DEVELOPMENT OF CHIA SEED FLOUR BASED COOKIES WITH IMPROVED FUNCTIONAL AND SENSORIAL ATTRIBUTES

काशी हिन्दू विश्वविद्यालय

BANARAS HINDU UNIVERSITY

THESIS

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Master of Science

In

Food Science and Technology

Supervisor

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Dear Sir,

I have great pleasure in forwarding the thesis entitled **"DEVELOPMENT OF CHIA SEED FLOUR BASED COOKIES WITH IMPROVED FUNCTIONAL AND SENSORIAL ATTRIBUTES"** submitted by **Ms. Pradeep Kumar Patel, I.D. No. 17412FST013** in partial fulfilment of the requirements for the degree of **Master of Science** in **Food Science and Technology,** from Centre of Food Science and Technology, Institute of Agricultural Sciences, BHU Varanasi.

I certify that the entire scheme of investigation, presented here in, was planned and carried solely by the candidate under my guidance. To the best of my knowledge, the data presented in the thesis are genuine and original.

Thanking you.

FARWARDED

(Coordinator)

YOUR FAITHFULLY

Dr. A. D. TRIPATHI
(Supervisor)

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by

Mr. Pradeep Kumar Patel

Thesis submitted in partial fulfilment of the requirements for the degree of

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ABBREVATIONS AND SYMBOL

ANOVA	:	Analysis of variance
F	:	F value
g	:	gram
h	:	hour
HCl	:	hydrochloric acid
Kg^{-1}	:	per kilogram
ppm	:	parts per million
DPPH	:	2,2-diphenyl-1-picrylhydrazyl
TPC	:	Total Phenolic Content
aw	:	water activity
GAE	:	Gallic acid equivalents
GT	:	green tea
BHA	:	Butylated hydroxyanisole
BHT	:	Butylated hydroxytoluene
LD	:	lethal Dose
AAS	:	Atomic Absorption spectrophotometer
TA	:	Texture Analyzer
LSD	:	Least Significant Difference
BS		Baking soda
BP		Baking Powder

INTRODUCTION

A cookie is a cooked or baked food that is small, sweet and flat. It generally contains common flour, sugar and oil or fat. Cookies may include other ingredients such as, nuts, chocolate chips and raisins, etc.

Almost all English-speaking countries except for the Canada and Unites State, crisp or crunchy cookies are called biscuits. Chewier type biscuits are sometimes called as cookies even in the United Kingdom. Generally some cookies may also be named by their bars, such as shape and date square.

Cookies are most commonly baked product until crisp or just long enough that they remain soft, but some kinds of cookies are not baked. Cookies are produces in a wide variety of shape, styles, using an array of ingredients including sugars, or sugar substitute, butter, peanut butter, nuts, or dried fruits and also by using spices. The softness of the cookie may be depends on how long it is baked.

A general principle of cookies may formulated by this way. It is descent from cakes and other sweetened breads, cookies in almost all its forms has lots of water as a source for cohesion. Water in cakes provide to make the base (in case of cakes called "batter") as thin as possible, which facilitate the bubbles – responsible for the cake's fluffiness – to better form. In the cookie, as cohesion agent we use fat and oil. Oils, we can say the form of butter, vegetable oils or lard, are more viscous than water and evaporate freely at a much higher temperature in comparison to water. A cake made with eggs or butter instead of water is far denser after removal from the oven.

Oils in baked cakes do not act as soda tends to in the finished result. Rather than it act as thickening and evaporating the mixture. They remain, saturating the bubbles of escaped gases from what little water there might have been in the egg if added and the carbon dioxide released by heating the baking powder. Saturation in the cookies build up the most texturally attractive traits and indeed all fried food, crispness saturated with a moisture (oil) that does not sink into it.

CLASSIFICATION

Bar cookies consist of batter or other ingredients that are poured or pressed into a pan (sometimes in multiple layers) and cut into cookie-sized pieces after baking. In British English, bar cookies are known as "tray bakes". Examples include brownies, fruit squares, and bars such as date squares.

- Drop cookies are made from a slightly soft dough that is dropped by spoonful's onto the baking sheet. During baking, the mounds of dough spread and flatten. Chocolate chip cookies, oatmeal raisin (or other oatmeal-based) cookies, and rock cakes are popular examples of drop cookies. These may include thumb print cookies, for which a small central depression is created with a thumb or small spoon before baking to contain a filling, such as jam or a chocolate chip.
- The rolled cookie dough is used for making the filled cookies, the filled cookies with a fruit or confectionery filling before baking.
- The stiffer dough is used for making the molded cookies that is molded into balls or cookie.
- Apes by hand before baking. Snicker doodle sand peanut butter cookies are the best examples of molded cookies.
- No-bake cookies made by mixing a filler, such as nuts and cereals into a melted confectionery binder and shaping into cookies or bars and allowing to cool or harden. Rum balls and Oatmeal clusters are no-bake cookies.
- Pressed cookies are made from the soft dough that is extruded from a cookie press into various shapes and decorative before baking. Example of a pressed cookie is Spritzgeback .
- Refrigerator cookies are made from a stiff dough that is refrigerated to make the raw dough even stiffer before cutting and baking. The dough is shaped into cylinders and cut into round cookies before baking.
- Stiffer dough is used for making rolled cookies, and then rolled out and cut into shapes with a cookie cutter.
- Sandwich cookies are made by pressing or rolled cookies, assembled as a sandwich with a sweet filling. Fillings include jam, marshmallow and icing. The example of sandwich cookies is Oreo cookie, made of two chocolate cookies with a vanilla icing filling
- Vegan cookies can be made with flour, sugar, non-dairy margarine and non-dairy milk. The icing can be made with the help of aqua faba to decorate the cookies.

Chia (*Salvia hispanica L.*) is an herbaceous plant and it is cultivated annually, which is native from southern Mexico and northern Guatemala **(Capitani, Spotorno, Nolasco, & Tomás, 2012).** The chia seed has a high oil content (30–40%), is rich in polyunsaturated fatty acids, mainly omega-3 fatty acids (linolenic acid, 54– 67%) and omega-6 (linoleic acid, 12–21%) **(Ixtaina et al., 2011)**, and a protein content of 15–25% **(Ali et al., 2012),** similar to that present in lentil (23%), pea (25%) and chickpea (21%) **(Olivos-Lugo,Valdivia-López& Tecante, 2010).** Furthermore, the fibers present, (18–30%) potentiate the use of chia in the production of functional foods **(Muñoz, Cobos, Diaz, & Aguilera, 2012).**

The risk of cardiovascular disease, type-2 diabetes and colorectal cancer increases with obesity. Diet and lifestyle can be modified to prevent and reduce the risks of these diseases. There is epidemiological evidence that diets that promote health are rich in dietary fiber and omega-3 fatty acid and low in saturated fat, trans fat and cholesterol **(Hu, 2002)**

The consumption of chia seeds products has increased day by day, and it has been suggested that the taking of this functional food in a daily human diet could contribute to improve consumers' health. However, a better knowledge about the composition of these products is mandatory. **(Sheila Cristina Oliveira Alvesa)**

The increasing interest in the study of chia seed is due to their nutritional and health promoting properties that have been recognized in some of their components, namely it's high content in essential fatty acids in the oil (21.4–32.6 g/100g), which contains higher polyunsaturated fatty acids, mainly a-linolenic acid (59.9– 63.2g/100 g) and a low percentage of saturated fatty acids **(PorrasLoaiza, Jiménez-Munguía, Sosa-Morales, Palou, & LopezMalo, 2014)**. Also the high content in minerals, proteins, dietary fiber and other bioactive components such as tocopherols and phenolic compounds **(Capitani, Spotorno, Nolasco, & Tomás, 2012; Marineli et al., 2014; Porras-Loaiza et al., 2014)** contribute to the interest of the scientific community and consumer in this product

The use of chia may be in the form of whole seeds, flour, mucilage and oil seed. Chia seed contain good amount of dietary fibre, phenolic compound, oil, protein and mineral**.(Ayerza & Coates, 2004)**. The chia seed is famous due to their oil content, which provides rich source of polyunsaturated fatty acids (PUFA).The chia oil is unique since it contains the highest proportion of omega-3 linolenic acid (ALA) of any known natural source available **(Ayerza, 1995; Coates & Ayerza, 1996)**. ALA plays an important role in health and is used in several foods and cosmetics. Many studies have provided evidence that regular consumption or dietary supplementation with long chain n-3 PUFA brings numerous health benefits, including the prevention of cardiovascular diseases, inflammatory diseases and

hypertension**(Albert et al., 2005; Garg, Wood, Singh, & Moughan, 2006).**

The addition of chia seed and oil contain a rich pool of natural antioxidants such as phytosterols, tocopherols, carotenoids **(ÁlvarezChávez, Valdivia-López, Aburto-Juárez, & Tecante, 2008; Ixtaina et al., 2011)** and phenolic compounds, including chlorogenic acid, caffeic acid, myricetin, quercetin and kaempferol **(Capitani et al., 2012; Reyes-Caudillo et al., 2008),** which protects consumers against many diseases and also promotes beneficial effects on human health **(Nijveldt et al., 2001).**

Chia seed reduces the risk of cardio vascular disease, type-2diabetes and colorectal cancer increases with obesity. Diet and lifestyle can be modified to prevent and reduce the risks of these diseases. There is epidemiological evidence that diets that promote health are rich in dietary fiber and omega-3 fatty acid and low in saturated fat, trans fat and cholesterol **(Hu, 2002).**

Honey has been known to have some health benefits and anti-microbial properties .Beyond many health claims and ability to mask any taste deficiency that may have resulted from ingredient interactions, inclusion of honey into cookies formulation is reported to offer functional benefits, improve water binding capacity of dough, provide increased volumes and improves shelf life of bake products .The substitution of sugar by another had typically been studied in food products that will improve the product characteristics.

Cookies are ideal for palatability, nutrient availability, compactness and convenience. They differ from other bakery products like cakes and bread because of having low moisture content, comparatively free from microbial spoilage long shelf life of the product.

Objectives: -

1. To develop chia seed based cookies incorporation with Honey.
2. To study textural and sensorial properties of products.
3. To study the nutritional and physico-chemical properties of optimized chia seed based product.

REVIEW OF LITERATURE

Chia seed (*Salvia hispanica L.*) is an annual herbaceous plant that belong of the family Lamiaceae. It is native from Northern Guatemala and Mexico. Now a day it is also grown for commercial purpose in Colombia, Argentina, Ecuador, Bolivia, Paraguay, Australia and Argentina **(Busilacchi.et al.2013)** Chia seed can be eaten, prepared in number of dishes or can be eaten as raw. Ground or chia sees on vegetable, rice, cereals or yogurt. Chia seed develop a gelatinous texture when soaked in water by which it is easy to mix and it is show very absorbent behavior. A Mexican dish called as Fresco which is made by soaking chia seed into water or fruit juice.

Loreto A. Muñoz et al. (2013) Mayas and Aztecs used oilseed (chia seed) as a foodstuff. It contain natural source of omega fatty acid, insoluble fiber and soluble fiber and protein and also contain some natural component vitamin, mineral and natural antioxidant. It can be put in the category of functional food because apart from the human nutrition, it help to prevent the cardiovascular disease, increase the satiety index, prevent nervous system and also prevent the inflammatory, and diabetes, among others. Now a day chia seed have a huge potential in the industrial of health, food, animal feed, due to its functional component it is also applicable in the field of pharmaceutical and nutraceuticals. Chia seed have great medical, physicochemical, functional and nutritional properties. The seed of chia seed have huge capacity as a source of nutrient and nutraceutical of high interest to medicine, science, technology and engineering.

There are he some most interesting feature of chia seed gluten free seed contain of antioxidant, it also contain high dietary fiber and high quality protein.

Laura Cassiday et al. (2017) The United State Department Of Agriculture (USDA) has reported that chia sees contain total carbohydrate 42.12% (including 34.4% total dietary fibre), protein-16.54%, moisture- 5.8%, total lipid-30.74% and ash contain about to 4.8%. Apart from these it contain high amount (335-860 mg/100g) of calcium, phosphorus, potassium and magnesium with 0lesser amount (4058-16 mg/100g) of sodium, iron and zinc. The major lipid in chia seed is alpha linolenic acid and linoleic acid with lesser amount of palmitic acid, oleic acid, and stearic acid. The human body can only ingest two essential amino acid ALA and LA because the body cannot synthesis them.

Oliviert Martínez et al. (2014) The phenolic contain contained by chia seed are very rich in antioxidant, which is suggest to cure or may decrease the invasiveness of cancer cell, remove reactive oxygen species and improve the clinical outcome. Chia seed also contain some isoflavones may be used as a novel source of these substance to prevent various estrogen related disorders.

Mohd Ali et al. (2012), chia as novel approved by European Parliament and the European Council. Chia seed contain about 15-24% protein, carbohydrates 26-41%, and fat 25-40%. The oil quality of chia seed have been already studied, possess almost 55-60% linolenic acid, and 18-20% linoleic acid , monounsaturated fatty acid is about 6% and 10% saturated fat. Chia seed has contain highly soluble and insoluble dietary fibre, over 35% of total weight and it is rich source of vitamin and mineral. Chia sees contain 6 times more calcium, 11 times more phosphorus and 4 times more potassium than 100g of milk. Chia seed contain high amount of natural antioxidant, such as phenolic compound, which protect against some adverse condition. The most important thing ischia seed does not contain gluten and it can be consumed by person with celiac disease.

