-picryihydrazyl) scavenging activity using DPPH as a free radical (Brand-Williams *et al.*,1995). 100µl of sample extract solution was added to 1 ml of 0.01 mm DPPH in methanol. The control sample contains all the reagents except extract. The mixture was shaken vigorously and left in the dark at room temperature for 20 min. The reaction solution was examined at 515 nm using a spectrophotometer. Free radical scavenging activity of the sample was determined in the same way with a concentration ranging from 25 to 100mg. The capacity to scavenge DPPH radicals was calculated by the following equation:

$$\text{Scavenging activity (\%)} = \frac{(Abs_{control} - Abs_{sample})}{Abs_{control}} \times 100$$

Where, Abs_{contol}= absorbance of control and Abs_{sample} = absorbance of sample

3.6 Microbial Count

Total plate count (TPC) was made as per the standard method (Ranganna, 2006) using nutrient agar medium. Serially diluted sample (0.1g) of appropriate dilution was used for inoculation of medium in petri plates followed by pouring of total plate count agar (10-15 ml) under sterilized conditions of laminar air flow. The plates were then incubated at 25±2˚C for 48 hours prior to counting. The results of total plate count (TPC) were expressed as log colony forming units (log cfu) of sample.

3.7 Sensory evaluation

The samples were evaluated on the basis of colour, texture/ body, taste and overall acceptability by semi-trained panel of 9-10 judges using 9 point hedonic scale assigning scores 9- like extremely to 1-dislike extremely (Appendix-I). A score of 5.5 and above was considered acceptable (Amerine *et al*. 1965).

3.8 Economics of the product

The cost of the product was determined by taking into consideration the cost of raw materials, chemicals and packaging materials etc. used in the preparation of the product.

3.9 Statistical analysis

The results obtained were statistically analysed using completely randomized design (OP Stat software) for interpretation of results through analysis of variance (Gomez and Gomez, 1984)

Chapter-4

Results

CHAPTER-IV

EXPERIMENTAL RESULTS

The present investigation entitled "Development of fibre rich oat-wheat flour blended biscuits using mango peel" was carried out in the Division of Food Science and Technology, SKUAST, Jammu, FOA Chatha. The results obtained from the present study are as under:

4.1 Chemical characteristics of raw material:

The proximate analysis of fresh mango peel samples of Chausa and Langra in Table 1, revealed that the moisture content, crude fiber, crude protein, crude fat, carbohydrate and ash were 69.63 and 68.26 per cent; 5.02 and 4.82 per cent; 2.21and 1.98per cent; 2.34 and 2.20 per cent; 23.93 and 25.88 per cent and 2.56 and 2.32 per cent respectively. The total phenolics and scavenging activity were reported as 84.14 and 78.01mg GAE/g and 67.23 and 58.13 per cent respectively. Whereas, the proximate composition of mango peel powder in Table 2 showed that moisture content, crude fiber, crude protein, crude fat, carbohydrate and ash were 6.98 and 6.23 per cent; 8.71 and 7.76 per cent; 2.88 and 2.61per cent; 2.31 and 2.20 per cent; 86.59 and 87.94 per cent; 3.26 and 3.02 per cent respectively. The total phenolics content and scavenging activity were observed to be 64.6 and 60.4 per cent and 53.30 and 45.6 per cent respectively.

The proximate composition of wheat flour and oat flour in Table 3 revealed that the moisture content, crude fiber, crude protein, crude fat, carbohydrate and ash were 10.80 and 7.41 per cent; 1.29 and 4.27 per cent; 10.72 and 13.48 per cent; 1.13 and 5.87 per cent; 75.17 and 70.51 per cent and 1.46 and 1.73 per cent respectively. The total phenolics content and scavenging activity were recorded as 1.78 and 6.01 and 30.3 and 32.9 respectively.

4.2 Physical parameters of fibre rich biscuits

The data pertaining to the physical parameters of the fibre rich biscuits shown in Table 4 reflects that the diameter of the biscuit ranged from 50 mm to 56.5 mm in treatment T_{12} (50:34:16::WF:OF:LMPP) and in treatment T_2 (0:100:0::WF:OF:MPP. The maximum thickness of 7.00 mm was observed in treatment

Table 1: Chemical parameters of fresh mango peel

S.No.	Parameters	Chausa	Langra
1.	Moisture (%)	69.63	68.26
2.	Crude Fiber (%)	5.02	4.82
3.	Crude Protein (%)	2.21	1.98
4.	Crude Fat (%)	2.34	2.20
5.	Total Carbohydrate (%)	23.93	25.88
6.	Ash (%)	2.56	2.32
7.	Total phenolics (mg GAE/g)	84.14	78.01
8.	Scavenging activity (%)	67.23	58.13

Table 2: Chemical parameters of mango peel powder

S.No.	Parameters	Chausa	Langra
1.	Moisture (%)	6.98	6.23
2.	Crude Fiber (%)	8.71	7.76
3.	Crude Protein (%)	2.88	2.61
4.	Crude Fat (%)	2.31	2.20
5.	Carbohydrate (%)	86.59	87.94
6.	Ash (%)	3.26	3.02
7.	Total phenolics (mg GAE/g)	64.6	60.4
8.	Scavenging activity (%)	53.30	45.6

Table 3: Chemical parameters of wheat flour and oat flour

S.No.	Parameters	Wheat flour	Oat flour
1.	Moisture (%)	10.80	7.41
2.	Crude Fiber (%)	1.29	4.27
3.	Crude Protein (%)	10.72	13.48
4.	Crude Fat (%)	1.13	5.87
5.	Total Carbohydrate (%)	75.17	70.51
6.	Ash (%)	1.46	1.73
7.	Total phenolics (mg GAE/g)	1.78	6.01
8.	Scavenging activity (%)	30.3	32.9

T_{11}(50:34:16::WF:OF:CMPP) and minimum of 6.30 mm was observed in treatment T_1 (100:0:0::WF:OF:MPP). The spread ratio was found maximum of 8.75 in treatment T_3 (100:0:0::WF:OF:CMPP) and minimum of 7.19 in treatment T_{12} (50:34:16::WF:OF:LMPP).

4.3 Chemical characteristics of fibre rich biscuits

4.3.1 Moisture Content

The moisture content of different treatments in Table-5 depicted a significant increase in moisture content during storage. At the beginning the highest moisture content of 4.37 per cent was recorded in treatment T_{11} (50:34:16::WF:OF:CMPP) and lowest of 2.55 per cent in treatment T_1 (100:0:0::WF:OF:MPP). After 90 days of storage the highest moisture content of 5.11 per cent was recorded in T_{11} (50:34:16::WF:OF:CMPP) and minimum moisture content of 3.34 per cent in treatment T_1 (100:0:0::WF:OF:MPP). The mean value of storage period showed a significant increase from initial value of3.76 to 4.39 per cent during 90 days of storage.

4.3.2 Crude fiber

It is evident from Table-6 that treatments significantly influenced crude fiber content of fibre rich biscuits. At initial day of storage the maximum value of 5.10 was recorded in treatment T_{11} (50:34:16::WF:OF:CMPP) and minimum value of 2.65 was recorded in treatment T_1 (100:0:0::WF:OF:MPP) which decreased significantly to 4.71 and 2.28 per cent after 90 days of storage respectively. The mean value of crude fiber content decreased from 4.69 at initial day of storage to 4.34 per cent after 90 days of storage.

4.3.3 Crude protein

The data pertaining to crude protein content of different treatments in Table -7 revealed that the highest value of 8.77 per cent was recorded in treatment T_2 (0:100:0::WF:OF:MPP) and minimum and the lowest of 6.99 was recorded in treatment in T_{12} (50:34:16::WF:OF:LMPP) at 0 day storage After 90 days of storage period treatment T_2 (0:100:0::WF:OF:MPP) recorded highest value of 8.60 per cent followed by treatment T_3 (50:42:8::WF:OF:CMPP) with crude protein content of 7.05

Table 4: Physical parameters of fibre rich biscuits

Treatments	Diameter(mm)	Thickness(mm)	Spread Ratio
T_1 (100:0:0::WF:OF:MPP)	**55.0**	**6.30**	**8.73**
T_2 (0:100:0::WF:OF:MPP)	**56.5**	**6.50**	**8.69**
T_3 (50:42:8::WF:OF:CMPP)	**56.0**	**6.40**	**8.75**
T_4 (50:42:8::WF:OF:LMPP)	**55.5**	**6.35**	**8.74**
T_5(50:40:10::WF:OF:CMPP)	**55.0**	**6.50**	**8.46**
T_6(50:40:10::WF:OF:LMPP)	**54.0**	**6.45**	**8.37**
T_7(50:38:12::WF:OF:CMPP)	**52.5**	**6.65**	**7.89**
T_8(50:38:12::WF:OF:LMPP)	**52.0**	**6.60**	**7.88**
T_9(50:36:14::WF:OF:CMPP)	**51.5**	**6.85**	**7.52**
T_{10}(50:36:14::WF:OF:LMPP)	**51.0**	**6.75**	**7.56**
T_{11}(50:34:16::WF:OF:CMPP)	**50.5**	**7.00**	**7.21**
T_{12}(50:34:16::WF:OF:LMPP)	**50.0**	**6.95**	**7.19**

WF: Wheat Flour OF: Oat flour MPP: Mango Peel Powder CMPP: Chausa Mango Peel Powder LMPP: Langra Mango Peel Powder

Table 5: Effect of treatments and storage period on moisture content (%) of fibre rich biscuits