Geographical Distribution and Production of Chia seed-

The maximum yield per hectare based on different types of situations, such as climatic region, cultivation technique, harvesting equipment and genetic health of seed. In low-input conditions, the average yield of commercial seeds is approx. 500-600 kg/ha. (**Cahill, 2003; Coates, 2011)** some growers have obtained up to 1200 kg/ha. **Cahill, 2003; Coates, 2011**;

Ullah et al., 2015 In optimal agronomic conditions a yield of 2500 kg/ha has also been reported**.**

Peperkamp et al., 2014 Bolivia was able to improve its yield from 350 kg/ha in 2013 to 650 kg/ha in 2014, lower than Argentina and Paraguay that can reach 800-900 kg/ha in optimal circumstances. SAGARPA, 2014 in some regions of Mexico, yields reached 470 kg/ha in 2013 and were improved to 600 kg/ha.

Lobo et al., 2011 Studies performed in Argentina yielded from 606 to 1400 kg ha-1. **Bochicchio et al., 2015** In Paraguay yields of 1600 kg ha-1 were reported while in the state of Mexico, Jalisco the main productive zone of chia seed in this country, average yields of 1200 kg/hac were obtained.

Distribution of Chia seed in India –

India is not top most producer of chia seed but its production increase day by day. Generally two type of chia seed are cultivated in India i.e black chia seed and another is white colored seed, which belongs to the family of mint plant. Both the variety is china plant, flower and yield tiny, healthy seeds and each variety of chia seed have different nutritional value. Chia seed generally cultivated in semi- arid region. Chia are generally cultivated in southern and northern region of India and also cultivated in some part of western region.

Chia seed:-

Chia seed (***Salvia hispanica L***.) is an annual summer plant and it is belonging to the mint family. The plant produces various small white and dark seeds and it mature in autumn. The seed contain about 30 g oil/ 100 g seed weight, and it is generally composed of unsaturated fatty acids **(Bushway, Belyea, & Bushway, 1981; Taga, Miller, & Pratt, 1984)**.

Coates et al., 2011. Chia seeds from Argentina contain 30.0-38.6 g oil/100 g, although 60.7- 67.8 g/100 g of linolenic acid

Weber et al.1991. It is a good source of protein (19- 27 g/100 g)

Ayerza et al., 2005 Chia seed protein content is more than that of other crops such as wheat, corn, rice, oat, barley and amararanth

Chia is not commercially grown as a protein source, its amino acid profile has no limiting factors in the adult diet **(Bushway et al., 1981),** but lysine, leucine and threonine were the limiting amino acids in a preschool child's diet **(Weber et al.,1991)**. After the oil-extraction process, residual part of chia seeds is a major source of dietary fiber **(Reyes-Caudillo, Tecante, & ValdiviaLópez, 2008)** and polyphenolic compounds with antioxidant activity **(Taga et al., 1984).** This seed could be used as a commercial applications due to source of its important natural antioxidants. **(Reyes-Caudillo et al., 2008). Charles W. Weber et all (2010)** The protein ranged in concentration from 19.0 to 26.5%, oil from 15.9 to 34.1%, fiber (ADF) from 22.1 to 33.4%, and total dietary fiber (TDF) from 47.1 to 59.8%. Threonine was the first limiting amino acid in chia seed, while lysine and leucine were the other limiting amino acids. **B.L. Olivos-Lugo et all. (2010)** Nutritional, functional and thermal properties of the main protein fractions of chia seed and a protein isolate of chia seed from the state of Mexico, were studied by differential scanning calorimetry(DSC), foaming, gelling and water-holding capacity (WHC) and oilholding capacity, amino acid profile, chemical score and in vitro digestibility tests. Isolated protein shows good WHC (4.06 g/g) and excellent oil-retention

capacities (4.04 g/g), making it attractive as an additive in bakery products and food emulsions. Chia seed also contained good amounts of glutamic acid (123 g/kg raw protein), arginine (80.6 g/kg raw protein) and aspartic acid (61.3 g/kg raw protein). However, its essential amino acid profile showed deficiencies with respect to the 1985 standard of the FAO/WHO/UNU for pre-school children. Therefore, Chia seed use as a sole protein source is not recommended, supplementation with a lysine-rich source would be necessary, as this was the limiting amino acid. **Norlaily M. A et all (2012)**

Chia seed contains about protein (15–25%), fats (30–33%),carbohydrates (26–41%), high dietary fiber (18–30%), ash (4-5%), minerals, vitamins, and dry matter (90–93%). It also contains a high amount of antioxidants. Analysis of heavy metal showed that chia seed contains them at safe levels, not exceeding the maximum metal levels for food safety, and the seed is also free from mycotoxins. Chia seed does not contain gluten this one is another key feature.

Honey:-

Honey is a nutritious natural sweetener from honey beecollected nectar from a variety of flowers. The health benefits and high value of honey, however, have motivated fraudulent acts of honey adulteration by either a direct or secondary inclusion of cheaper sweeteners. Honey is a popular, sweet and highly nutritional substance produced by the foraging activity of honeybees, actively collecting nectar from a myriad of flowering plants. Bees secrete a specific substance which converts nectar into honey before storing in honeycombs for maturity (Codex Stan, 1981). The composition of honey is characterized by the type of plants where bees collect their nectar, climatic conditions, environmental factors, as well as bee farming practices **(Meo et al., 2017; Anklam, 1998).**

Generally, honeys are classified into two categories, namely blossom and honeydew **(Pita-Calvo and Vázquez, 2017)**. Blossom is sourced from flower nectar while the latter is produced from the secretion of living plants parts left behind by plant sucking insects (Codex Stan, 1981; Official Journal of the European Communities, 2001). The main constituents of honey are carbohydrates (sugars), contributing to nearly 95% (w/w) of its dry weight **(Pita-Calvo et al., 2017),** of which contains 75% (w/w) of monosaccharides (fructose and glucose), as well as minute amounts of disaccharides (sucrose) and 10 − 15% (w/w) of other types of sugars (oligosaccharides and tetrasaccharides). It has been described that sugars in honey are used for energy supply, as well as contributing to the observed physical characteristics of honey such as viscosity, hygroscopicity and granulation **(Kamal and Klein, 2011).** Honey contains

nearly 0.5% proteins, mainly enzymes and free amino acids. Protein content has been reported in honey from different floral sources, where high protein contents were considered as over 1000 μg/g **(Azeredo et al, 2003)**. However the contribution of that fraction to human protein intake is low. Honey contain main three enzymes are invertase (sucrose, αglucosidase), decomposing sucrose into fructose and glucose,glucose oxidase, producing hydrogen peroxide and gluconic acid from glucose, diastase (amylase), decomposing starch or glycogen into smaller sugar units **(Bogdanov et al 2008)**. Amino acids in honey account for 1% (w/w). The quantity of total free amino acids in honey is about to between 10-200 mg/100g, with proline as their major contributor, corresponding to around 50% of the total free amino acids **(Iglesias et al, 2004)** The main amino acids identified in honey from different botanical and geographical origin are: glutamic acid, aspartic acid, asparagine serine, glutamine, histidine , glycine, threonine, balanine, arginine, a-alanine, g-amino butyric acid, proline, tyrosine, valine ammonium ion, methionine, cysteine, isoleucine, leucine, tryptophan , phenylalanine, ornithine and lysine **(Perez et al, 2007)**. Flavour of honey is an important characteristic for its application in food industry and also a selection criterion for consumer's choice.

The another group is polyphenol of compounds with respect to appearance and functional properties. 56 to 500 mg/kg total polyphenols were found in different honey types, depending on the honey type **(Gheldolf and Engeseth, 2002)**. Polyphenols in honey are mainly flavonoids (e.g. quercetin, luteolin, kaempferol, apigenin, chrysin, and galangin), phenolic acids and phenolic acid derivatives **(Tomas Barberan et al, 2001)** The effect of honey on the antibody production against thymus-dependent antigen sheep red blood cells and thymusindependent antigen (Escherichia coli) in mice was studied. According to this study oral honey stimulates antibody production during primary and secondary immune responses against thymus-dependent and thymus-independent antigens **(Al Waili and Haq, 2004).**

Dough Rheology:-

Dough Structure

Dough is a wet mass developed after mixing of wheat flour, water and other ingredient. Physico- chemical properties of dough play important role in the bakery. Paste and ready to eat cereals processing industry. Dough is developed due to complex interaction among wheat constituent during mixing operation. The process of dough development begin with addition of water and commencement of mixing operation. Initially all ingredient are hydrated

and appear like a sticky paste. On further kneading the viscosity increase, sticky characteristic of dough disappear and a non- sticky mass is developed at peak consistency of dough. At this stage dough behaves likes a viscoelastic mass either both elastic and extensible characteristic.

Dough Rheology:-

Rheology is the study deformation and flow of matter. Deformation relates to solids and the force exerted and the deformation achieved is measured. The magnitude of the forces that has to be applied to the material to deform I depends upon the area over which it is applied. Rheology is a separate field of study that involves stress & strain measurement. In the field of baking dough rheology is of particular interest due to the effect of elasticity & extensibility of bread dough on final bread qualities. Water absorption is the mainly affected parameter of the bread rheology. In the baking industry, dough rheology & water absorption is frequently studied by farinograph & mixograph.

Origin:-

Rheology was the given to the discipline of a society in 1929, that was engaged in study of how material deform in response to forces. The goal of rheology is to provide quantitative parameter that how a material will deform as a function of forces, time & spatial orientation.

"Everything Flow" Heraclitus, however, everything does flow but depending on the forces, direction & the length of time.

Function:- Dough rheology is the studies because it is related to bread making quality.

Importance:-

Importance of dough is well recognized in predicting and controlling the quality of baked products. Variation in the elastic and viscous behavior of different wheat flour dough is considered as key quality factor in bakery application. The primary aim of rheology measurement remain to differentiate between wheat varieties according to their baking performance without actually performing the baking test. Rheological test that can correctly predict the baking performance of any wheat variety would save time, material and labor.

METHOD:-

- Farinograph
- Mixograph
- Extensograph
- Alveograph
- Rapid ViscoAnalyser
- Viscometer.

MATERIALS AND METHODS

Flours and other ingredients

Different types of cereals and course cereals used in the preparation of cookies. Here chia seed and wheat flour were purchased from local market of Varanasi. Other ingredients such as butter, honey, salt, milk powder, baking powder, baking soda were also purchased from the Lanka Varanasi. Various instruments that have been used in manufacturing and analysis of chia seed flour based cookies are enlisted in Table 3.1.

3.1 Instruments used in Manufacturing and analysis of cookies.

Name of instruments	Company ,Model And , Country
Electronic weighing balance	Metller toledo ,jb i 603 – cif act , Switzerland
ph meter	Thermo scientific sn821899, Singapore
Micro-oven	ifb25sc2, India
Texture profile analyser	Text plus texture profile analyzer stable micro systems ,u k
Vortex shaker	Macro scientific marks pvt. ltd , Delhi
Hot air oven	Per fit , 992110 , India
Laminar air flow	Lab tech lcb 1201v, daihan pvt. lmt., India
Centrifuge machine	Sigma , 3-30k , Germany
Incubator	Remi, India
Soxhlet Apparatur	SOCS PLUS, SCS-4, Chennai
Spectrophotometer	Shimadzu, Japan
High Pressure Steam Sterilizer	Tomy, SX-500, Japan

1. Chemicals

Almost chemical used in this study were of analytical grade. The chemicals were procured from HI Media Laboratories Pvt. Ltd. (Mumbai, India), Merck Specialties Pvt. Ltd, (Mumbai, India), Fisher Scientific, (Mumbai, India).

1. Electronic balance

A top pan electronic balance of high accuracy least count of 0.01g was used for weighing the samples.

2. Soxhlet

A Soxhlet extractor is a piece of laboratory apparatus (Laurence M. Harwood) invented in 1879 by Franz von soxhlet (Soxhlet, F. Die). It was originally designed for extraction of lipid from solid material. A soxhlet extractor is not limited to extraction of lipids. Typically, soxhlet extractor is required where the desired compounds have a limited solubility in a solvent, and the impurity is insoluble in that solvent. If desired compounds have significant solubility into a solvent then a simple filtration can be used to separate the compounds from the insoluble substance.

3. Muffle Furnace

A muffle furnace with an externally heated apartment, the walls of which radiantly heat the contents of the apartment, so that the sample being heated has no contact with flame. Muffle furnaces are mostly used in laboratories as a compact means of creating extremely high – temperature. They are employed to conduct test characteristics of materials at extremely high & accurate temperatures. It also known as a retort furnace.

4. UV spectrophotometer

UV spectrometer (UV-1800, Shimandzu) was used for the determination of optical density/browning index of the samples. It was used for the spectrophotometer analysis of samples. The output was available on the digital display in terms of optical density (absorbance), percentage transmission (%) and concentration (C) .It used a diffraction grating as the monochromatic and produces linear spectrum. The grading has high resolution of 600 lines / nm, ensuring there by, a narrow band width. An automatic shelter was provided , so that

the light passes through the cuvette-containing sample only when it was inserted in the housing , thereby , increasing the life of the photo –detector .The instruments had wavelength in the range of 340 to 960 nm with a resolution of 5 nm .