Treatments	Storage period(days)				Mean
	0	30	60	90	
T_1 (100:0:0::WF:OF:MPP)	2.55	2.71	2.94	3.34	2.89
T_2 (0:100:0::WF:OF:MPP)	2.94	3.14	3.45	3.76	3.32
T_3 (50:42:8::WF:OF:CMPP)	3.46	3.65	3.85	4.35	3.83
T_4 (50:42:8::WF:OF:LMPP)	3.38	3.44	3.74	4.20	3.69
T_5(50:40:10::WF:OF:CMPP)	3.89	4.02	4.15	4.42	4.12
T_6(50:40:10::WF:OF:LMPP)	3.71	3.84	4.04	4.24	3.96
T_7(50:38:12::WF:OF:CMPP)	4.04	4.15	4.26	4.53	4.24
T_8(50:38:12::WF:OF:LMPP)	3.93	4.06	4.21	4.50	4.19
T_9(50:36:14::WF:OF:CMPP)	4.27	4.44	4.53	4.64	4.47
T_{10}(50:36:14::WF:OF:LMPP)	4.20	4.34	4.48	4.59	4.41
T_{11}(50:34:16::WF:OF:CMPP)	4.37	4.67	4.86	5.11	4.75
T_{12}(50:34:16::WF:OF:LMPP)	4.31	4.55	4.65	5.03	4.63
	3.76	3.92	4.10	4.39	

Factors C.D.	(p=0.05)
Treatment	0.01
Storage	0.02
Treatment x Storage	0.04

WF: Wheat Flour OF: Oat flour MPP: Mango Peel Powder CMPP: Chausa Mango Peel Powder LMPP: Langra Mango Peel Powder

Table 6: Effect of treatments and storage period on crude fibre content (%) of fibre rich biscuits

Treatments	Storage period(days)				Mean
	0	30	60	90	
T_1 (100:0:0::WF:OF:MPP)	2.65	2.58	2.45	2.28	2.49
T_2 (0:100:0::WF:OF:MPP)	4.57	4.51	4.40	4.22	4.43
T_3 (50:42:8::WF:OF:CMPP)	4.80	4.74	4.64	4.46	4.66
T_4 (50:42:8::WF:OF:LMPP)	4.71	4.63	4.49	4.34	4.54
T_5(50:40:10::WF:OF:CMPP)	4.88	4.82	4.69	4.55	4.74
T_6(50:40:10::WF:OF:LMPP)	4.77	4.69	4.58	4.44	4.62
T_7(50:38:12::WF:OF:CMPP)	4.95	4.87	4.77	4.65	4.81
T_8(50:38:12::WF:OF:LMPP)	4.86	4.79	4.67	4.48	4.70
T_9(50:36:14::WF:OF:CMPP)	5.01	4.94	4.83	4.66	4.86
T_{10}(50:36:14::WF:OF:LMPP)	4.93	4.88	4.74	4.58	4.78
T_{11}(50:34:16::WF:OF:CMPP)	5.10	5.01	4.87	4.71	4.92
T_{12}(50:34:16::WF:OF:LMPP)	5.03	4.96	4.83	4.67	4.87
	4.69	4.62	4.50	4.34	

Factors C.D.	(p=0.05)
Treatment	0.01
Storage	0.01
Treatment x Storage	0.03

WF: Wheat Flour OF: Oat flour MPP: Mango Peel Powder CMPP: Chausa Mango Peel Powder LMPP: Langra Mango Peel Powder

per cent. The minimum value of 6.52 of crude protein content was recorded in treatment T_{12} (50:34:16::WF:OF:LMPP). The crude protein content of decreased significantly during storage. The mean values of total sugars showed decrease from initial value of 7.36 to 6.96 per cent during 90 days of storage.

4.3.4 Crude Fat

The data presented in Table - 8 showed the effects of various treatments and storage period on crude fat content of fibre rich biscuits. At initial day of storage the highest crude fat content of 22.85 was recorded in treatment T_{11} (50:34:16::WF:OF:CMPP) and the lowest of 20.87 was recorded in treatment T_1 (100:0:0::WF:OF:MPP) whereas the treatment T_2 (0:100:0::WF:OF:MPP) obtained higher value of 21.89 per cent than treatment T_1. After 90 days of storage the value decreased to 22.57 per cent in treatment T_{11} (50:34:16::WF:OF:CMPP) and 20.33 per cent in in treatment T_1 (100:0:0::WF:OF:MPP). Crude fat was significantly affected by storage period. There was significant decrease in crude fat content of fibre rich biscuits from 0 to 90 days of storage. The mean values of storage period showed a decrease from initial value of 21.92 to 21.25 during 90 days of storage.

4.3.5 Carbohydrate

Table-9 illustrated the effect of various treatments and storage period on carbohydrate content of fibre rich biscuits. The data revealed that the treatments significantly influenced the carbohydrate content of fibre rich biscuits. At initial day of storage, the minimum and maximum carbohydrate content of 56.55 and 65.42 per cent was recorded in T_2 (0:100:0::WF:OF:MPP) and T_1 (100:0:0::WF:OF:MPP), respectively. After 90 days of storage the highest carbohydrate content of 66.55 per cent was recorded in treatment T_1 (100:0:0::WF:OF:MPP) and the lowest of 59.38 in treatment T_{11} (50:34:16::WF:OF:CMPP). The mean values of carbohydrate content increased significantly from the initial levels of 60.22 per cent to 61.46 per cent.

4.3.6 Ash

The data presented in Table- 10 showed the effect of various treatments and storage period on ash content of fibre rich biscuit. The data revealed that the treatments significantly influenced the ash content of fibre rich biscuit. At initial day of storage the highest ash content of 2.42 per cent was recorded in treatment T_2

Table 7: Effect of treatments and storage period on crude protein(%) of fibre rich biscuits

Treatments	Storage period(days)				Mean
	0	30	60	90	
T_1 (100:0:0::WF:OF:MPP)	7.17	7.04	6.96	6.80	6.99
T_2 (0:100:0::WF:OF:MPP)	8.77	8.72	8.66	8.60	8.69
T_3 (50:42:8::WF:OF:CMPP)	7.49	7.37	7.22	7.05	7.28
T_4 (50:42:8::WF:OF:LMPP)	7.47	7.35	7.19	7.01	7.25
T_5(50:40:10::WF:OF:CMPP)	7.37	7.25	7.11	6.97	7.18
T_6(50:40:10::WF:OF:LMPP)	7.35	7.20	7.06	6.93	7.14
T_7(50:38:12::WF:OF:CMPP)	7.25	7.15	6.99	6.82	7.05
T_8(50:38:12::WF:OF:LMPP)	7.22	7.09	6.97	6.79	7.02
T_9(50:36:14::WF:OF:CMPP)	7.13	7.00	6.89	6.76	6.95
T_{10}(50:36:14::WF:OF:LMPP)	7.09	6.96	6.87	6.72	6.92
T_{11}(50:34:16::WF:OF:CMPP)	7.02	6.83	6.69	6.55	6.77
T_{12}(50:34:16::WF:OF:LMPP)	6.99	6.79	6.66	6.52	6.74
	7.36	7.30	7.11	6.96	

Factors C.D.	(p=0.05)
Treatment	0.01
Storage	0.01
Treatment x Storage	0.02

WF: Wheat Flour OF: Oat flour MPP: Mango Peel Powder CMPP: Chausa Mango Peel Powder LMPP: Langra Mango Peel Powder

Table 8: Effect of treatments and storage period on crude fat (%) of fibre rich biscuits

Treatments	Storage period(days)				Mean
	0	30	60	90	
T_1 (100:0:0::WF:OF:MPP)	20.87	20.75	20.54	20.33	20.63
T_2 (0:100:0::WF:OF:MPP)	21.89	21.56	20.89	20.58	21.23
T_3 (50:42:8::WF:OF:CMPP)	21.61	21.52	21.21	20.88	21.31
T_4 (50:42:8::WF:OF:LMPP)	21.57	21.44	21.15	20.79	21.24
T_5(50:40:10::WF:OF:CMPP)	21.75	21.68	21.46	21.11	21.50
T_6(50:40:10::WF:OF:LMPP)	21.72	21.63	21.40	21.07	21.45
T_7(50:38:12::WF:OF:CMPP)	21.91	21.86	21.60	21.33	21.67
T_8(50:38:12::WF:OF:LMPP)	21.88	21.76	21.56	21.21	21.60
T_9(50:36:14::WF:OF:CMPP)	22.11	21.98	21.76	21.43	21.82
T_{10}(50:36:14::WF:OF:LMPP)	22.09	21.95	21.70	21.31	21.76
T_{11}(50:34:16::WF:OF:CMPP)	22.85	22.76	22.65	22.57	22.71
T_{12}(50:34:16::WF:OF:LMPP)	22.79	22.74	22.63	22.43	22.65
	21.92	21.80	21.55	21.25	

Factors C.D.	(p=0.05)
Treatment	0.02
Storage	0.01
Treatment x Storage	0.04

WF: Wheat Flour OF: Oat flour MPP: Mango Peel Powder CMPP: Chausa Mango Peel Powder LMPP: Langra Mango Peel Powder

Table 9: Effect of treatments and storage period on carbohydrate (%) of fibre rich biscuits

Treatments	Storage period(days)				Mean
	0	30	60	90	
T_1 (100:0:0::WF:OF:MPP)	65.42	65.80	66.18	66.55	65.99
T_2 (0:100:0::WF:OF:MPP)	56.55	57.80	58.87	59.63	58.21
T_3 (50:42:8::WF:OF:CMPP)	60.67	61.00	61.53	61.74	61.23
T_4 (50:42:8::WF:OF:LMPP)	61.20	61.58	61.94	62.24	61.74
T_5(50:40:10::WF:OF:CMPP)	60.17	60.49	60.94	61.34	60.73
T_6(50:40:10::WF:OF:LMPP)	60.73	61.01	61.41	61.92	61.27
T_7(50:38:12::WF:OF:CMPP)	59.93	60.18	60.70	61.20	60.50
T_8(50:38:12::WF:OF:LMPP)	60.41	60.73	61.08	61.42	60.91
T_9(50:36:14::WF:OF:CMPP)	59.54	59.83	60.23	60.85	60.11
T_{10}(50:36:14::WF:OF:LMPP)	59.98	60.30	60.70	61.32	60.57
T_{11}(50:34:16::WF:OF:CMPP)	58.78	58.87	59.38	59.38	59.05
T_{12}(50:34:16::WF:OF:LMPP)	59.24	59.43	59.72	59.93	59.58
	60.22	60.58	61.04	61.46	

Factors C.D.	(p=0.05)
Treatment	0.01
Storage	0.01
Treatment x Storage	0.03

WF: Wheat Flour OF: Oat flour MPP: Mango Peel Powder CMPP: Chausa Mango Peel Powder LMPP: Langra Mango Peel Powder

Table 10: Effect of treatments and storage period on ash (%) of fibre rich biscuits

Treatments	Storage period(days)				Mean
	0	30	60	90	
T_1 (100:0:0::WF:OF:MPP)	1.30	1.21	1.12	1.09	1.18
T_2 (0:100:0::WF:OF:MPP)	2.42	2.35	2.29	2.25	2.33
T_3 (50:42:8::WF:OF:CMPP)	1.81	1.73	1.61	1.52	1.67
T_4 (50:42:8::WF:OF:LMPP)	1.62	1.55	1.44	1.34	1.49
T_5(50:40:10::WF:OF:CMPP)	1.85	1.77	1.65	1.55	1.71
T_6(50:40:10::WF:OF:LMPP)	1.66	1.59	1.48	1.38	1.53
T_7(50:38:12::WF:OF:CMPP)	1.89	1.80	1.69	1.59	1.74
T_8(50:38:12::WF:OF:LMPP)	1.70	1.63	1.52	1.42	1.57
T_9(50:36:14::WF:OF:CMPP)	1.93	1.84	1.73	1.63	1.78
T_{10}(50:36:14::WF:OF:LMPP)	1.74	1.67	1.56	1.46	1.61
T_{11}(50:34:16::WF:OF:CMPP)	1.97	1.88	1.77	1.67	1.82
T_{12}(50:34:16::WF:OF:LMPP)	1.78	1.71	1.60	1.50	1.65
	1.81	1.73	1.62	1.53	

Factors C.D.	(p=0.05)
Treatment	0.01
Storage	0.01
Treatment x Storage	0.02

WF: Wheat Flour OF: Oat flour MPP: Mango Peel Powder CMPP: Chausa Mango Peel Powder LMPP: Langra Mango Peel Powder

(0:100:0::WF:OF:MPP) followed by 1.97 per cent in treatment T_{11} (50:34:16::WF:OF:CMPP) and lowest ash content of 1.30 in treatment T_1 (100:0:0::WF:OF:MPP). After 90 days of storage the value decreased to2.25 per cent in treatment T_2 (0:100:0::WF:OF:MPP) 1.09 in treatment T_1 (100:0:0::WF:OF:MPP) Ash content was significantly affected by storage period. There was significant decrease in ash content of fibre rich biscuits. The mean ash content of fibre rich biscuit during 90 days of storage period decreased significantly from 1.81 to 1.53 per cent.

4.3.7 Total phenolic

It is evident from Table- 11 that treatments significantly influenced the total phenolic content of fibre rich biscuits. Among the treatments, treatment T_{11} (50:34:16::WF:OF:CMPP) recorded the highest value of 7.33 mgGAE/g followed by treatment T_{12} (50:34:16::WF:OF:LMPP) 7.24 mgGAE/g at initial day. After 90 days of storage, the treatment T_{11} (50:34:16::WF:OF:CMPP) recorded the highest value of 6.96 mgGAE/g followed by treatment T_{12} (50:34:16::WF:OF:LMPP) having the total phenolic content of 6.89 mgGAE/g. The minimum value of 1.47 mgGAE/g of total phenolic was recorded in treatment T_1 (100:0:0::WF:OF:MPP) during 90 days of storage. There was a significant decrease in total phenolic content with the progress in storage period. The mean values of storage period showed decrease from initial value of 4.83 to 4.53mgGAE/g during 90 days of storage.

4.3.8 Scavenging activity

It is evident from Table-12 that treatments significantly influenced scavenging activity of fibre rich biscuits. The data on the scavenging activity at different intervals showed that at initial day of storage the maximum value of 33.14 was recorded in treatment T_{11} (50:34:16::WF:OF:CMPP) and minimum value of 28.72 was recorded in treatment T_1 (100:0:0::WF:OF:MPP). Scavenging activity slightly decreased with the advancement of storage period. After 90 days of storage the maximum scavenging activity of 30.88 was recorded in treatment T_{11} (50:34:16::WF:OF:CMPP) whereas minimum value of 25.30 in treatment T_1 (100:0:0::WF:OF:MPP).. The mean value of scavenging activity decreased from 31.36 at initial day of storage to 29.23 during 90 days of storage.

Table 11: Effect of treatments and storage period on total phenolics (mgGAE/g) of fibre rich biscuits

Treatments	Storage period(days)				Mean
	0	30	60	90	
T_1 (100:0:0::WF:OF:MPP)	1.74	1.68	1.54	1.47	1.61
T_2 (0:100:0::WF:OF:MPP)	5.13	5.06	5.0	4.90	5.02
T_3 (50:42:8::WF:OF:CMPP)	3.79	3.68	3.51	3.46	3.61
T_4 (50:42:8::WF:OF:LMPP)	3.66	3.58	3.49	3.39	3.53
T_5(50:40:10::WF:OF:CMPP)	4.45	4.32	4.26	4.16	4.30
T_6(50:40:10::WF:OF:LMPP)	4.37	4.24	4.17	4.05	4.21
T_7(50:38:12::WF:OF:CMPP)	5.58	5.47	5.32	5.14	5.38
T_8(50:38:12::WF:OF:LMPP)	5.52	5.43	5.28	5.10	5.3
T_9(50:36:14::WF:OF:CMPP)	6.88	6.73	6.56	6.43	6.65
T_{10}(50:36:14::WF:OF:LMPP)	6.76	6.63	6.53	6.39	6.58
T_{11}(50:34:16::WF:OF:CMPP)	7.33	7.22	7.09	6.96	7.15
T_{12}(50:34:16::WF:OF:LMPP)	7.24	7.16	7.02	6.89	7.08
	4.83	4.77	4.65	4.53	

Factors C.D.	(p=0.05)
Treatment	0.01
Storage	0.01
Treatment x Storage	0.03

WF: Wheat Flour OF: Oat flour MPP: Mango Peel Powder CMPP: Chausa Mango Peel Powder LMPP: Langra Mango Peel Powder

Table 12: Effect of treatments and storage period on scavenging activity (%) of fibre rich biscuits

Treatments	Storage period(days)				Mean
	0	30	60	90	
T_1 (100:0:0::WF:OF:MPP)	28.72	27.55	26.90	25.30	27.12
T_2 (0:100:0::WF:OF:MPP)	30.15	29.31	28.75	28.26	29.12
T_3 (50:42:8::WF:OF:CMPP)	31.28	30.69	29.94	29.24	30.29
T_4 (50:42:8::WF:OF:LMPP)	30.67	29.99	29.43	28.85	29.74
T_5(50:40:10::WF:OF:CMPP)	31.75	31.11	30.51	29.88	30.81
T_6(50:40:10::WF:OF:LMPP)	30.98	30.25	29.68	28.98	29.97
T_7(50:38:12::WF:OF:CMPP)	32.22	31.56	30.87	30.06	31.18
T_8(50:38:12::WF:OF:LMPP)	31.27	30.64	30.13	29.39	30.36
T_9(50:36:14::WF:OF:CMPP)	32.67	31.97	31.28	30.49	31.60
T_{10}(50:36:14::WF:OF:LMPP)	31.59	30.88	30.20	29.61	30.57
T_{11}(50:34:16::WF:OF:CMPP)	33.14	32.41	31.72	30.88	32.04
T_{12}(50:34:16::WF:OF:LMPP)	31.91	31.27	30.59	29.82	30.90
	31.36	30.64	30.00	29.23	

Factors C.D.	(p=0.05)
Treatment	0.01
Storage	0.01
Treatment x Storage	0.02

WF: Wheat Flour OF: Oat flour MPP: Mango Peel Powder CMPP: Chausa Mango Peel Powder LMPP: Langra Mango Peel Powder

Table 13: Effect of treatments and storage period on microbial count ($x10^2$ c.f.u/g) of fibre rich biscuits

Treatments	Storage period(days)				Mean
	0	30	60	90	
T_1 (100:0:0::WF:OF:MPP)	N.D	1.50	2.75	3.73	2.00
T_2 (0:100:0::WF:OF:MPP)	N.D	1.60	2.89	3.90	2.10
T_3 (50:42:8::WF:OF:CMPP)	N.D	1.13	2.30	3.38	1.70
T_4 (50:42:8::WF:OF:LMPP)	N.D	1.09	2.18	3.34	1.65
T_5(50:40:10::WF:OF:CMPP)	N.D	1.24	2.55	3.43	1.81
T_6(50:40:10::WF:OF:LMPP)	N.D	1.18	2.45	3.38	1.75
T_7(50:38:12::WF:OF:CMPP)	N.D	1.38	2.70	3.63	1.93
T_8(50:38:12::WF:OF:LMPP)	N.D	1.33	2.63	3.53	1.88
T_9(50:36:14::WF:OF:CMPP)	N.D	1.48	2.85	3.90	2.06
T_{10}(50:36:14::WF:OF:LMPP)	N.D	1.43	2.78	3.78	2.00
T_{11}(50:34:16::WF:OF:CMPP)	N.D	1.63	3.00	4.08	2.18
T_{12}(50:34:16::WF:OF:LMPP)	N.D	1.58	2.93	4.03	2.14
		1.38	2.67	3.68	