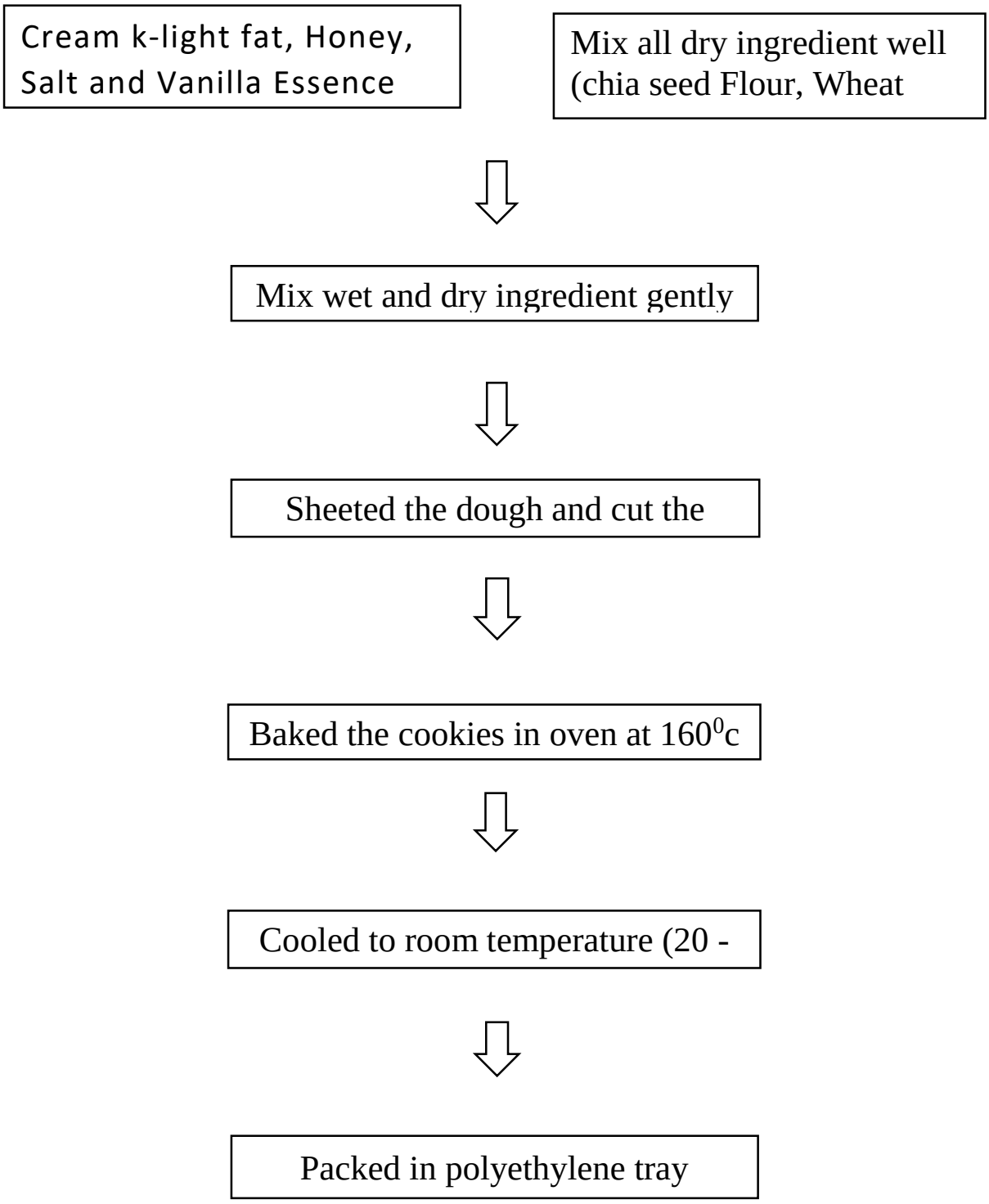
5. Preparation of Chia Seed Cookies

For the manufacturing of 100g of chia seed cookies, wet mixture was prepared by mixing margarine, honey, salt and essence. Separately a dry mix was prepared by wheat flour, chia seed flour, skimmed milk powder, baking powder, baking soda and was sieved. A dry mix was added to the wet mix to make dough. The prepared dough was sheeted with the help of rolling pin and cut in desired size and shape by cookies cutter. The prepared cookies baked in oven at 160^0C for 25 min.

3.2 Ingredients of chia seed cookies.

Ingredients	Amount/100g
Chia seed f flour	8.41
Whole wheat flour	41.59
K – lite fat	28.165
Honey	33.165
Skimmed Milk Powder	5
Baking powder	1
Baking soda	1
Salt	1
Essence	1

Flow Chart for preparation of Chia seed cookies



Experimental Design

Trial No		INGREDIENTS								
	Chia seed Flour(g)	**Wheat flour(g)**	**K-light Fat(g)**	**Honey (g)**	**SMP (g)**	**B.P (g)**	**B.S (g)**	**Salt (g)**	**Essence (ml)**	**Total**
T_1	15	35	15	20	5	1	1	1	1	
T_2	12.5	37.5	20	25	5	1	1	1	1	
T_3	10	40	15	30	5	1	1	1	1	
T_4	10	40	25	20	5	1	1	1	1	
T_5	15	35	25	30	5	1	1	1	1	
T_6	15	35	15	30	5	1	1	1	1	
T_7	10	40	25	30	5	1	1	1	1	
T_8	15	35	25	20	5	1	1	1	1	
T_9	10	40	15	20	5	1	1	1	1	
T_{10}	12.5	37.5	20	16.8	5	1	1	1	1	
T_{11}	12.5	37.5	25	11.8	5	1	1	1	1	
T_{12}	16.58	33.42	20	25	5	1	1	1	1	
T_{13}	8.41	41.59	20	25	5	1	1	1	1	
T_{14}	12.5	37.5	28.165	25	5	1	1	1	1	
T_{15}	12.5	37.5	20	33.165	5	1	1	1	1	

Note:- SMP is skimmed milk powder, BP is baking powder, BS is baking soda, T_1, T_2, T_3.....T_{20} is trial no one, two, three …….trial twenty correspondence.

Optimization of Chia Seed cookies.

The parameters for the optimization

Sensory Evaluation

Chia seed cookies were analysed for different sensory characteristics like color and appearance, body and texture, aroma and taste and overall acceptability. Sensory evaluation was performed by a panel of 9 semi trained judges from the Centre of Food Science and Technology and Department, Banaras Hindu University, Varanasi (India). Sensory evaluation was done at 27^0 C and 60 % relative humidity. 9 – Point Hedonic rating scale (1= dislike extremely , 9 like extremely) (Amerine et al ,. 1965) was used for color appearance , body and texture (hardness and gumminess) , aroma and taste and overall acceptability . The sensory score sheet is shown in appendix-1.

3.5 Physico – Chemical Analysis of Chia Seed Flour based Cookies.

1. Texture analysis (TA)

Textural parameters of product like hardness, springiness, chewiness, gumminess, cohesiveness and resilience were analyzed using Texture Analyser (TA.XT plus texture profile Analyser, Stable Micro Systems, and UK).

3.5. Texture Analysis setting for texture profile analysis of Hardness.

TA Setting	Mode	Measure Force in Compression
	Option	Return to start
	Pre- Test speed	1.5mm/s
	Test speed	1.0mm/s
	Post- test speed	10.0mm/s
	Distance	5.0mm
	Trigger force	Auto-25g
	Tare force	Auto
	Data acquisition rate	200pps
Accessory	HDP/BSK:BLADE SET WITH KNIFE	

1. Texture Analysis of Hardness

1.1 Hardness

Hardness is defined as the maximum peak force during the first compression cycle (first bite) and has often been substitute by term firmness. Within the TPA macro, the parameter was displayed as force 2. Unit were kg, g or N.

1.2 Cohesiveness

It is defined as the ratio of the positive force area during second compression and first compression cycle. It may also be dictated as rate at which the material disintegrates under mechanical action. It has no units. It was calculated as ratio of area of second compression cycle to that of area of first compression cycle.

1.3 Springiness

Also known as elasticity and related to the height that the food recovers during the time that elapses between the end of the first bite and the start of the second bite. It was calculated as ratio of time taken to complete second compression cycle to that of time taken for completion of first cycle. It is dimensionless.

1.4 Gumminess

Gumminess is defined as the multiplication of product hardness and cohesiveness. A semisolid food is characterized by high degree of cohesiveness and lo degree of hardness. It was calculated as Force cohesiveness. NO units are defined for this parameter.

1.5 Chewiness

It is the product of gumminess and springiness it was calculated as force 2 cohesiveness springiness, there are no unit for this parameter.

1.6 Resilience

The resilience is a measurement of how the sample recover from information both in term of speed and force derived. There is no unit for this parameter.

2. Moisture (AOAC, 1980)

Weighed sample of finely ground material (5g) is dried in a hot air oven for 8 hours at 105 C. In case of wet sample. It is dried to constant weight. China crucible with dried material is transferred immediately to a desiccators cooled and weighed.

$$\% \text{ Moisture content} = \frac{W3 - W1}{W2 - W1} \times 100$$

Where, W1 = Weight of empty petri-plate

W2 = Weight of empty petri-plate + Sample

W3 = Weight of petri-plate after drying

3. Ash content (AOAC, 1980)

Procedure:

5 g of completely homogenized sample was taken accurately in moisture free silica crucible. The crucibles were then placed on hot plate at 130oC till smoke disappeared. The crucibles were then placed in muffle furnace at 550oC (6 h.). Weights of the cooled crucibles were noted down.

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

4. Protein Determination

The protein content in the chia seed flour based cookies was estimated by following the protocol of AOAC (2000).

Digestion

The system was switched ON, and the digestion unit was pre-heated up to 350 ◦C. 0.2g sample was weighed (W) in the filter paper and wrapped inside it, in triplicates. The sample was taken in 250ml Macro DTL tube. Then to the sample, 10ml conc. H_2SO_4 was added, followed by addition of 5g of catalyst mixture [(5:1) (Potassium Sulphate: Copper Sulphate). The sample tube was then loaded in the digestion unit with manifold &KEL FLOW setup. Tap water was connected with maximum pressure for KEL FLOW. The temperature was increased to 420^{o} C. Digestion was carried out till clear green color appeared. According to the sample, ninety minutes were taken for digestion. Then the digested mixture was cooled on the cooling rack for approximately thirty minutes

Distillation

The system was switched ON and the solutions viz. 4% Boric acid, 40% Alkali and 0.1N HCL were prepared and kept. The Alkali, Boric acid and $KMnO_4$ were loaded to the system through silicon hoses provided at the back of the equipment while waiting for READY

signal. In a 250ml conical flask 25ml Boric acid was taken with indicator and placed at the receiver end. The sample was diluted with distilled water (dilution 10ml to 20ml). Then the sample tube was loaded in the sample side. Before starting the sample testing, the water was allowed to flow through the system for cooling purpose (check the INLET and the OUTLET). The sample testing was started after the READY signal appeared. 40ml of the 40% Alkali was added to the above (until dark brown color appears). Then the process was started. During the process, liquid ammonia was collected into Boric acid and its color changed according to the indicator used. After the completion of the process the conical flask was removed from the receiver end and then titrated. The tube from the sample side was now removed.

Titration

0.1N HCL was taken in the burette and titrated first against blank and then against the sample. Titre value was noted down.

Calculation

$$\% \text{ Nitrogen} = \frac{\mathbf{14.01}\times\mathbf{0.1}\boldsymbol{N}\times(\boldsymbol{TV}-\boldsymbol{BV})}{\boldsymbol{W}\times\mathbf{1000}} \times 100$$

% Protein = %N × 6.25 (for food samples)

Where, TV Titre value

BV Blank value

W Sample weights

5 .Fat Analysis (IS: 1011: 2002)

Procedure:

Five grams of sample was taken in a thimble and the thimble was placed in previously weighed soxhlet beaker. The beakers were then placed in the extractor (SocsPlus). After that extractor was filled with petroleum ether and their top were covered with cotton plugs. The Soxhlet apparatus (SOCS PLUS, SCS-4, Chennai) was then switched on with a set temperature of 70 °C for 90 minutes. After completion of extraction, the temperature was

increased up to 150 °C again for 90 minutes, for the complete removal of moisture. The beakers were removed from the Soxhlet apparatus and cooled in desiccator. The cooled beakers were then weighed.

Calculation:-

$$\% \text{ Fat} = \frac{\textbf{Weight of residue}}{\textbf{Weight of sample}} \times 100$$

Where,

Weight of residue = Weight of beaker after drying – Weight of empty beaker.

6. Antioxidant activity

Procedure for DPPH inhibition method:

Determination of antioxidant activity of sample was done by DPPH inhibition method (Nishino et al. 2000). 2 g finely ground Sample was taken in 25 ml ethanol and was kept overnight in dark at room temperature. 0.2 ml of eluted extract was taken and to it 1 ml of DPPH solution (80 µg/ml ethanol) was added. A control was set up with 0.2 ml distilled water as blank and left at room temperature for 30 min. The sample sets were centrifuged at 3000 rpm for 15 min. In cuvette 0.5 ml of centrifuged solution was taken and to it 1ml of ethanol was added. Absorbance was taken at 517 nm separately for blank and samples using ethanol as reference.

$$\textbf{\% DPPH inhibition} = \frac{AB - AS}{AS} \times 100$$

Where,

AB = OD for blank

AS = OD for sample.