Factors C.D.	(p=0.05)
Treatment	0.01
Storage	0.02
Treatment x Storage	0.04

WF: Wheat Flour OF: Oat flour MPP: Mango Peel Powder CMPP: Chausa Mango Peel Powder LMPP: Langra Mango Peel Powder

4.4 Microbial count

It is evident from the Table-13 that initially there was no microbial contamination. After 30 days of storage period, the highest total plate count of 1.63 x 10^2 cfu/g was observed in treatment T_{11} (50:34:16::WF:OF:CMPP) and lowest of 1.09 x10^2 cfu /g in T_4 (50:42:8::WF:OF:LMPP). During 90 days of storage the maximum microbial count of 4.08 x10^2cfu /g was recorded in treatment T_{11} (50:34:16::WF:OF:CMPP) and minimum of 3.34 x10^2cfu /g in T_4 (50:42:8::WF:OF:LMPP). There was an increase in mean value of microbial count from 1.38 to 3.68 x10^2cfu/g in 30 to 90 days of storage period, which is considered as significantly low and safe for consumption

4.5 Organoleptic evaluation

4.5.1 Colour

It is evident from Table- 14 that colour score of fibre rich biscuit decreased significantly during entire storage period. At initial day the maximum score of 8.08 was observed in treatment T_1 (100:0:0::WF:OF:MPP) followed by 7.95 in T_3 (50:42:8:: WF:OF:CMPP). After 90 days of the storage period, scores decreased 7.80 in T_1 (100:0:0::WF:OF:MPP) and 7.58 in T_3 (50:42:8::WF:OF:CMPP) respectively. The highest overall mean colour score of 7.97 was recorded in T_1 (100:0:0::WF:OF:MPP) followed by 7.80 in treatment T_3 (50:42:8::WF:OF:CMPP). During storage period, there was significant decrease in the mean score from 7.51 at initial day to 7.09 during 90 days of storage period.

4.5.2 Texture

Table -15 illustrates the score for texture in fibre rich biscuits during the storage period. Initially, the maximum score of 8.02 was recorded in treatment T_1 (100:0:0::WF:OF:MPP) which reduced to 6.52 in treatment T_{12} (50:34:16::WF:OF:LMPP). After 90 days of storage period, scores decreased from 7.65 in treatmentT_1 (100:0:0::WF:OF:MPP) and 6.07 in treatment T_{12} (50:34:16:: WF:OF:LMPP). The highest overall mean of 7.87 was recorded in treatment T_1(100:0:0::WF:OF:MPP) followed by 7.26 was recorded in treatment T_2(0:100:0::WF: OF:MPP). During storage period, there was significant decrease in the mean score from 7.14 at initial day to 6.70 during 90 days of storage period.

Table 14: Effect of treatments and storage period on colour score of fibre rich biscuits

Treatments	Storage period(days)				Mean
	0	30	60	90	
T_1 (100:0:0::WF:OF:MPP)	8.08	8.05	7.94	7.80	7.97
T_2 (0:100:0::WF:OF:MPP)	7.58	7.52	7.36	7.16	7.41
T_3 (50:42:8::WF:OF:CMPP)	7.95	7.90	7.77	7.58	7.80
T_4 (50:42:8::WF:OF:LMPP)	7.90	7.84	7.73	7.49	7.74
T_5(50:40:10::WF:OF:CMPP)	7.83	7.76	7.61	7.38	7.64
T_6(50:40:10::WF:OF:LMPP)	7.78	7.70	7.55	7.33	7.59
T_7(50:38:12::WF:OF:CMPP)	7.53	7.45	7.33	7.13	7.36
T_8(50:38:12::WF:OF:LMPP)	7.49	7.40	7.27	7.02	7.30
T_9(50:36:14::WF:OF:CMPP)	7.13	7.05	6.93	6.68	6.95
T_{10}(50:36:14::WF:OF:LMPP)	7.09	6.98	6.84	6.63	6.89
T_{11}(50:34:16::WF:OF:CMPP)	6.92	6.84	6.70	6.46	6.73
T_{12}(50:34:16::WF:OF:LMPP)	6.86	6.78	6.63	6.41	6.67
	7.51	7.44	7.31	7.09	

Factors C.D.	(p=0.05)
Treatment	0.01
Storage	0.01
Treatment x Storage	0.03

WF: Wheat Flour OF: Oat flour MPP: Mango Peel Powder CMPP: Chausa Mango Peel Powder LMPP: Langra Mango Peel Powder

Table 15: Effect of treatments and storage period on texture score of fibre rich biscuits

Treatments	Storage period(days)				Mean
	0	30	60	90	
T_1 (100:0:0::WF:OF:MPP)	8.02	7.98	7.83	7.65	7.87
T_2 (0:100:0::WF:OF:MPP)	7.46	7.32	7.21	7.04	7.26
T_3 (50:42:8::WF:OF:CMPP)	7.37	7.28	7.19	7.01	7.21
T_4 (50:42:8::WF:OF:LMPP)	7.33	7.22	7.14	6.97	7.17
T_5(50:40:10::WF:OF:CMPP)	7.26	7.19	7.05	6.85	7.09
T_6(50:40:10::WF:OF:LMPP)	7.21	7.12	6.97	6.82	7.03
T_7(50:38:12::WF:OF:CMPP)	7.16	7.09	6.88	6.65	6.95
T_8(50:38:12::WF:OF:LMPP)	7.09	6.96	6.84	6.62	6.88
T_9(50:36:14::WF:OF:CMPP)	6.86	6.79	6.57	6.33	6.64
T_{10}(50:36:14::WF:OF:LMPP)	6.82	6.75	6.52	6.29	6.60
T_{11}(50:34:16::WF:OF:CMPP)	6.56	6.49	6.36	6.12	6.38
T_{12}(50:34:16::WF:OF:LMPP)	6.52	6.44	6.32	6.07	6.34
	7.14	7.05	6.91	6.70	

Factors C.D.	(p=0.05)
Treatment	0.01
Storage	0.01
Treatment x Storage	0.03

WF: Wheat Flour OF: Oat flour MPP: Mango Peel Powder CMPP: Chausa Mango Peel Powder LMPP: Langra Mango Peel Powder

4.5.3 Flavour

Table-16 shows that flavour recorded highest in 8.06 in treatment T_1 (100:0:0::WF:OF:MPP) followed by 8.0 in treatment T_5(50:40:10::WF:OF:CMPP). After 90 days of storage, the values decreased to 7.64 in treatment T_1 (100:0:0::WF:OF:MPP) followed by 7.51 T_5(50:40:10::WF:OF:CMPP). During storage period, there was significant decrease in mean score from 7.64 to 7.27 after 90 days of storage.

4.5.4 Taste

From Table- 17, it was found that the sensory scores for taste of fibre rich biscuit showed a significant gradual decrease up to end of 90 days storage period. At initial day, highest taste score of 8.16 was observed in control treatment T_1 (100:0:0:: WF:OF:MPP) which was followed by 8.06 treatment T_5(50:40:10:: WF:OF:CMPP) and lowest of 7.05 in treatment T_{12}(50:34:16:: WF:OF:LMPP),. After 90 days of storage, the values decreased to 7.55 in T_1 (100:0:0::WF:OF:MPP) followed by 7.47 in treatment T_5(50:40:10::WF:OF:CMPP). The highest mean score of 7.89 was assigned to treatment T_1 (100:0:0::WF:OF:MPP) followed by 7.80 in T_5(50:40:10::WF:OF:CMPP). During storage period, there was significant decrease in mean score from 7.67 to 7.04 after 90 days of storage period.

4.4.5 Overall acceptability

Table-18 pertaining to score of overall acceptability revealed that at initial day, the highest score of 8.08 was recorded in treatment T_1 (100:0:0::WF:OF:MPP) followed by 7.78 in treatment T_5(50:40:10::WF:OF:CMPP). During 90 days of storage the values decreased to 7.55 in treatment T_1 (100:0:0::WF:OF:MPP) and 7.32 in treatment T_3(50:42:8::WF:OF:CMPP). The mean value of treatments varied significantly and the highest mean score of 7.87 assigned to treatment T_1 (100:0:0::WF:OF:MPP) followed by 7.58 in treatment T_5(50:40:10::WF:OF:CMPP). During storage period, there was significant decrease in mean score from 7.49 at initial day to 7.01 at the end of 90 days of storage period.

Table 16: Effect of treatments and storage period on flavour score of fibre rich biscuits

Treatments	Storage period(days)				Mean
	0	30	60	90	
T_1 (100:0:0::WF:OF:MPP)	8.06	8.01	7.85	7.64	7.89
T_2 (0:100:0::WF:OF:MPP)	7.57	7.50	7.34	7.12	7.38
T_3 (50:42:8::WF:OF:CMPP)	7.77	7.69	7.56	7.44	7.61
T_4 (50:42:8::WF:OF:LMPP)	7.70	7.58	7.49	7.40	7.54
T_5(50:40:10::WF:OF:CMPP)	8.00	7.92	7.77	7.51	7.80
T_6(50:40:10::WF:OF:LMPP)	7.95	7.83	7.63	7.43	7.71
T_7(50:38:12::WF:OF:CMPP)	7.63	7.55	7.44	7.32	7.48
T_8(50:38:12::WF:OF:LMPP)	7.59	7.50	7.40	7.29	7.44
T_9(50:36:14::WF:OF:CMPP)	7.50	7.45	7.38	7.18	7.38
T_{10}(50:36:14::WF:OF:LMPP)	7.47	7.40	7.34	7.11	7.33
T_{11}(50:34:16::WF:OF:CMPP)	7.24	7.13	7.01	6.94	7.08
T_{12}(50:34:16::WF:OF:LMPP)	7.19	7.07	6.98	6.87	7.03
	7.64	7.55	7.43	7.27	

Factors C.D.	(p=0.05)
Treatment	0.01
Storage	0.01
Treatment x Storage	0.02

WF: Wheat Flour OF: Oat flour MPP: Mango Peel Powder CMPP: Chausa Mango Peel Powder LMPP: Langra Mango Peel Powder

Table 17: Effect of treatments and storage period on taste score of fibre rich biscuits

Treatments	Storage period(days)				Mean
	0	30	60	90	
T_1 (100:0:0::WF:OF:MPP)	8.16	8.03	7.83	7.55	7.89
T_2 (0:100:0::WF:OF:MPP)	7.74	7.60	7.43	7.18	7.49
T_3 (50:42:8::WF:OF:CMPP)	7.90	7.72	7.51	7.25	7.60
T_4 (50:42:8::WF:OF:LMPP)	7.82	7.61	7.40	7.15	7.50
T_5(50:40:10::WF:OF:CMPP)	8.06	7.96	7.72	7.47	7.80
T_6(50:40:10::WF:OF:LMPP)	8.00	7.86	7.60	7.36	7.71
T_7(50:38:12::WF:OF:CMPP)	7.71	7.58	7.32	7.10	7.43
T_8(50:38:12::WF:OF:LMPP)	7.68	7.53	7.25	7.01	7.37
T_9(50:36:14::WF:OF:CMPP)	7.43	7.23	7.05	6.78	7.12
T_{10}(50:36:14::WF:OF:LMPP)	7.39	7.18	7.00	6.70	7.07
T_{11}(50:34:16::WF:OF:CMPP)	7.11	6.97	6.75	6.50	6.83
T_{12}(50:34:16::WF:OF:LMPP)	7.05	6.89	6.67	6.41	6.75
	7.67	7.51	7.39	7.04	

Factors C.D.	(p=0.05)
Treatment	0.01
Storage	0.01
Treatment x Storage	0.03

WF: Wheat Flour OF: Oat flour MPP: Mango Peel Powder CMPP: Chausa Mango Peel Powder LMPP: Langra Mango Peel Powder

Table-18: Effect of treatments and storage period on overall acceptability score of fibre rich biscuits

Treatments	Storage period(days)				Mean
	0	30	60	90	
T_1 (100:0:0::WF:OF:MPP)	8.08	8.02	7.83	7.55	7.87
T_2 (0:100:0::WF:OF:MPP)	7.59	7.48	7.32	7.12	7.38
T_3 (50:42:8::WF:OF:CMPP)	7.73	7.65	7.51	7.32	7.55
T_4 (50:42:8::WF:OF:LMPP)	7.68	7.55	7.43	7.24	7.48
T_5(50:40:10::WF:OF:CMPP)	7.78	7.71	7.53	7.29	7.58
T_6(50:40:10::WF:OF:LMPP)	7.73	7.62	7.42	7.25	7.50
T_7(50:38:12::WF:OF:CMPP)	7.51	7.43	7.23	7.04	7.30
T_8(50:38:12::WF:OF:LMPP)	7.43	7.33	7.19	6.99	7.23
T_9(50:36:14::WF:OF:CMPP)	7.23	7.15	6.97	6.76	7.03
T_{10}(50:36:14::WF:OF:LMPP)	7.19	7.07	6.92	6.66	6.96
T_{11}(50:34:16::WF:OF:CMPP)	6.97	6.85	6.73	6.50	6.76
T_{12}(50:34:16::WF:OF:LMPP)	6.93	6.79	6.64	6.42	6.70
	7.49	7.39	7.23	7.01	

Factors C.D.	(p=0.05)
Treatment	0.01
Storage	0.01
Treatment x Storage	0.02

WF: Wheat Flour OF: Oat flour MPP: Mango Peel Powder CMPP: Chausa Mango Peel Powder LMPP: Langra Mango Peel Powder

Table 19: Cost of production of fibre rich biscuit of treatment T_5(50:40:10::WF:OF:CMPP)

Ingredient	Rate(Rs.)	Quantity	Amount
Wheat flour	20/kg	300g	Rs.6.00
Oat flour	100/kg	240g	Rs.24.00
Mango peel	Rs10/kg	60 g	Rs.2.50
Sugar	40/kg	180g	Rs.7.20
Vegetable fat	120/kg	150g	Rs.18.00
Baking powder	32/100g	2.4g	Rs.0.77
Glucose	155/kg	12g	Rs.1.86
Salt	18/kg	6g	Rs0.11
Skim milk powder	425/kg	12g	Rs.5.10
Laminate pouches	1/pouch	8	Rs.8.00
Total cost of ingredients			73.54
Overhead charges (including electricity, fuel, machine depreciation)	@20%		14.71
Profit	@15%		13.24
Good Service Tax (GST)	@18%		18.27
Grand total			119.76
Unit price/ pouch			14.97

4.5 Economics of the blended product

Table-19 depicted that the cost of production of biscuit of treatment T_5 (50:40:10::WF:OF:CMPP) includes the material cost, labour cost, power/fuel and other expenses. It basically consists of all raw materials either purchased from outside or manufactured. The cost of biscuit was found to be Rs.14.97/100g which is cheap as compared to commercially available biscuit which is usually Rs.20/100g.

Plate - 1

Mango (Cv. Chausa)

Mango(Cv. Langra)

Mango peel (Chausa)

Mango peel (Langra)

Plate -2

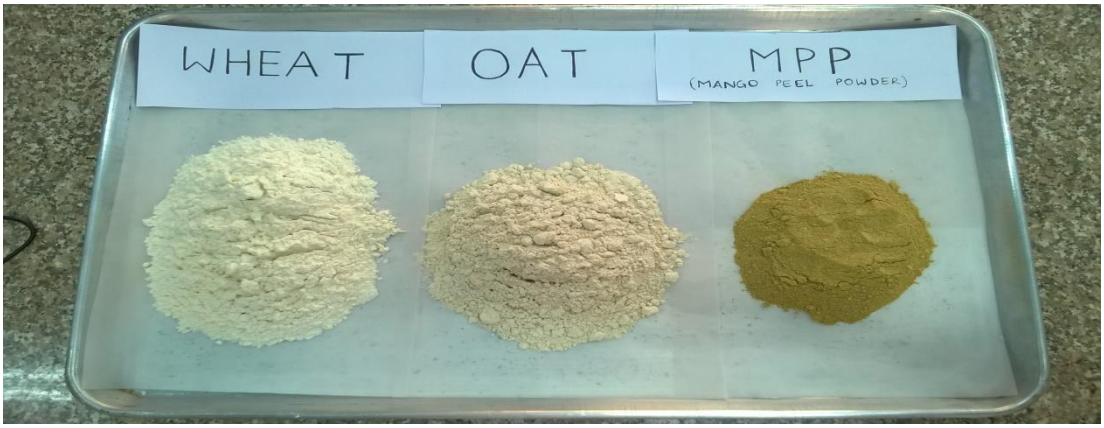
Dried peel (Chausa)

Dried peel (Langra)

Chausa Mango peel powder

Langra Mango peel powder

Plate-3



Wheat flour, Oat flour and Mango Peel Powder

Creaming

Mixing

Kneading

Sheeting

Plate-4

Cutting

Baking

Biscuits

Chapter-5

Discussion

CHAPTER-V

DISCUSSION

The present investigation was conducted to develop a value added product from wheat flour, oat flour and mango peel powder as a source of fibre. The quality with respect to chemical composition of developed product was monitored by drawing the periodic samples during ambient storage period of three months. The quality of the product was further ascertained by sensory evaluation. The results obtained are discussed in this chapter under the following headings.

5.1 Chemical Characteristics of raw materials

The proximate analysis of fresh mango peel samples of Chausa and Langra in Table 1, revealed that the moisture content, crude fiber, crude protein, crude fat, carbohydrate and ash were 69.63 and 68.26 per cent; 5.02 and 4.82 per cent; 2.21 and 1.98 per cent; 2.34 and 2.20 per cent; 23.93 and 25.88 per cent and 2.56 and 2.32 per cent respectively. These values were in close compliance to the finding of Arumugam and Manikandan (2011) in the mango peel of Alphonso variety. The total phenolics and scavenging activity were reported as 84.14 and 78.01mg GAE/g and 67.23 and 58.13 per cent respectively. The values of total phenolics were in accordance with the findings of Larrauri *et al*. (1996) in Hayden variety of mango and also in accordance with the results of Ajila *et al*. (2007) in Raspuri and Badami variety of mango. The result concerning DPPH activity are in agreement with the outcomes of Ribeiro *et al*. (2008) who observed that mango peel has higher free radical scavenging activity than that of seed in Hayden, Tommy Atkins, Palmer, and Uba cultivars of mango.

The results of chemical characteristics of mango peel powder var. Chausa and Langra as presented in Table-2 showed moisture content, crude fiber, crude protein, crude fat, ash, total phenolics and scavenging activity were 6.98 and 6.23 per cent; 8.71 and 7.76 per cent; 2.88 and 2.61 per cent; 2.31 and 2.20 per cent; 3.26 and 3.02 per cent; 64.6 and 60.4 mg GAE/ g and 53.30 and 45.60 per cent respectively. These results were in close accordance with those reported by Ashoush and Gadallah (2011) in Zebda variety of mango. The result findings are also in close harmony with those reported by Aziz *et al***.** (2012) in Chokanan variety of mango. The values of total

polyphenol and scavenging activity were reported slightly reduced as compared to the findings of Ajila *et al*. (2008) in Raspuri and Badami variety of mango.