7. Total Phenolic Content

The total phenolic content was determine by the Folin-Ciocalteau method (**Singleton and Rossi, 1965**) and (**Kaur and Kapooor, 2002**). 2g sample were homogenized in 15ml of 80 % v/v aqueous ethanol at room temperature and centrifuge in cold condition at 10,000 rpm for 15 min at 4^0C and the supernatant was poured into petri dishes and evaporated to dryness at room temperature. Residue was dissolved in 5ml of distilled water. 100µl of this extract was diluted to 3 ml of water and 0.02ml of the Folin- Ciocalteau reagent was added. After 3 minute, 2ml of 20% sodium carbonate was added and content were mixed thoroughly and blue was developed. The absorbance was measured at 750 nm in UV- Spectrophotometer (Shimadzu, Japan) using tannic acid as a standard. The result were expressed as mg tannic acid /100g fresh material.

8. Hydroxy- methyl Furfural (HMF) Content

Total HMF in cookies was done by the method recommended by (**Keeney and Bassette, 1959**) with slight modification.

Procedure

0.3g of sample was taken in a test tube of 50ml and then 5ml oxalic acid and 7ml of distilled water were added. The test tube were placed at a temperature of 100^0C for 1 h. the test tube wee cooled at room temperature and then 5mk of 40% w/v tri-chloro acetic acid was added. After that filtration of above solution was done through whatman paper no 42. The filtrate amounting 0.5ml was taken and 3.5ml water and 1g cookies 0.05M thio- barbituric acid (TBA) were added. The test tube were then placed in circulating bath 40^0C for 50 min. the sample were then cooled and absorbance was taken at 443 nm using UV-Spectrophotometer(Shimadzu,Japan).

RESULTS AND DISCUSSION

The present study was undertaken with an objective to optimize the process for chia seed based cookies with blend of honey. In the initial stages of the study, the levels of the ingredients were optimized using 9 point hedonic sensory characteristics scale and textural parameters using texture analyzer. Finally, the product was assessed for its physico– chemical and functional properties.

4.1 Optimization of the chia seed based cookies using 9 point hedonic scale.

Sensory Evaluation

The sensory quality of the chia seed based cookies samples prepared from different levels of the ingredients were evaluated by a panel of judges. The sensory parameters like color and appearance, aroma and taste, body and texture were evaluated. Sensory analysis is performed in order to identify the chia seed based cookies with the highest acceptability.

The convenience, the maximum 9 point hedonic scale marks were used given by American et.al. (1965) and all attributes were presented were presented here under.

A. Color and Appearance

B. Aroma and Taste

C. Body and Texture

D. Overall Acceptability

Experimental Design

Table No. 4.1

Trial No		INGREDIENTS								
	Chia seed Flour(g)	Wheat flour(g)	K-light Fat(g)	Honey (g)	SMP (g)	B.P (g)	B.S (g)	Salt (g)	Essence (ml)	Total
T_1	15	35	15	20	5	1	1	1	1	
T_2	12.5	37.5	20	25	5	1	1	1	1	
T_3	10	40	15	30	5	1	1	1	1	
T_4	10	40	25	20	5	1	1	1	1	
T_5	15	35	25	30	5	1	1	1	1	
T_6	15	35	15	30	5	1	1	1	1	
T_7	10	40	25	30	5	1	1	1	1	
T_8	15	35	25	20	5	1	1	1	1	
T_9	10	40	15	20	5	1	1	1	1	
T_{10}	12.5	37.5	20	16.8	5	1	1	1	1	
T_{11}	12.5	37.5	25	11.8	5	1	1	1	1	
T_{12}	16.58	33.42	20	25	5	1	1	1	1	
T_{13}	8.41	41.59	20	25	5	1	1	1	1	
T_{14}	12.5	37.5	28.165	25	5	1	1	1	1	
T_{15}	12.5	37.5	20	33.165	5	1	1	1	1	

Given application of abbreviations, SMP is skimmed milk powder, BP is baking powder, BS is baking soda, T_1, T_2, T_3.....T_{20} is trial no one, two, three …….trial twenty correspondence.

Table No 4.2 Optimized recipe of chia seed cookies.

Ingredients	Amount/100g
Chia seed f flour	8.41
Whole wheat flour	41.59
K – lite fat	28.165
Honey	33.165
Skimmed Milk Powder	5
Baking powder	1
Baking soda	1
Salt	1
Essence	1

4.1.1Interactive effect of chosen variable on color and appearance

The color and appearance score varied from 6.131 to 8.69 (Table No.4.3). The minimum color and appearance score was obtained in T_3, while the maximum color and appearance score was observed in T_{12}. The amount of chia seed flour, fat and sugar in the T_3 were 30, 15 and 30 %, respectively. The T_{12} amount of chia seed flour, fat and sugar were 25, 20 and 25 %, respectively.

The positive coefficient term color and appearance score showed that the amount of chia seed flour, fat and sugar showed positive interactive effect on color and appearance. The quadratic term for the Interactive effect of chosen variable these three variable were significant.

Fig 4.1 shows that the 3D surface plot for the color and appearance as influenced by the changing the level of chia seed flour and fat while keeping the sugar constant. From the fig 4.1 it can be observed that with the increase in the level of chia seed flour color and appearance score quality increase however there was a slightly increase in color and appearance score due to increased fat content.

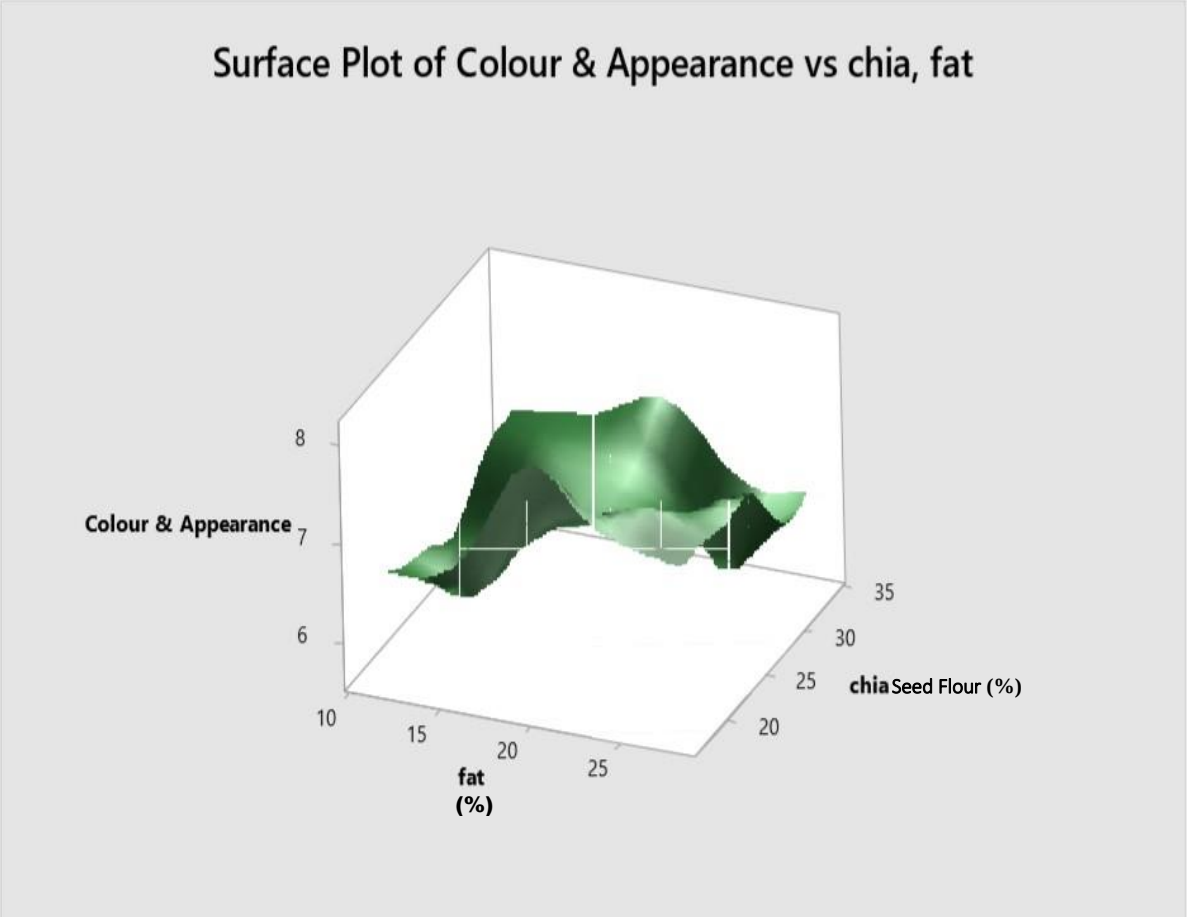


Fig 4.1 3D surface plot for color and appearance as influenced by the level of chia seed flour and fat (at constant sugar level).

4.1.2Interactive effect of chosen variable on color and appearance

The color and appearance score varied from 6.131 to 8.69 (Table No.4.3). The minimum color and appearance score was obtained in T_3, while the maximum color and appearance score was observed in T_{12}. The amount of chia seed flour, fat and sugar in the T_3 were 30, 15 and 30 %, respectively. The T_{12} amount of chia seed flour, fat and sugar were 25, 20 and 25 %, respectively.

The positive coefficient term color and appearance score showed that the amount of chia seed flour, fat and sugar showed positive interactive effect on color and appearance. The quadratic term for the Interactive effect of chosen variable these three variable were significant.

Fig 4.2 shows that the 3D surface plot for the color and appearance as influenced by the changing the level of chia seed flour and sugar while keeping the fat constant. From the fig 4.2 it can be observed that with the increase in the level of fat, color and appearance score quality increase however there was a slightly increase in color and appearance score due to

increased chia seed flour content.

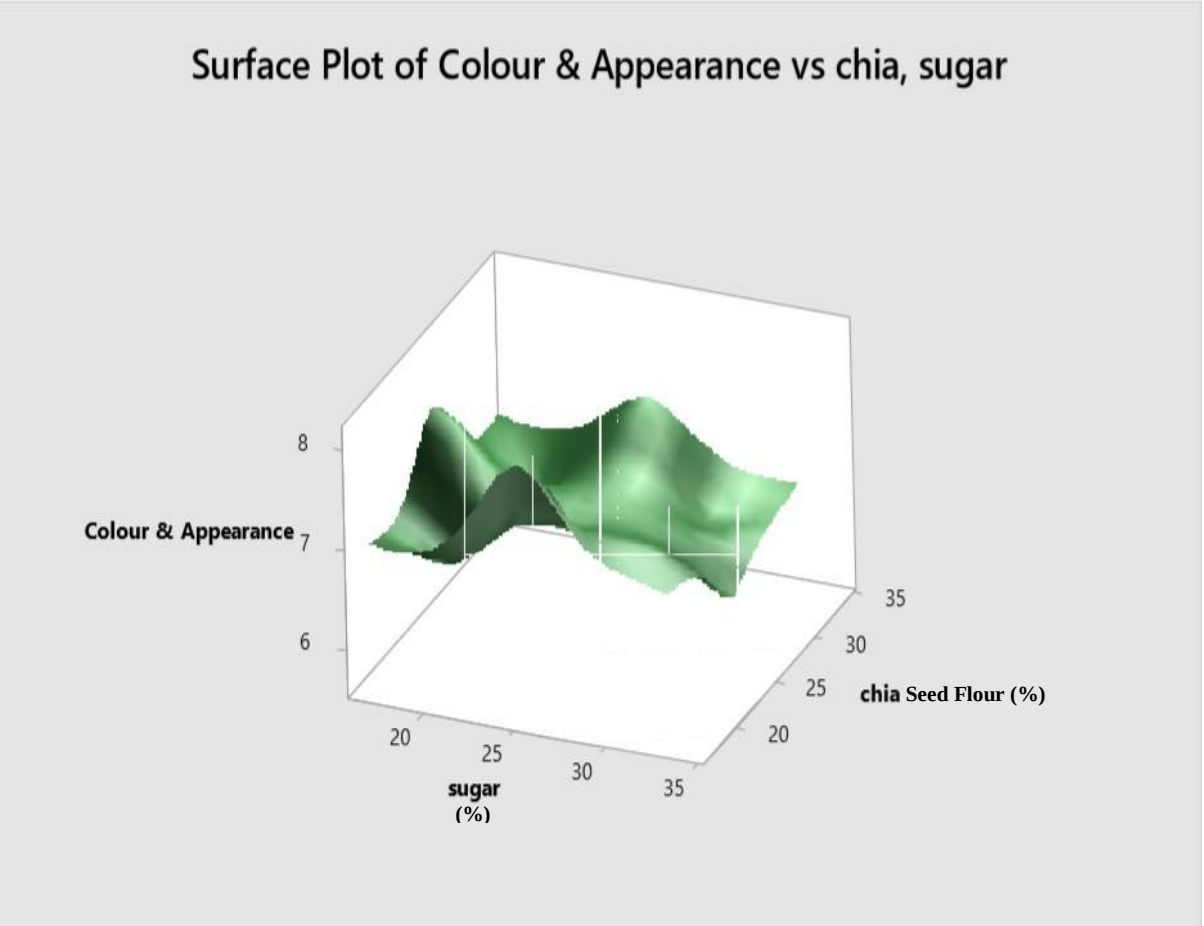


Fig 4.2 3D surface plot for color and appearance as influenced by the level of chia seed flour and sugar (as constant fat level)

4.1.3 Interactive effect of chosen variable on color and appearance

The color and appearance score varied from 6.131 to 8.69 (Table No.4.3). The minimum color and appearance score was obtained in T_3, while the maximum color and appearance score was observed in T_{12}. The amount of chia seed flour, fat and sugar in the T_3 were 30, 15 and 30 %, respectively. The T_{12} amount of chia seed flour, fat and sugar were 25, 20 and 25 %, respectively.

The positive coefficient term color and appearance score showed that the amount of chia seed flour, fat and sugar showed positive interactive effect on color and appearance. The quadratic term for the Interactive effect of chosen variable these three variable were significant.

Fig 4.3 shows that the 3D surface plot for the color and appearance as influenced by

the changing the level of sugar and fat while keeping the chia seed flour constant. From the fig 4.3 it can be observed that with the decrease in the level of fat and sugar color and appearance score quality increase however there was a slightly increase in color and appearance score due to increased chia seed flour content.

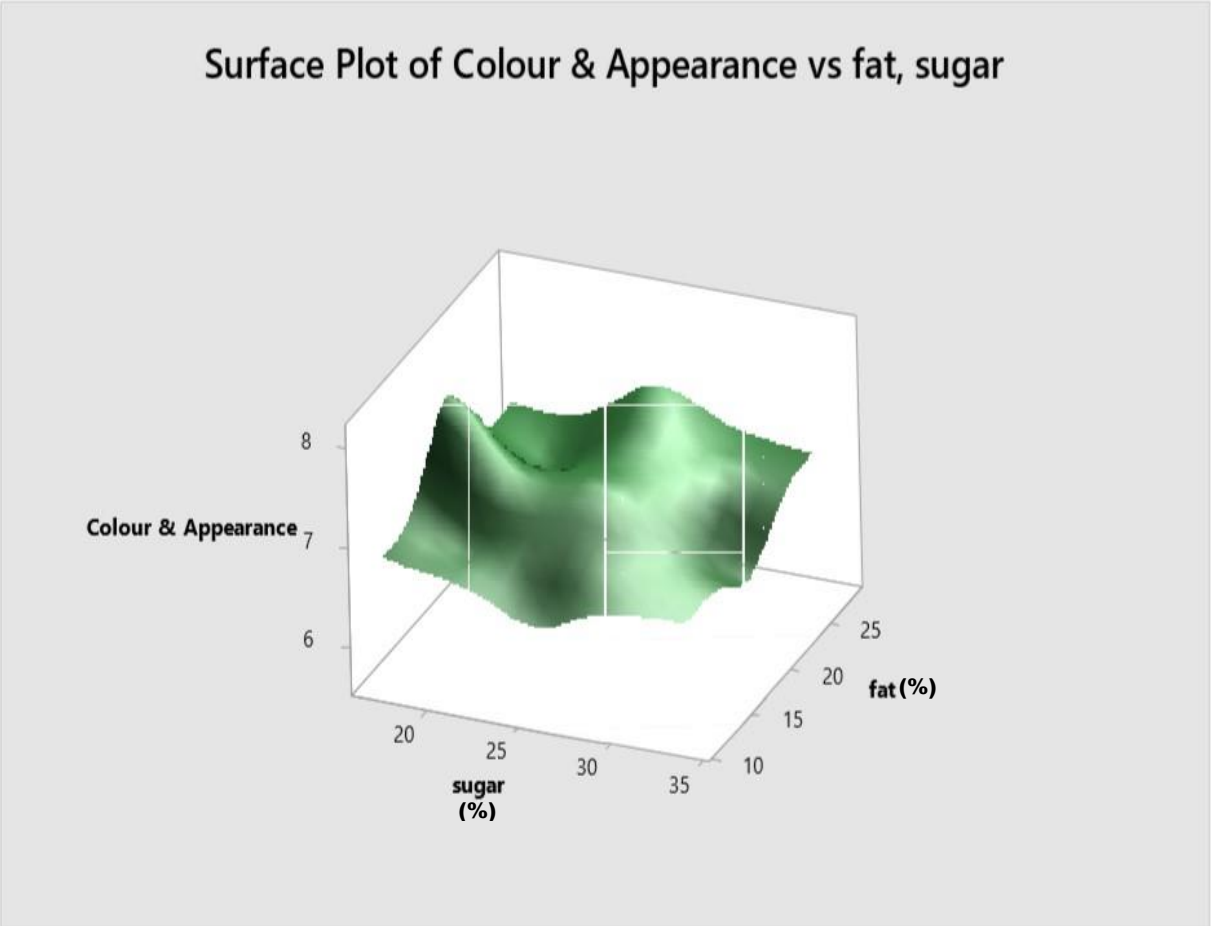


Fig 4.3 3D surface plot for color and appearance as influenced by the level of sugar and fat (as constant chia seed flour level)

Table 4.3 Comparative Values For sensory attributes of chia seed based cookies.

Trial No	Mean value for color and appearance	Mean value for body and texture	Mean value for aroma and taste	Mean value for overall acceptance
T_1	6.33±0.471	7.66±0.471	6.66±0.471	7.21±0.315
T_2	6.33±0.471	7±0.471	7.33±0.471	6.88±0.416
T_3	5.66±0.471	7.33±0	6.66±0.816	6.55±0.062
T_4	7.6±0.489	7.7±0.781	7.3±0.458	7.53±0.169
T_5	7.3±1.004	7.5±0.670	7.5±0.921	7.4±0.094
T_6	7.3±1.004	7.5±0.670	7.5±0.921	7.4±0.094
T_7	5.9±0.7	6.1±0.830	6.5±0.806	6.1±0.249
T_8	5.66±0.471	7.33±0	6.66±0.471	6.55±0.686
T_9	7.4±0.916	7.4±0.663	7.4±0.663	7.4±0.062
T_{10}	5.66±0.471	7.33±0.471	6.66±0.471	6.55± 0.681
T_{11}	7.3±1.004	7.5±0.670	7.5±0.921	7.4±0.094
T_{12}	7.3±1.004	7.5±0.670	6.5±0.921	6.1±0.094
T_{13}	8.1±0.538	7.8±0.40	7.6±0.916	7.83±0.205
T_{14}	6.66±0.471	7±0.816	7±0	6.88±0.160
T_{15}	6.33±0.471	7.66±0.471	7±0	6.99±0.542
T_{16}	7.3±0.458	7.4±0.489	7.4±1.004	7.36±0.047
T_{17}	7.66±0.471	6.33±0.471	7±0.471	6.96±0.542
T_{18}	6.33±0.471	7±0	6.33±0.471	6.44±0.315
T_{19}	7.3±1.004	7.5±0.670	7.5±0.921	7.4±0.094
T_{20}	7.3±1.004	7.5±0.670	7.5±0.921	7.4±0.094

Given application of abbreviation value are mean ± standard deviation. Mean in the same column with control ($P \leq 0.05$) as analyzed by analysis of variance and T_1, T_2, T_3.....T_{20} is trial no one, two, three …….trial twenty correspondence.

4.2 Aroma and Taste

From the table 4.3 it can be inferred that the aroma and taste (flavor) score of chia seed based cookies was highest in trial T_{13} (8.52) and the lowest value was for trial T_{18} (6.401) . It was clearly inferred from the T_{13} that the flavor mainly was dependent upon the amount of honey. An increase in the amount of honey depicts an increase in the acceptability of chia seed flour based cookies in terms of aroma and taste. Formulation, T_{13} has been most liked by the panelists due to more pleasant taste perception. Thus, in the case of sensory evaluation, taste is a predominant factor. So the taste score for variant T_{13} was the highest making it more likely to be accepted than rest of variants and therefore in this research it (T_{13}) can be taken as the most acceptable product or optimum product than the rest.

4.2.1Interactive effect of chosen variable on Aroma and Taste.

The aroma and taste score varied from 8.52 to 6.401 (Table No.4.3). The minimum aroma and taste score was obtained in T_{18}, while the maximum color and appearance score was observed in T_{13}. The amount of chia seed flour, fat and sugar in the T_{18} were 25, 20 and 33.165 %, respectively. The T_{13} amount of chia seed flour, fat and sugar were 16.84, 20 and 25 %, respectively.

The positive coefficient term aroma and taste score showed that the amount of chia seed flour, fat and sugar showed positive interactive effect on aroma and taste. The quadratic term for the Interactive effect of chosen variable these three variable were significant.

Fig 4.4 shows that the 3D surface plot for the aroma and taste as influenced by the changing the level of chia seed flour and fat while keeping the sugar constant. From the fig 4.4 it can be observed that with the increase in the level of chia seed flour and fat aroma and taste score quality decrease however there was a slightly increase in aroma and taste score as we constant the level of chia seed flour and fat.

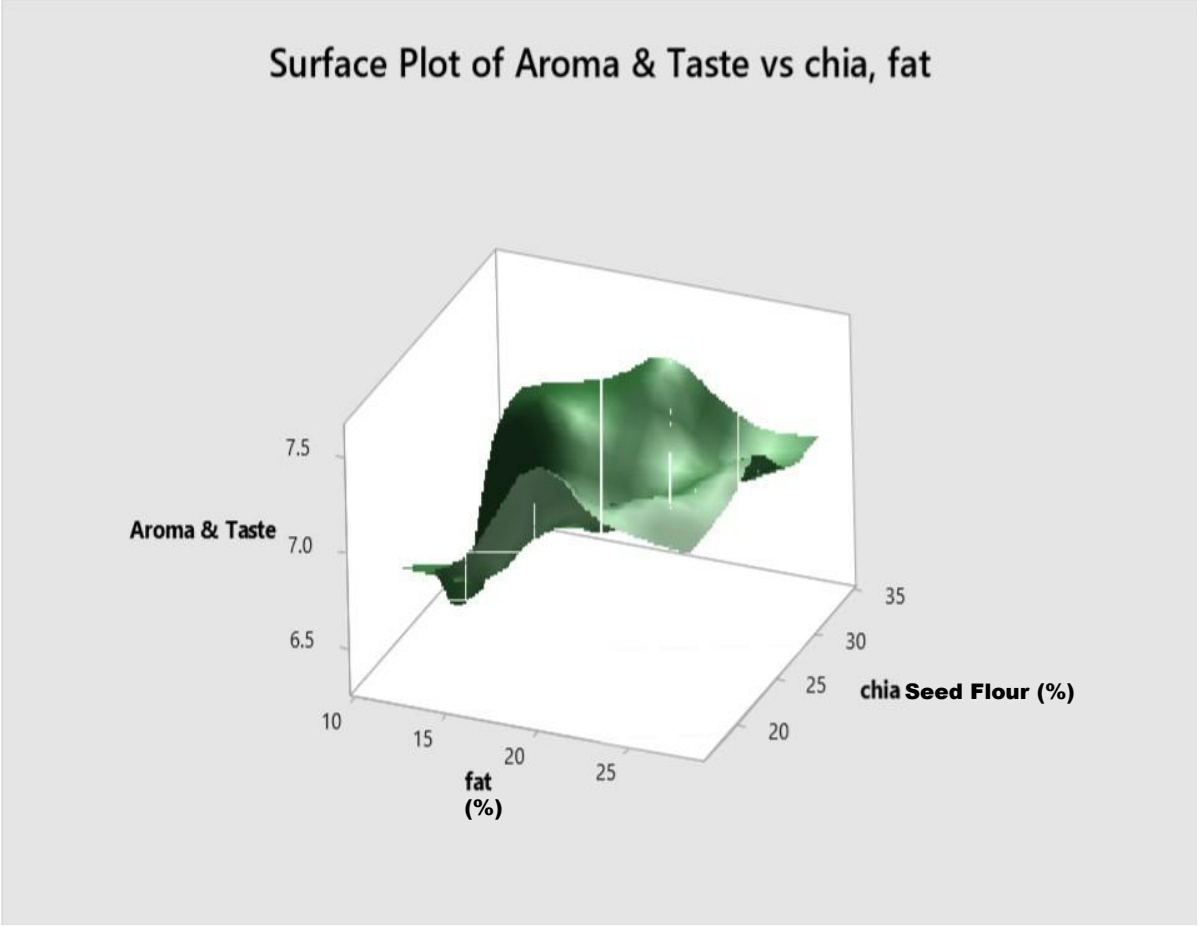


Fig 4.4 3D surface plot for aroma and taste as influenced by the level of chia seed flour and fat (as constant sugar level)

4.2.2Interactive effect of chosen variable on Aroma and Taste

The aroma and taste score varied from 8.52 to 6.401 (Table No.4.3). The minimum aroma and taste score was obtained in T_{18}, while the maximum aroma and taste score was observed in T_{13}. The amount of chia seed flour, fat and sugar in the T_{13} were 16.84, 20 and 25 %, respectively. The T_{18} amount of chia seed flour, fat and sugar were 25, 20 and 33.165 %, respectively.

The positive coefficient term aroma and taste score showed that the amount of chia seed flour, fat and sugar showed positive interactive effect on aroma and taste. The quadratic term for the Interactive effect of chosen variable these three variable were significant.

Fig 4.5 shows that the 3D surface plot for the aroma and taste as influenced by the changing the level of chia seed flour and sugar while keeping the fat constant. From the fig 4.5 it can be observed that with the increase in the level of fat decrease in level of chia seed flour

aroma and taste score quality increase however there was a slightly increase in aroma and taste score due to increased chia seed flour content.