The analysis of chemical characteristics of wheat flour and oat flour in Table-3 yielded moisture content, crude fiber, crude protein, crude fat and ash as 10.80 and 7.41 per cent; 1.29 and 4.27 per cent; 10.72 and 13.48 per cent; 1.13 and 5.87 per cent and 1.46 and 1.73 per cent respectively. The results of chemical composition of oat flour are comparable with the results found by Asif (2009). The oat flour yielded higher contents of protein, fat, ash and crude fibre as compared to wheat flour sample. The wheat flour yielded higher moisture content. These results of proximate composition are comparable with the results found by Salehifar (2007). The total phenolics content and scavenging activity of wheat flour and oat flour were reported as 1.78 and 6.01 and 30.3 and 32.9 respectively. These observations are in close compliance with total phenolic content and antioxidant activity in naked oats estimated by Brindzova *et al.* (2008).

5.2 Physical parameters of biscuits.

Biscuits prepared with varying levels of replacement were evaluated for diameter, thickness and spread ratio. The physical properties of biscuit were studied and the data was presented in Table-4.

5.2.1 Diameter

The result showed that all the treatments showed decrease in diameter from 55.0 mm to 50.0 mm .The decrease in diameter of biscuits could be attributed to mango peel powder and oat flour replacement and may be due to improper leavening during baking in high fibre biscuits. Nassar *et al*. (2008) reported decrease in diameter with increasing levels of orange peel pulp. Sudha *et al*. (2007) also reported decrease in diameter of biscuits upon addition of wheat bran, rice bran,oat bran, and barley bran.

5.2.2 Thickness

Thickness of biscuits showed a gradual increase with values ranging from 6.30 mm to 6.95 mm. Increase in thickness may be due to the decrease in the diameter. Nassar *et al*. (2008) also reported increase in thickness of citrus by-product

substituted biscuits with increasing levels of orange peel and pulp. A similar finding for thickness was reported by Khalil *et al*. (2015) in wheat flour oat bran blended biscuits.

5.2.3 Spread Ratio

The spread ratio of the biscuits decreased from 8.73 to 7.19 in treatments. The results are in close agreement with Mishra and Chandra. (2012) in rice bran and soy fortified biscuits. Mridula *et al*. (2007) reported decrease in spread ratio of biscuit with increase in proportion of sorghum flour in wheat/ sorghum composite biscuit. The decrease in spread ratio could be attributed to decrease in dough strength. Other researchers also reported reduction in spread ratio when soy flour and fenugreek flour were substituted for wheat flour (Singh *et al.*, 1996; Hooda and Jood 2005).

5.3 Chemical composition of Biscuits

5.4.1 Moisture Content

The moisture content in Table-5 depicted a significant increase in all treatments. Initially, the highest moisture content of 4.37 per cent was recorded in treatment T_{11} (50:34:16::WF:OF:CMPP) and lowest of 2.55 per cent in treatment T_1 (100:0:0::WF:OF:MPP). After 90 days of storage, the highest moisture content of 5.11 per cent was recorded in T_{11} (50:34:16::WF:OF:CMPP) and minimum moisture content of 3.34 per cent in treatment T_1 (100:0:0::WF:OF:MPP). Zhang *et al*. (1998) stated that the increase water absorption by wheat-oat flours blends was due to high β-glucan content of oats. These findings were in agreement with those of Desmond *et al*. (1998) who found that the oat fibre aided in water retention, produced juicier low-fat beef patties. Oat starch has higher water absorption than other cereals (Rossel, 2001). Ajila *et al*. (2008) reported that increase in moisture content of mango peel powder incorporated biscuits which may be due to increased water absorption of dietary fiber present in mango peel powder.

The mean value of storage period showed a significant increase from initial value of 3.76 to 4.39 per cent during 90 days of storage. Nagi *et al*. (2012) also reported gain in moisture content in cereal bran (wheat bran, rice bran, corn bran, barley bran and oat bran) incorporated biscuits during three months of storage. Aslam

et al. (2014) observed an increase in moisture content of biscuits incorporated with mango peel powder and mango kernel powder during 30 days of storage.

5.4.2 Crude fibre

The crude fibre content in Table 6 recorded a significant increase as compared to control in all levels of substitutions. At initial day of storage the maximum value of 5.10 was recorded in treatment T_{11} (50:34:16::WF:OF:CMPP) and minimum value of 2.65 was recorded in treatment T_1(100:0:0::WF:OF:MPP) which decreased significantly to 4.71 and 2.28 per cent after 90 days of storage respectively. As observed by Dawkins *et al*. (1999) and Huang *et al*. (2011), oat flour inclusion increased the crude fiber level in the product since the insoluble fiber content of oats is higher. Ajila *et al*. (2008) reported significant increase in the total dietary fiber content in biscuits incorporated with mango peel powder. The increasing trend in the crude fiber content of the cookies made from cereal bran was also reported by Satinder *et al*. (2011). These findings conforms to the observation of Gernah *et al*. (2010) for the increasing trend in the crude fiber content of cookies made from wheat-brewers spent grain flour blends.

The mean value of crude fibre content decreased from 4.69 at initial day of storage to 4.34 per cent after 90 days of storage. A slight decrease in the fibre content of biscuits was because of pectin, starch, cellulose and other carbohydrates degrade after a long storage The decrease in the fiber content was also reported by Mridula and Gupta (2008) by incorporation of bajra flour in the biscuits fortified with defatted soy flour. Pasha (2002) reported decrease in crude fiber content of cookies by replacing sucrose with dietetic sweeteners fructose, sorbitol and mannitol during 60 days of storage.

5.4.3 Crude protein

The data pertaining to crude protein of different treatments in Table 7 depicted a significant decrease in treatments. The highest protein content of 8.77 per cent was recorded in treatment T_2 (0:100:0::WF:OF:MPP) and the lowest of 6.99 was recorded in treatment in T_{12} (50:34:16::WF:OF:LMPP) at 0 day storage. After 90 days of storage period treatment T_2 (0:100:0::WF:OF:MPP) recorded highest value of 8.60 per cent and the minimum value of 6.52 of crude protein content was recorded in

treatment T_{12} (50:34:16::WF:OF:LMPP). Nassar *et al*. (2008) reported decrease in protein content of citrus by-products substituted biscuits. Oluwamukomi *et al*. (2010) also reported decrease in protein content by addition of cassava flour. Baljeet *et al*. (2010) also reported decrease in protein content when barley wheat flour concentration was increased.

The mean values of showed decrease from initial value of 7.36 to 6.96 per cent during 90 days of storage. The decrease in protein content might be due to malliard reaction and it's a major cause of quality change and degradation of nutritional content of many foods. Kerr *et al*. (2005) observed a decrease in crude protein and fat levels with increase in the levels of oat flour which may be attributed to the contribution of carbohydrates from oat flour. Pasha *et al*. (2005) also reported decrease in protein content from during 60 days of storage in biscuits by replacing sucrose with dietetic sweeteners fructose, sorbitol, and mannitol. Sujirtha and Mahendran (2011) also reported that protein content of wheat-defatted coconut flour biscuits decreased significantly during storage period.

5.4.4 Crude fat

The data in Table 8 showed that the fat content of the biscuits increased significantly in all treatments. The highest crude fat content of 22.85 was recorded in treatment T_{11} (50:34:16::WF:OF:CMPP) and the lowest of 20.87 was recorded in treatment T_1 (100:0:0::WF:OF:MPP). After 90 days of storage the value decreased to 22.57 per cent in treatment T_{11} (50:34:16::WF:OF:CMPP) and 20.33 per cent in in treatment T_1 (100:0:0::WF:OF:MPP). The increase in the fat content could be due the increase in the proportion of mango peel powder. Oomah (1983) reported that the improvements in the properties of the weak wheat flour following threw addition of oat products may be due to their high lipid content. Hood and Jood (2005) also reported an increase in fat content of biscuits on increasing fenugreek flour in wheat flour.

The mean values of fat content decreased from 21.92 to 21.25 per cent from initial to 90 days of storage. The decrease in fat content during storage might be due to lipolytic activity of the enzymes i.e. lipase and lipoxidase. Singh *et al*. (2008) also reported that during storage the crude fat decreased in biscuits supplemented with various levels of jaggery. Sujirtha and Mahendran (2015) also reported decrease in fat

content of wheat-defatted coconut flour biscuits during storage period. Reduction was due to the oxidation of unsaturated fatty acids with atmospheric oxygen and moisture uptake.

5.4.5 Carbohydrate

The data reported in Table 9 showed that carbohydrate decreased significantly in all treatments. The maximum carbohydrate content of 65.42 per cent was recorded in treatment T_1 (100:0:0::WF:OF:MPP) followed by 61.20 per cent in treatment T_4 (50:42:8::WF:OF:LMPP) and minimum carbohydrate content of 56.55 per cent was recorded in treatment T_2 (0:100:0::WF:OF:MPP) followed by 58.78 per cent in treatment T_{11} (50:34:16::WF:OF:CMPP). After 90 days of storage the highest carbohydrate content of 66.55 per cent was recorded in treatment T_1 (100:0:0::WF:OF:MPP) and the lowest of 59.38 per cent in treatment T_{11} (50:34:16::WF:OF:CMPP). Bertagnolli *et al*. (2014) reported that the carbohydrate levels decreased when greater amount of wheat flour was replaced with guava peel flour. Perez and Germani (2007) observed decrease in carbohydrate percentages with increasing proportions of eggplant flour in crackers. Similarly, decreasing trend in the carbohydrate content of cookies made from wheat-brewers spent grain flour blends and whole wheat-full fat soya flour blends was reported by Gernah *et al*. (2010) and Ndife *et al*. (2014) respectively.

The mean values of carbohydrate content increased significantly from the initial levels of 60.22 per cent to 61.46 per cent. The increase in the carbohydrate values might be due to the breakdown of insoluble polysaccharides into simple sugars during storage. Similar fiindings have been reported by Varshney *et al*. (2008) in defatted peanut and cereal biscuits and Mohsen *et al*. (2009) in soy protein substituted wheat cookies.

5.4.6 Ash

Ash content of a food material is an indication of the mineral constituents present. The data pertaining to ash content of different treatments in Table 10 depicted a significant increase. At initial day of storage the highest ash content of 2.42 per cent was recorded in treatment T_2 (0:100:0::WF:OF:MPP) followed by 1.97 per cent in treatment T_{11} (50:34:16::WF:OF:CMPP) and lowest ash content of 1.30 in treatment

T_1 (100:0:0::WF:OF:MPP) followed by 1.62 per cent in treatment T_4 (50:42:8::WF:OF:LMPP) After 90 days of storage the value decreased to 2.25 per cent in treatment T_2 (0:100:0::WF:OF:MPP) and 1.09 in treatment T_1 (100:0:0::WF:OF:MPP). Bertagnolli *et al*. (2014) reported increase in the ash content with the increasing Guava peel flour. Omeire and Ohambele (2010) observed increasing trend in the ash content (1.66-2.20%) in cookies produced from wheat-defatted cashew nut flours. The increase in ash content might be due to high ash content of oat flour and mango peel powder

Ash content was significantly affected by storage period. The mean ash content of fibre rich biscuit during 90 days of storage period decreased significantly from 1.81 to 1.53 per cent. Pasha (2001) in cookies prepared with addition of dietetic sweeteners reported decrease in ash content during storage. Similar findings have also been reported by Hooda and Jood (2005) in biscuit supplemented with fenugreek flour.

5.4.7 Total phenolics

The data in the Table 11 showed that treatment T_{11} (50:34:16::WF:OF:CMPP) recorded the highest value of total phenolic content 7.33 mgGAE/g and lowest value of 1.74 mgGAE/g was recorded in treatment T_1 (100:0:0::WF:OF:MPP) at initial day. After 90 days of storage, the treatment T_{11} (50:34:16::WF:OF:CMPP) recorded the highest value of 6.96 mgGAE/g and the lowest value of 1.47 mgGAE/g of total phenolic was recorded in treatment T_1 (100:0:0::WF:OF:MPP) during 90 days of storage. The total phenolic content increased in fibre rich biscuit with the incorporation of mango peel powder due to the high total phenolic content of mango peel powder. Similar results were reported by Ajila *et al*. (2008) the enrichment of biscuit with mango peel powder increased the total polyphenol content. These findings are also in agreement with Ashoush and Gadallah (2011) who reported that with increasing incorporation levels of MPP and MKP the total phenolic content increased. Bertagnolli *et al*. (2014) also reported that with the incorporation of increased quantities of guava peel flour in the cookies resulted significant increase in the phenolic compounds.

There was a significant decrease in total phenolic content with the progress in storage period. The mean values of storage period showed decrease from 4.83 to 4.53

mgGAE/g during 90 days of storage. Storage studies revealed that there was decrease in the phenolic contents. Kim and Padilla-Zakour (2004) reported that decrease in total phenolic which could be mainly resulted from oxidation, degradation of phenolic compounds and the polymerization of phenolic compounds with proteins. Oral *et al*. (2014) reported that all phenolic compounds decreased in biscuit during storage.

5.4.8 Scavenging activity

Scavenging the stable DPPH radical model is another widely used method to evaluate antioxidant activity. Table 12 showed that at initial day of storage the maximum value of 33.14 was recorded in treatment T_{11} (50:34:16::WF:OF:CMPP) and minimum value of 28.72 was recorded in treatment T_1 (100:0:0::WF:OF:MPP). Scavenging activity slightly decreased with the advancement of storage period. After 90 days of storage the maximum scavenging activity of 30.88 was recorded in treatment T_{11} (50:34:16::WF:OF:CMPP) whereas minimum value of 25.30 in treatment T_1 (100:0:0::WF:OF:MPP). Ajila *et al*. (2008) also reported an increase in DPPH radical scavenging activity with the increased levels of MPP.

The mean value of scavenging activity decreased from 31.36 to 29.23 during 90 days of storage. Reddy *et al*. (2005) found decrease in antioxidant activity during storage period in biscuits containing amla and raisins extracts. Valencia *et al*. (2007) used mango dietary fiber concentrate for cookies and bread and reported satisfactory shelf life. Nanditha *et al*. (2009) reported that there was loss of antioxidant activity during storage of five natural antioxidants and their carry-through property in biscuit.

5.5 Microbial analysis

The data presented in Table -13 showed that during 30 days of storage period, the highest total plate count of 1.63 x 10^2 cfu/g was observed in treatment T_{11} (50:34:16::WF:OF:CMPP) and lowest of 1.09 x10^2 cfu /g in T_4 (50:42:8::WF:OF:LMPP). During 90 days of storage the maximum microbial count of 4.08 x10^2cfu /g was recorded in treatment T_{11} (50:34:16::WF:OF:CMPP) and minimum of 3.34 x10^2cfu /g in T_4 (50:42:8::WF:OF:LMPP).

There was an increase in mean value of microbial count from 1.38 to 3.68 x10^2cfu/g in 30 to 90 days of storage period, which is considered as significantly low and safe for consumption. The increase in the microbial count might be due to

increase in moisture content during storage. The counts were minimal and within acceptable limits after the period of three month of storage (Fawole *et al*., 2007). The results of the microbial count are in conformity with Krishan and Aradhita (2007) in storage of button mushroom powder fortified biscuits. Nagi *et al*. (2012) also reported increase in microbial count after three months of storage in cereal bran incorporated biscuits. Similar increase in microbial count of amaranth biscuits and crackers was reported by Hozova *et al*. (1997). Desayi (2012) also reported significant increase in total plate count of mushroom fortified biscuits during storage of 30 days.

5.6 Organoleptic evaluation

5.6.1 Colour

A decrease in the sensory scores of colour was observed in Table -14. At initial day the maximum score of 8.08 was observed in treatment T_1 (100:0:0::WF:OF:MPP) followed by 7.95 in T_3 (50:42:8:: WF:OF:CMPP). After 90 days of the storage period, scores decreased 7.80 in T_1 (100:0:0::WF:OF:MPP) and 7.58 in T_3 (50:42:8::WF:OF:CMPP) respectively. The highest overall mean colour score of 7.97 was recorded in T_1 (100:0:0::WF:OF:MPP) followed by 7.80 in treatment T_3 (50:42:8::WF:OF:CMPP). The colour score of the biscuits containing MPP up to 10 per cent i.e treatment T_5 (50:40:10::WF:OF:CMPP) was reported as acceptable as control biscuits. It was noticed that incorporation above 10 per cent show relatively dark colour which may be due to enzymatic browning. Aziah and Komathi (2009) also reported that mango peel flour imparts dark brown colour to crackers; this might have given a panelists an impression of over baked product, thus affected their likings. The biscuits with incorporated oats were slightly darker, similar observation was reported by Sudha *et al*. (2007) in biscuits made by incorporation of oat bran, but use of barley bran resulted in marginal variation.

During storage period, there was significant decrease in the mean score from 7.51 at initial day to 7.09 during 90 days of storage period. The darker colour may be due to the non-enzymatic reaction (Maillard reaction) between reducing sugar molecules and lysine protein explained by Decker *et al*. (2002) and Tsuji *et al*. (2001). Swapna and Rao (2016) also reported decrease in colour score during storage of 90 days.

5.6.2 Texture

A gradual decrease in the texture scores in all the treatment was observed during 90 days of storage (Table-15). Initially, the maximum score of 8.02 was recorded in treatment T_1 (100:0:0::WF:OF:MPP) and the minimum of 6.52 in treatment T_{12} (50:34:16::WF:OF:LMPP). After 90 days of storage period, scores decreased from 7.65 in treatment T_1 (100:0:0::WF:OF:MPP) and 6.07 in treatment T_{12} (50:34:16:: WF:OF:LMPP). Results revealed that the biscuits had acceptable texture up to 10 per cent of MPP as compared to the control. The high replacements of MPP resulted in harder biscuits due to greater water absorption capacity as reported by Ashoush and Gadallah (2011). These obtained results are also in harmony with those of Smith (1972).

During storage period, there was significant decrease in the mean score from 7.14 at initial day to 6.70 during 90 days of storage period. The textural changes are expected to take place in biscuits during storage because of conformational changes that continue even during static storage of processed foods as reported by Brennan (2006). Swapna and Rao (2016) reported that as the storage increased body and texture score of the biscuit decreased from 0 to 90 days. Khalil *et al*. (2015) reported that mean values of biscuit decreased with increasing levels of substitution of oat bran from 0 to 30 per cent

5.6.3 Flavour

Table-16 showed that maximum value for flavour 8.06 was recorded in treatment T_1 (100:0:0:: WF:OF:MPP) followed by 8.0 in treatment T_5(50:40:10::WF:OF:CMPP). After 90 days of storage, the values decreased to 7.64 in treatment T_1 (100:0:0::WF:OF:MPP) followed by 7.51 in treatment T_5(50:40:10::WF:OF:CMPP). The flavour of the biscuit was improved with incorporation of MPP as they had typical mango flavour and pleasant flavour of oats. Similar decrease in flavour content was reported by Ajila *et al*. (2008) in mango peel powder incorporated biscuits and Ashoush and Gadallah (2011) in mango peel powder and mango kernel powder incorporated biscuits.