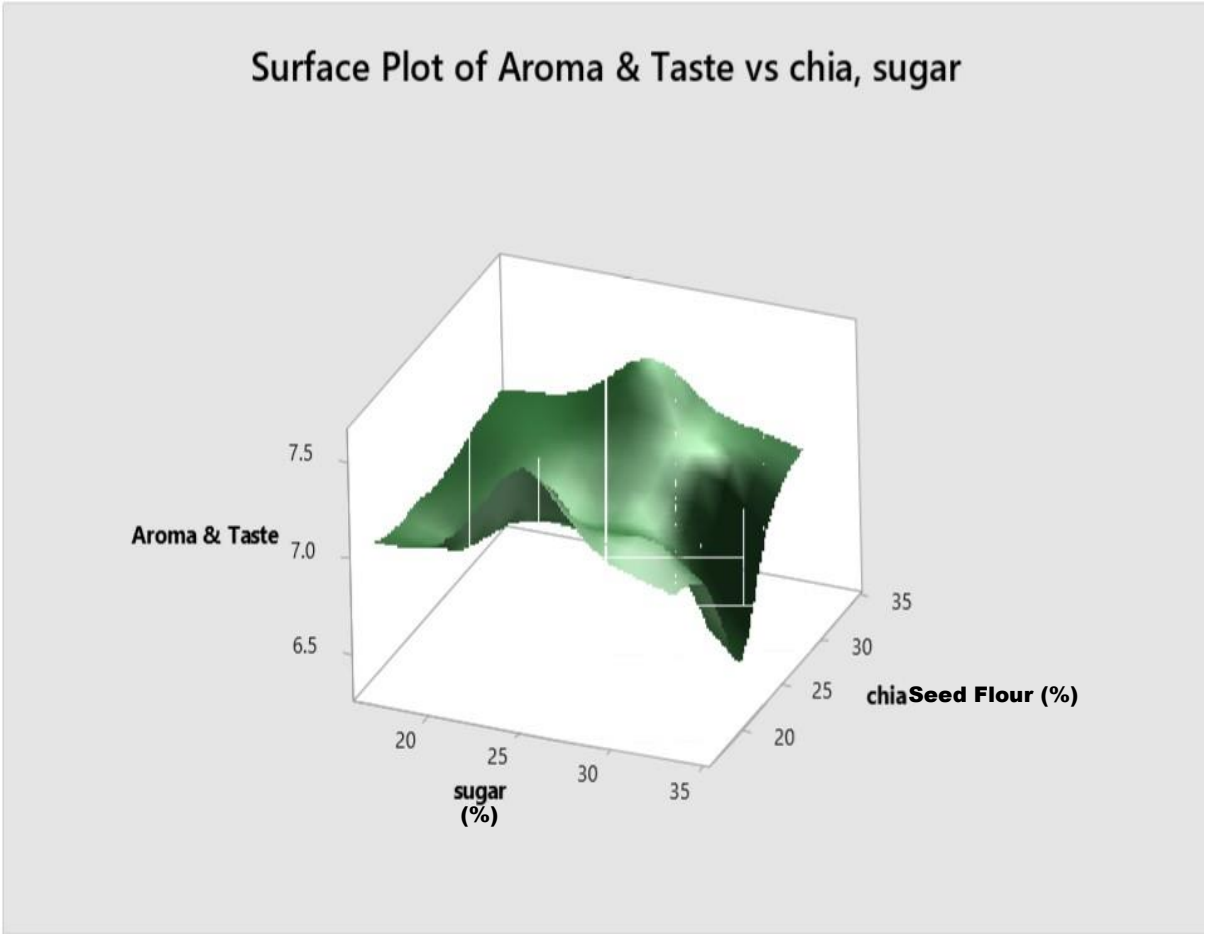


Fig 4.5 3D surface plot for aroma and taste as influenced by the level of chia seed flour and sugar (as constant fat level)

4.2.3Interactive effect of chosen variable on Aroma and Taste

The aroma and taste score varied from 8.52 to 6.401 (Table No.4.3). The minimum aroma and taste score was obtained in T_{18}, while the maximum color and appearance score was observed in T_{13}. The amount of chia seed flour, fat and sugar in the T_{18} were 25, 20 and 33.165 %, respectively. The T_{13} amount of chia seed flour, fat and sugar were 16.835, 20 and 25 %, respectively.

The positive coefficient term aroma and taste score showed that the amount of chia seed flour, fat and sugar showed positive interactive effect on aroma and taste. The quadratic term for the Interactive effect of chosen variable these three variable were significant.

Fig 4.6 shows that the 3D surface plot for the aroma and taste as influenced by the changing the level of sugar and fat while keeping the chia seed flour constant. From the fig 4.6 it can be observed that with the increase in the level of chia seed flour and fat aroma and taste score quality increase however there was a slightly increase in aroma and taste score due to increased fat content.

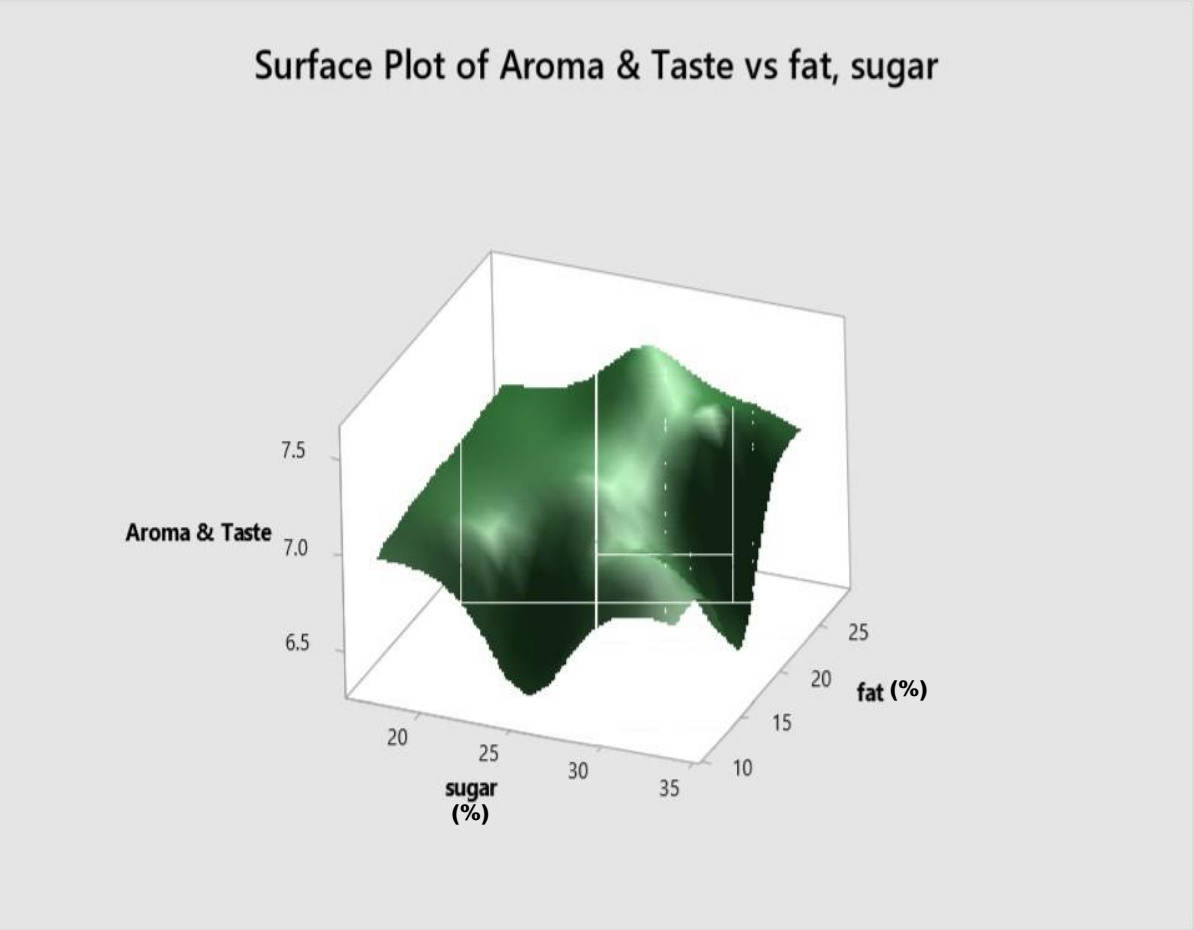


Fig 4.6 3D surface plot for aroma and taste as influenced by the level of sugar and fat (at constant chia seed flour level)

4.3 Body and texture

The sensory mean values for body and texture of the chia seed flour based cookies are clearly stated in table 4.3. The values recorded for T_4 (8.481) was significantly higher than the values recorded for the rest of the trial. The minimum value for body texture was for T_{16} (6.801). The values of body and texture of all the twenty trials were found to be significantly different from each other. [Table 4.1]. Body and texture is mostly affected by the amount of honey. With the increase in the level of concentration honey the hardness of the cookies increase. Texture has been given a fair acceptability for all the variants. T_4 was given the highest score as it had a perfect amount of honey making it neither too hard nor too chewy.

4.3.1Interactive effect of chosen variable on body and texture

The body and texture score varied from 8.481 to 6.801 (Table No.4.3). The minimum body and texture score was obtained in T_{16}, while the maximum body and texture score was observed in T_4. The amount of chia seed flour, fat and sugar in the T_{16} were 25, 28.165 and 25 %, respectively. The T_4 amount of chia seed flour, fat and sugar were 20, 25 and 30 %, respectively.

The positive coefficient term body and texture score showed that the amount of chia seed flour, fat and sugar showed positive interactive effect on body and texture. The quadratic term for the Interactive effect of chosen variable these three variable were significant.

Fig 4.7 shows that the 3D surface plot for the body and texture as influenced by the changing the level of chia seed flour and fat while keeping the sugar constant. From the fig 4.7 it can be observed that with the increase in the level of chia seed flour body and texture score quality increase however there was a slightly increase in body and texture score due to increased fat content.

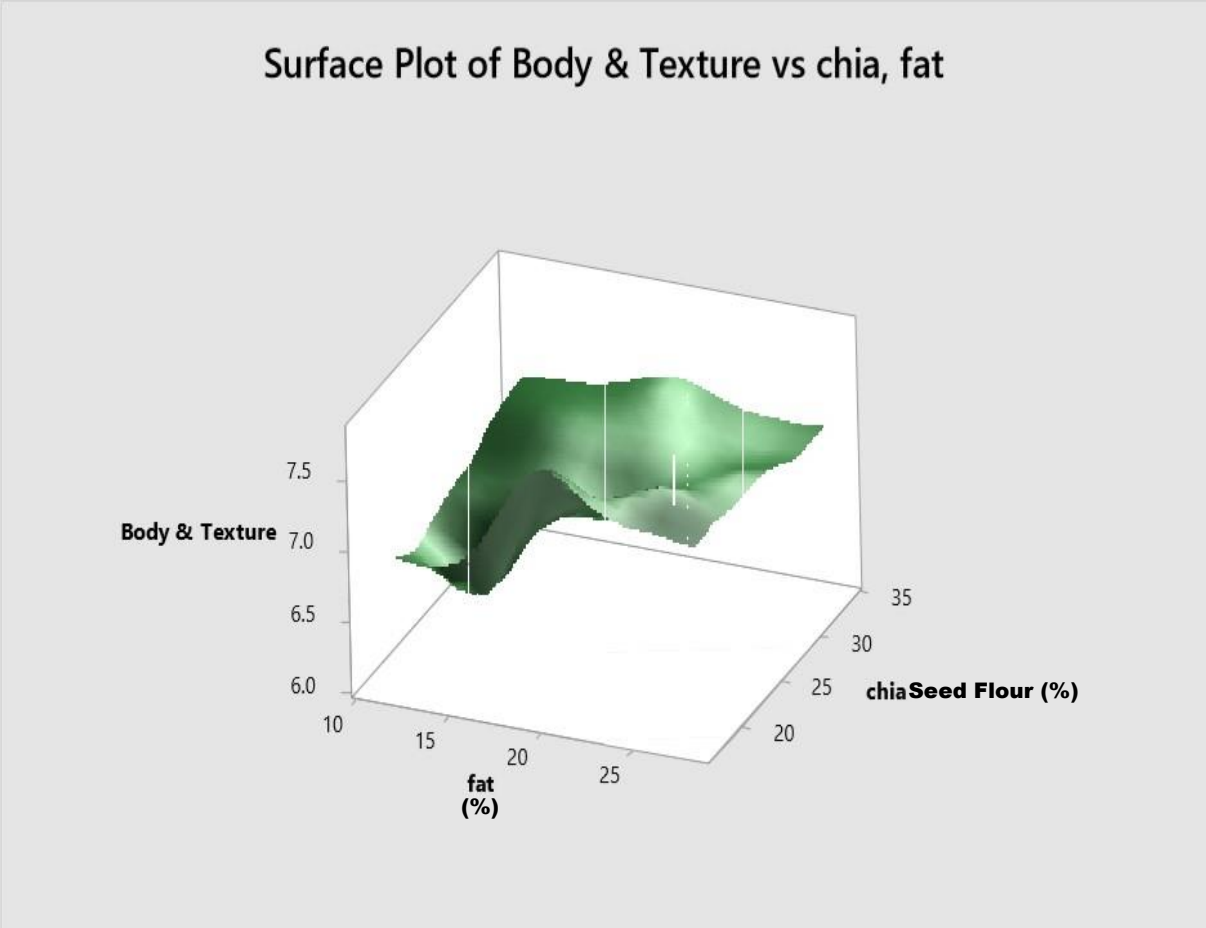


Fig 4.7 3D surface plot for body and texture as influenced by the level of chia seed flour and fat (at constant sugar level)

4.3.2Interactive effect of chosen variable on body and texture

The body and texture score varied from 8.481 to 6.801(Table No.4.3). The minimum body and texture score was obtained in T_{16}, while the maximum body and texture score was observed in T_4. The amount of chia seed flour, fat and sugar in the T_{16} were 25, 28.165 and 25 %, respectively. The T_4 amount of chia seed flour, fat and sugar were 20, 25 and 30 %, respectively.