During storage period, there was significant decrease in mean score from 7.64 to 7.27 after 90 days of storage. The decrease in flavour on storage may be due to

volatile nature of flavouring components and the chemical interactions taking place between various constituents. Chugh *et al*. (2015) also reported decrease in flavour content during 90 days of storage in low-fat biscuit containing polydextrose and guar gum.

5.6.4 Taste

Table-17 revealed a decreasing trend in taste scores. At initial day, highest taste score of 8.16 was observed in control treatment T_1 (100:0:0:: WF:OF:MPP) which was followed by 8.06 in treatment T_5(50:40:10:: WF:OF:CMPP) and lowest of 7.05 in treatment T_{12}(50:34:16:: WF:OF:LMPP). After 90 days of storage, the values decreased to 7.55 in T_1 (100:0:0::WF:OF:MPP) followed by 7.47 in treatment T_5(50:40:10::WF:OF:CMPP). The taste scores increased with the incorporation of MPP upto 10 per cent. However, incorporation above 10 per cent had a slight bitter taste. The results for taste are in close accordance with those reported by Ashoush and Gadallah (2011) at incorporation of 10 per cent of mango peel powder and 40 per cent of mango kernel powder in biscuit.

During storage period, there was significant decrease in mean score from 7.67 to 7.04. Similar findings were reported by Hooda and Jood, (2005) whose sensory results showed that a maximum of 10% fenugreek flour can be incorporated to prepare acceptable quality biscuits and can be safely stored in polypropylene bags upto 1 month without altering their organoleptic properties.

5.6.5 Overall acceptability

Overall acceptability in Table-18 showed that all the scores were in acceptable range during the entire period of storage study. Initially, the highest overall acceptability score of 8.08 was recorded in treatment T_1 (100:0:0::WF:OF:MPP) followed by 7.78 in treatment T_5(50:40:10::WF:OF:CMPP) and lowest of 6.93 in treatment T_{12}(50:34:16::WF:OF:LMPP). During 90 days of storage the values decreased to 7.55 in treatment T_1 (100:0:0::WF:OF:MPP) and 7.32 in treatment T_3(50:42:8:: WF:OF:CMPP).The overall acceptability of treatment T_5 (50:40: 10::WF:OF:CMPP) was found acceptable as compared to control. Sensory results of Hooda and Jood(2005) revealed that 10 per cent fenugreek flour can be added to acceptable quality biscuits. Nassar *et al*. (2008) also reported that 5 and 15 per cent

orange pulp and peel had the highest level of acceptance for all sensory characteristics. Aziah and Komathi (2009) reported lowest score values of mango peel crackers could be due to unattractive colour and unpleasant taste.

The mean overall acceptability decreased from 7.49 to 7.01 during 90 days. Swapna and Rao (2016) reported that overall acceptability score of cheese incorporated oat biscuit showed decreasing trend from 0 to 90 days but were all in acceptable range. Similar results have been reported by Stojceska *et al*. (2008) in cereal based ready to eat expanded snacks using cauliflower by products.

5.7 Economics of the blended product

The cost of production of biscuit of treatment T_5 (50:40:10::WF:OF:CMPP) included the material cost, labour cost, power/fuel and other expenses. The cost of biscuit was found to be Rs.14.97/100g which is cheap as compared to commercially available biscuit which is usually Rs.20/100g.

Chapter-6

Summary and Conclusions

CHAPTER-VI

SUMMARY AND CONCLUSION

The present investigation entitled "Development of fibre rich oat-wheat flour blended biscuits using mango peel" was carried out in the Division of Food Science and Technology, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha. The developed products were analysed for physico-chemical, microbiological and organoleptic parameters at a regular interval of 30 days. The results are summarized as under:

- The chemical composition of fresh mango peel of Chausa and Langra had moisture, crude fiber, crude protein, crude fat, carbohydrate and ash content as 69.63and 68.26; 5.02 and 4.82; 2.21 and 1.98; 2.34 and 2.20; 23.93 and 25.88 and 2.56 and 2.32 per cent respectively. The values for mango peel powder of Chausa and Langra were in the range of 6.98 and 6.23; 8.71 and 7.76; 2.88 and 2.61; 2.31 and 2.20; 86.59 and 87.94 and 3.26 and 3.02 per cent for moistures, crude fiber, crude protein, crude fat, carbohydrate and ash content.

- The chemical composition of wheat flour had moisture content, crude fiber, crude protein, crude fat, carbohydrate and ash content as 10.80, 1.29, 10.72, 1.13, 75.17 and 1.46, respectively. The chemical composition of oat flour had relatively higher crude fiber 4.27, higher crude protein 13.48, higher crude fat 5.87 and higher ash content of 1.73 as compared to wheat flour except moisture content 7.41 per cent, respectively.

- With the incorporation of mango peel powder and oat flour the moisture content of biscuit showed an increase from 2.89 to 4.63 per cent. During storage period of 90 days, the moisture content of the biscuits increased from 3.76 to 4.39 per cent.

- Highest crude fiber content of 5.10 per cent was recorded in treatment T_{11} (50:34:16::WF:OF:CMPP) and lowest crude fiber content of 2.65 per cent was recorded in treatment T_1 (100:0:0::WF:OF:MPP). The mean value of crude fiber content decreased from the initial level of 4.69 to 4.34 per cent during storage.

- The highest protein content of 8.77 per cent was recorded in treatment T_2 (0:100:0::WF:OF:MPP) and the lowest of 6.99 per cent was recorded in treatment in T_{12} (50:34:16::WF:OF:LMPP) at 0 day storage. During storage period, the mean value of the protein content decreased from 7.36 to 6.96 per cent.

- The highest crude fat content of 22.85 was recorded in treatment T_{11} (50:34:16::WF:OF:CMPP) and the lowest of 20.87 was recorded in treatment T_1 (100:0:0::WF:OF:MPP). The mean values of fat content decreased from 21.92 to 21.25 per cent during storage.

- The minimum and maximum carbohydrate content of 56.55 and 65.42 per cent was recorded in T_2 (0:100:0::WF:OF:MPP) and T_1 (100:0:0::WF:OF:MPP), respectively. The mean values of the carbohydrate increased significantly from 60.22 to 61.46 per cent during storage period.

- The treatment T_2 (0:100:0::WF:OF:MPP) recorded the highest value of ash content of 2.42 per cent at 0 day storage. With the progression of storage period, a significant decrease in the ash content was reported.

- The highest phenolic content of 7.33 mgGAE/g was recorded in treatment T_{11} (50:34:16::WF:OF:CMPP) and lowest of 1.74 mgGAE/g was recorded in treatment T_1 (100:0:0::WF:OF:MPP). Storage studies revealed that there was decrease in the phenolic content during storage.

- With increase in the levels of treatments the scavenging activity increased from 28.72 in treatment T_1 (100:0:0::WF:OF:MPP) to 33.14 per cent in treatment T_{11} (50:34:16::WF:OF:CMPP) at initial days of storage. During the storage period the mean values of the scavenging activity was found to decrease from 31.36 to 29.23.

- In the microbial evaluation, during 30 days of storage period, the highest total plate count of 1.63 x 10^2 cfu/g was observed in treatment T_{11} (50:34:16::WF:OF:CMPP) and lowest of 1.09 x10^2 cfu /g in treatment T_4 (50:42:8::WF:OF:LMPP). There was significant increase in the total plate count of biscuits during storage. The mean value ranged from 1.38 x10^2 to 3.68 x 10^2cfu/g.

- On the basis of sensory evaluation treatment T_5 (50:40:10::WF:OF:CMPP) was found to be best scoring values 7.80 for taste, 7.80 for flavour and 7.58 for overall acceptability.

Conclusion `

It is concluded from the present study that with the growing interest of consumers in health –related foods, the addition of oat and mango peel powder to wheat flour affected the nutrition composition and sensory characteristics in various ways.

This reflects the potential for use of oat and mango peel powder into wheat flour for enhancement of these chemical constituents. The improvement in the chemical constituents such as protein, fat, fiber and ash was due to the fact that oat flour and mango peel powder had higher content of these constituents.

Sensory evaluation of biscuits revealed that biscuits with 10 per cent mango peel powder and 40 per cent oat flour had the highest level of acceptance. There was no significant difference between the treatment T_5(50:40:10::WF:OF:CMPP) and control treatment T_1 (100:0:0::WF:OF:MPP).

The cost of production of biscuit of treatment T_5 (50:40:10::WF:OF:CMPP) was also found cheaper as compared to commercially available biscuits. The incorporation enhanced consumer's acceptance of the product and increased its nutritional content.

Hence it can be concluded oat and mango peel powder can be used as a suitable source of dietary fiber with associated bioactive compounds and can be incorporated as ingredient in large variety of food products.

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Appendix

Annexure-1

Evaluation Card for Hedonic Rating of_____

Name: **Date:**

Evaluate these samples and check how much you like or dislike each one. Use appropriate scale to show your attitude by checking at the point that best describe about the sample.

Treatment	Colour	Texture	Flavour	Taste	Overall Acceptability
T_1					
T_2					
T_3					
T_4					
T_5					
T_6					
T_7					
T_8					
T_9					
T_{10}					
T_{11}					
T_{12}					

Scores:

9: Like extremely	8: Like very much	7: Like moderately
6: Like slightly	5: Neither like nor dislike	4: Dislike slightly
3: Dislike moderately	2: Dislike very much	1: Dislike extremely

Signature of Evaluator

Vita

VITA

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OGPA/ % Marks	7.35/10

CERTIFICATE – IV

Certified that all the necessary corrections as suggested by the external examiner and the advisory committee have been duly incorporated in the thesis entitled **"Development of fibre rich oat-wheat flour blended biscuits using mango peel"** submitted by **Ms. Ankita Choudhary,** Registration No. **J-15-M-417.**

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