The positive coefficient term body and texture score showed that the amount of chia seed flour, fat and sugar showed positive interactive effect on body and texture. The quadratic term for the Interactive effect of chosen variable these three variable were significant.

Fig 4.8 shows that the 3D surface plot for the body and texture as influenced by the changing the level of chia seed flour and sugar while keeping the fat constant. From the fig 4.8

it can be observed that with the increase in the level of sugar body and texture score quality increase however there was a slightly increase in body and texture score due to increased chia seed flour content.

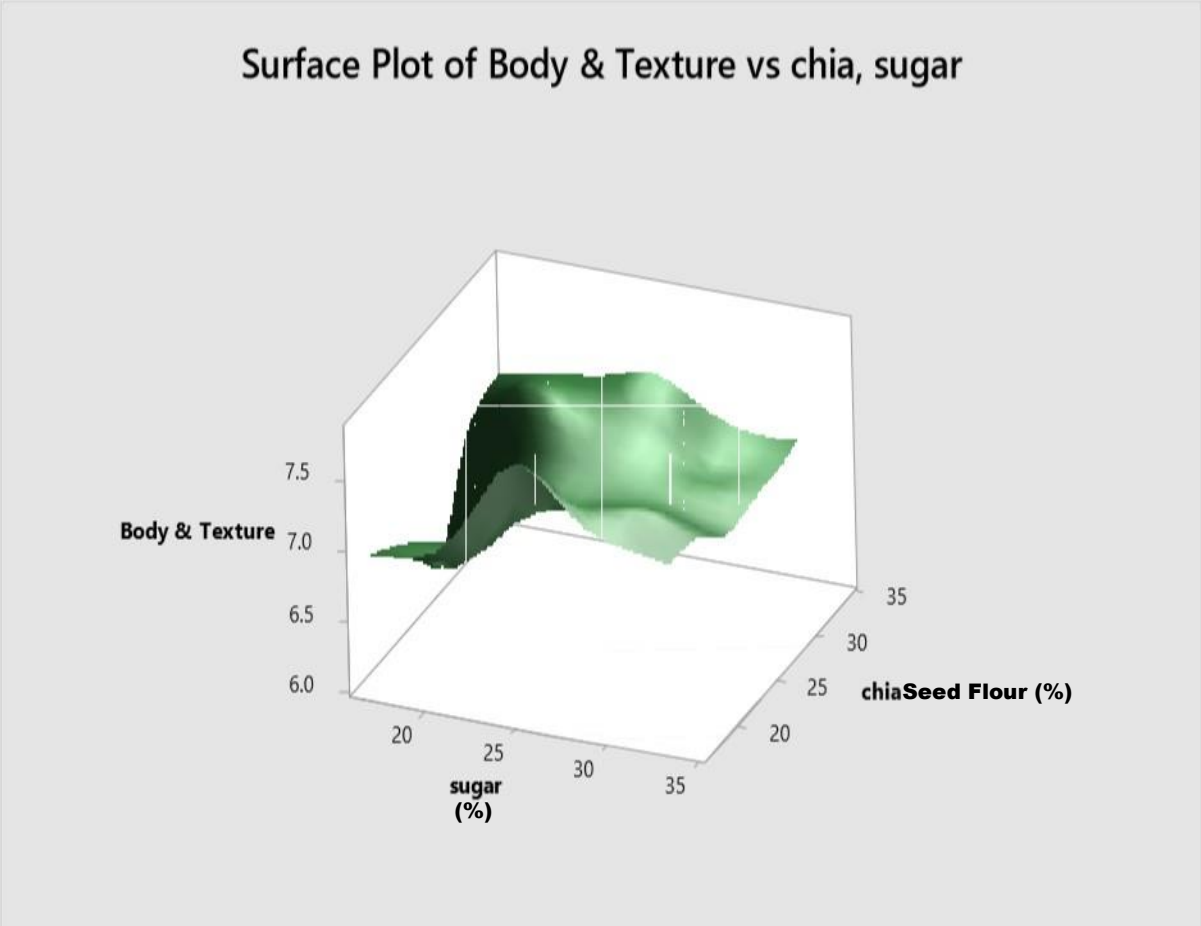


Fig 4.8 3D surface plot for body and texture as influenced by the level of chia seed flour and sugar (at constant fat level)

4.3.3Interactive effect of chosen variable on body and texture

The body and texture score varied from 8.481 to 6.801 (Table No.4.3). The minimum body and texture score was obtained in T_{16}, while the maximum body and texture score was observed in T_4. The amount of chia seed flour, fat and sugar in the T_{16} were 25, 28.165 and 25 %, respectively. The T_4 amount of chia seed flour, fat and sugar were 20, 25 and 30 %, respectively.

The positive coefficient term body and texture score showed that the amount of chia seed flour, fat and sugar showed positive interactive effect on body and texture. The quadratic term for the Interactive effect of chosen variable these three variable were significant.

Fig 4.9 shows that the 3D surface plot for the body and texture as influenced by the changing the level of sugar and fat while keeping the chia seed value constant. From the fig 4.9 it can be observed that with the increase in the level of sugar body and texture score quality increase however there was a slightly increase in body and texture score due to increased fat content.

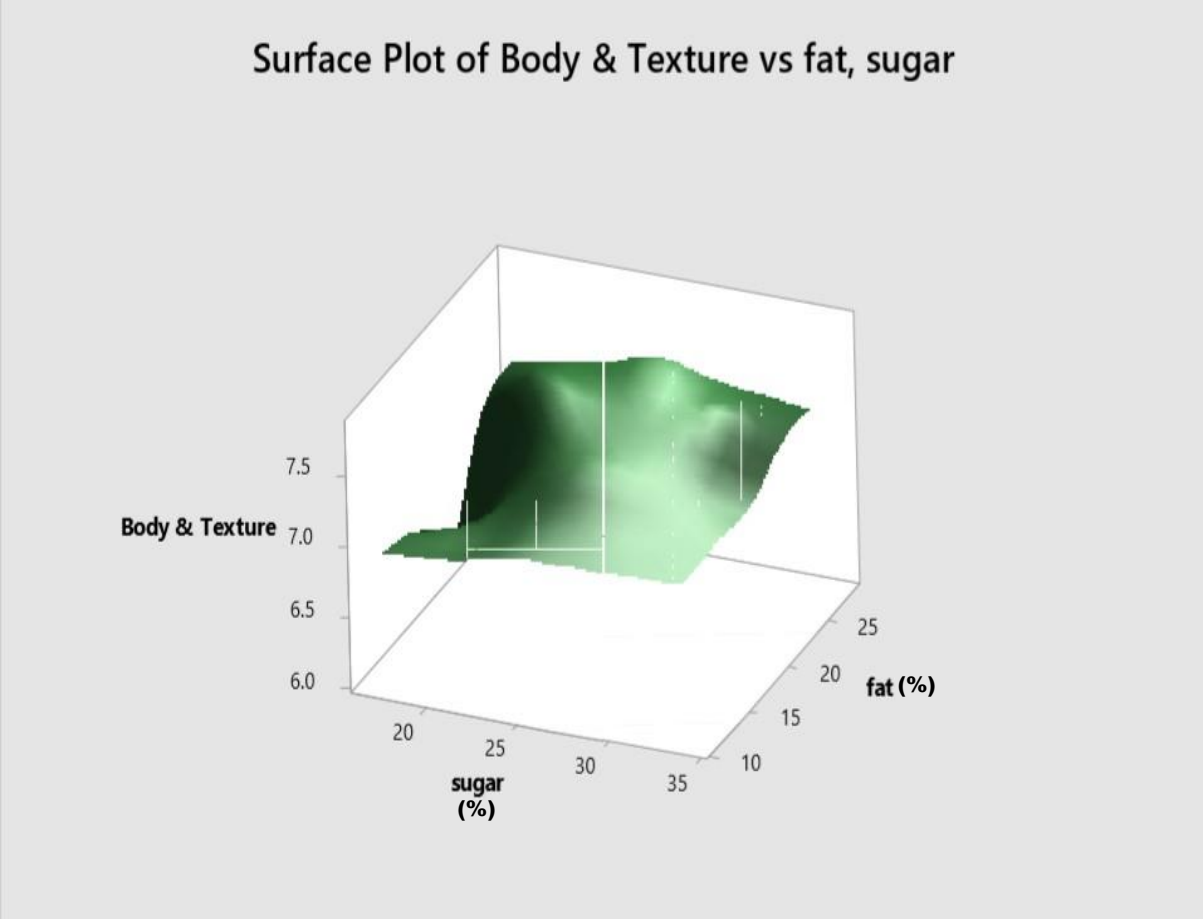


Fig 4.9 3D surface plot for body and texture as influenced by the level of sugar and fat (at constant chia seed flour level)

4.4 Overall acceptability

It can be clearly concluded from Table 4.3 that overall acceptability was highest in case of trial T_{13} (8.035) as it is having the highest mean score and lowest in case of trial T_3 (6.112). The difference in values between all the variants were significant. Overall acceptability also showed a significant sample effect. All samples had mean scores that corresponded to descriptors from 'like moderately 'to like very much '. No variants fell into category of dislike or neither like nor dislike .Among the cookies samples that the percentage of responses in the 'like' categories was highest for trial T_{13}. Taking all these factors into consideration trial T_{13} has more acceptability in terms of color, flavor and texture thus, making trial T_{13} is most acceptable variant in terms of overall sensory attribute.

4.4.1Interactive effect of chosen variable on Overall Acceptability

The overall acceptability score varied from 8.035 to 6.11 (Table No.4.3). The minimum overall acceptability score was obtained in T_3, while the maximum overall acceptability score was observed in T_{13}. The amount of chia seed flour, fat and sugar in the T_3 were 30, 15 and 30 %, respectively. The T_{13} amount of chia seed flour, fat and sugar were 16.84, 20 and 25 %, respectively.

The positive coefficient term overall acceptability score showed that the amount of chia seed flour, fat and sugar showed positive interactive effect on overall acceptability. The quadratic term for the Interactive effect of chosen variable these three variable were significant.

Fig 4.10 shows that the 3D surface plot for the overall acceptability as influenced by the changing the level of chia seed flour and fat while keeping the sugar constant. From the fig 4.10 it can be observed that with the increase in the level of chia seed flour overall acceptability score quality increase however there was a slightly increase in overall acceptability score due to increased fat content.

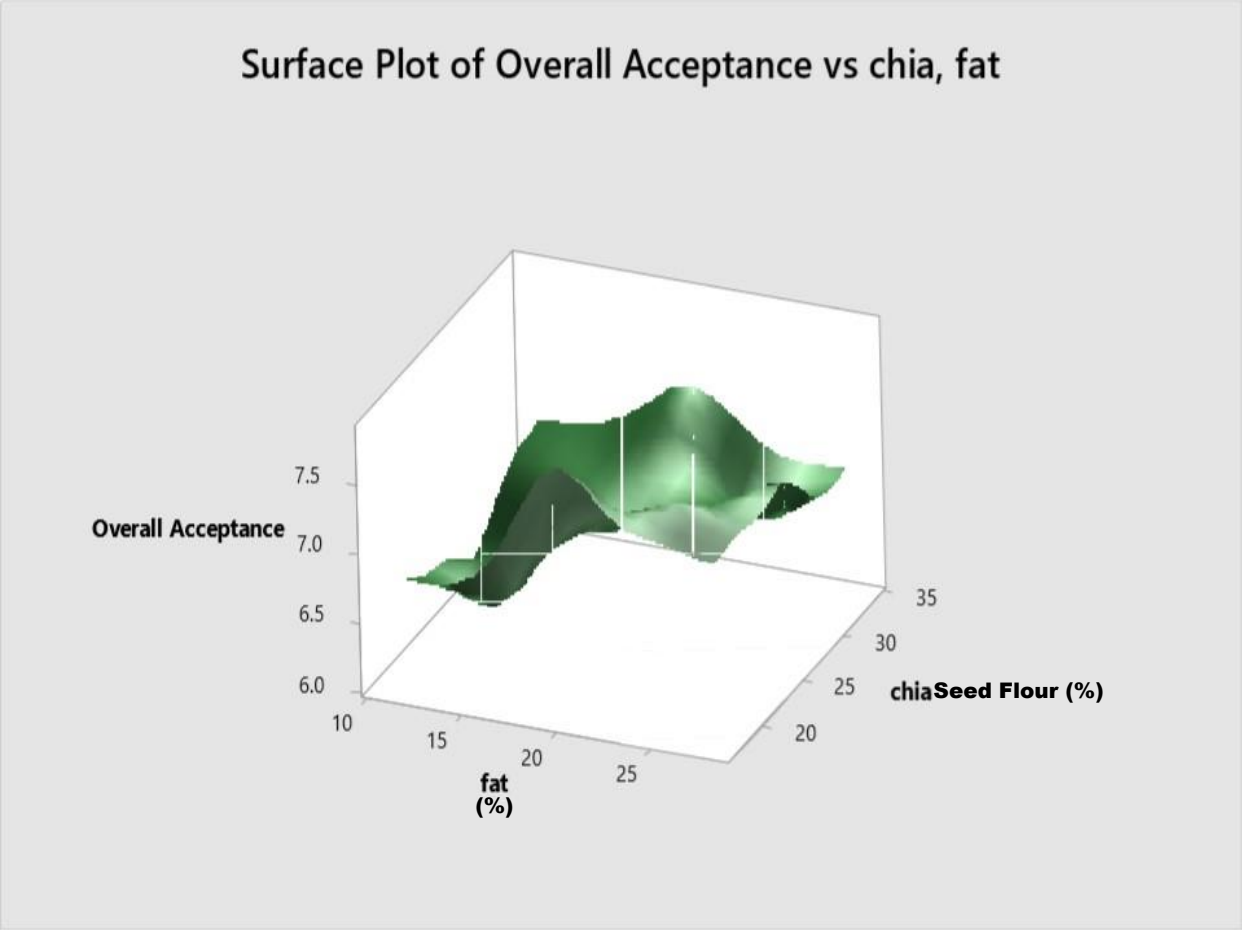


Fig 4.10 3D surface plot for overall acceptance as influenced by the level of chia seed flour and fat (at constant sugar level)

4.4.2 Interactive effect of chosen variable on Overall Acceptability

The overall acceptability score varied from 8.035 to 6.112 (Table No.4.3). The minimum overall acceptability score was obtained in T_3, while the maximum color and appearance score was observed in T_{13}. The amount of chia seed flour, fat and sugar in the T_3 were 30, 15 and 30 %, respectively. The T_{13} amount of chia seed flour, fat and sugar were 16.835, 20 and 25 %, respectively.

The positive coefficient term overall acceptability score showed that the amount of chia seed flour, fat and sugar showed positive interactive effect on overall acceptability. The quadratic term for the Interactive effect of chosen variable these three variable were significant.

Fig 4.11 shows that the 3D surface plot for the overall acceptability as influenced by the changing the level of chia seed flour and sugar while keeping the fat constant. From the fig 4.11 it can be observed that with the increase in the level of chia seed flour overall acceptability

score quality increase however there was a slightly increase in overall acceptability score due to increased sugar content.

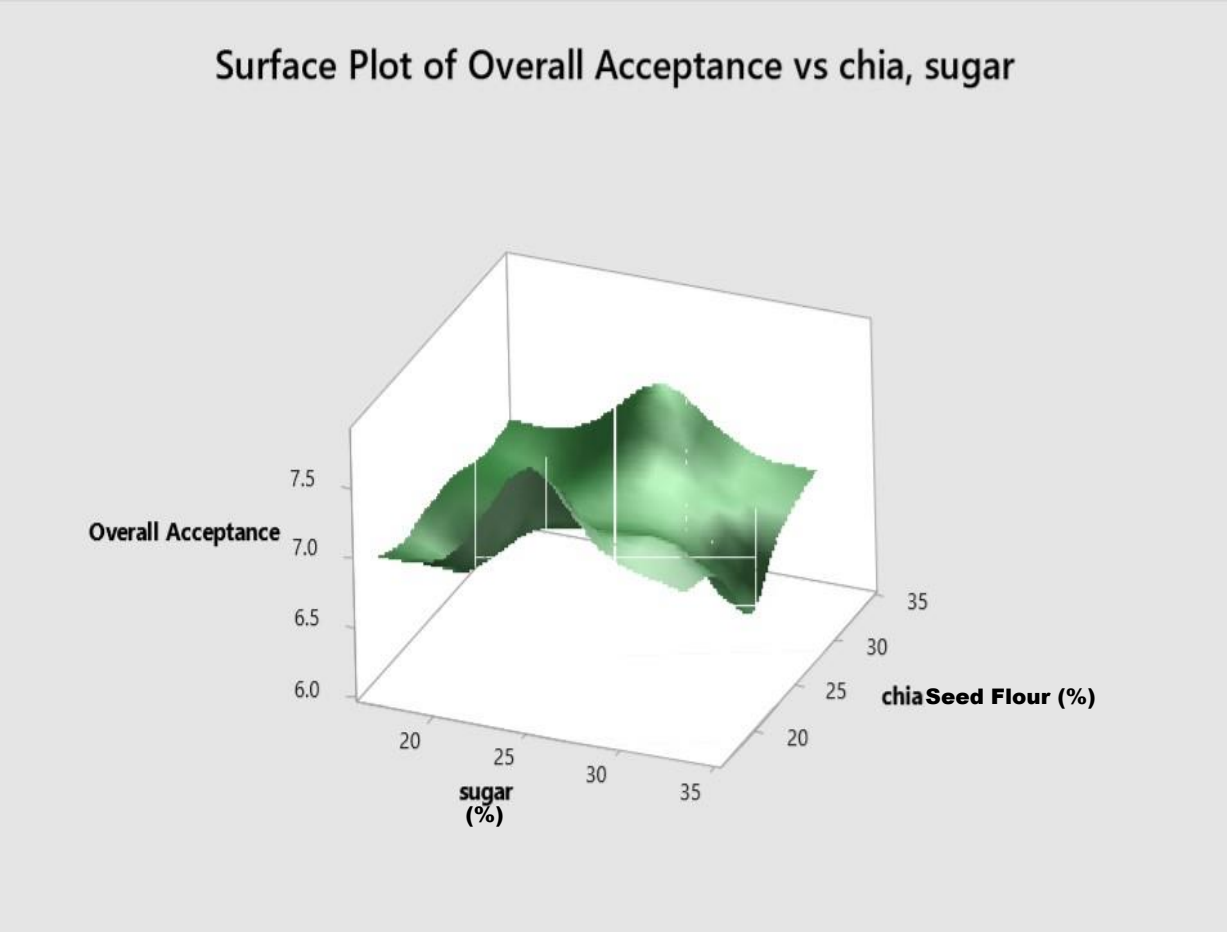


Fig 4.11 3D surface plot for overall acceptance as influenced by the level of chia seed flour and sugar (at constant fat level)

4.4.3Interactive effect of chosen variable on Overall Acceptability

The overall acceptability score varied from 8.035 to 6.112 (Table No.4.3). The minimum overall acceptability score was obtained in T_3, while the maximum overall acceptability score was observed in T_{13}. The amount of chia seed flour, fat and sugar in the T_3 were 30, 15 and 30 %, respectively. The T_{13} amount of chia seed flour, fat and sugar were 16.835, 20 and 25 %, respectively.

The positive coefficient term overall acceptability score showed that the amount of chia seed flour, fat and sugar showed positive interactive effect on overall acceptability. The quadratic term for the Interactive effect of chosen variable these three variable were significant.

Fig 4.12 shows that the 3D surface plot for the overall acceptability as influenced by the changing the level of sugar and fat while keeping the chia seed flour constant. From the fig 4.12 it can be observed that with the increase in the level of fat overall acceptability score quality increase however there was a slightly increase in overall acceptability score due to increased fat content.

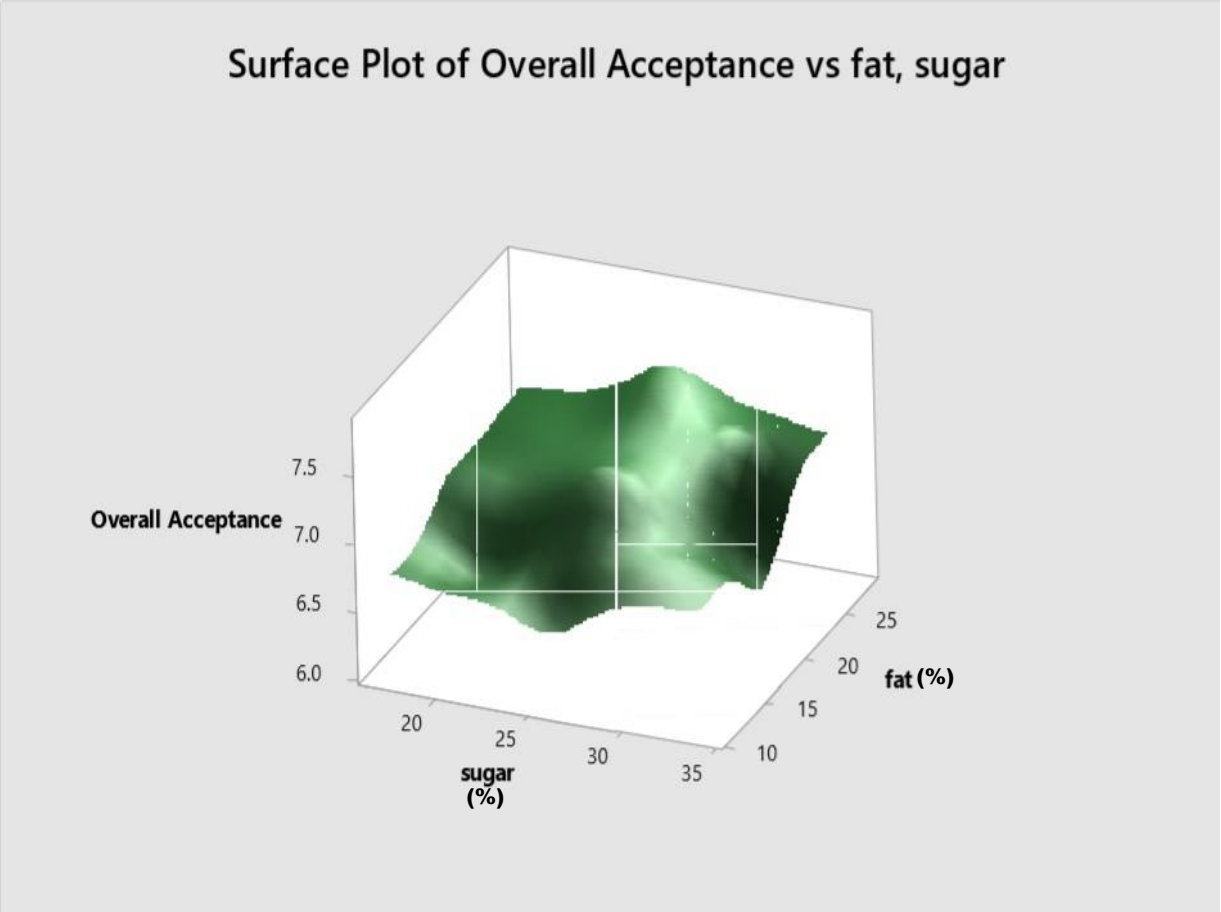


Fig 4.12 3D surface plot for overall acceptance as influenced by the level of sugar and fat

4.5 Texture profile of chia seed cookies.

The textural properties of the cookies were measured in terms of hardness Cohesiveness, Springiness, Gumminess, Chewiness and Resiliencies using texture analyzer (Table 4.2). The control sample had hardness (19.811 N) and optimized sample had (15.142N).Texture attributes are used to monitor and control product quality and acceptability.

4.6 Comparative values for textural properties of chia seed based cookies.

Textural properties	Optimized	Control
Hardness (N)	15.142	19.811
Springiness	0.971	0.801
Chewiness	22.3120	34.01
Cohesiveness	0.99751	1.015
Resiliencies	0.872	0.662
Gumminess	24.871	41.92

Fig No. 4. Chia Seed Flour Cookies

4.7 Proximate analysis of chia seed flour based cookies

Table 4.2 shows the physicochemical properties of optical product Optimisation flour recipe chia seed flour, wheat flour, fat and sugar contain 16.835%, 33.165%, 20% and 25% respectively.

Table 4.2 Chemical Properties of optimized chia seed cookies.

Attributes	Control Sample	Optimized Product Sample	Optimized flour Mix
Moisture	4.766%	6.0%	10%
Protein	7.69%	8.38%	10.38%
Fat	12.026%	32.6%	7.25%
Fibre	0.66g/100g	1.69g/100g	1.89g/100g
Ash	0.856%	2.0%	1.2%
DPPH	22.65%	24.50%	19.43%
Total phenolic content	0.49mg GAE/g d.m	0.82mg GAE/g d.m	0.80mg GAE/g d.m
HMF	1.55mg/100g	2.10mg/100g	1.83mg/100g
Bulk density	0.58g/ml	0.64g/ml	0.51g/ml
Dispersbility	32.6	35.6	35.6

SUMMARY AND CONCLUSION

The present study was undertaken with the objective to optimize the process for chia seed based cookies with blend honey. The project was undertaken with two main objectives. The first objective was to optimize the level of ingredients using ANOVA. In, this twenty sets of experiments were performed taking into account the all the ingredients namely chia seed flour, whole wheat flour, fat and sugar. The twenty trials were examined for sensory (color and appearance, aroma and taste, body and texture), textural (hardness), antioxidant attributes (as the DPPH inhibition) for selection of a variants with the optimum level of ingredients. The second objective was to study the physic – chemical property, functional property along with proximate analysis of the optimized chia seed flour based cookies.

5.1 Effect of ingredients on properties of chia seed based cookies

- Sensory properties are examine with the help of 9-point Hedonic rating scale (1 = dislike extremely, 9 = like extremely) was used. The score for the body and texture varied from 6.801 to 8.481, for color and appearance it varied from 6.131 to 8.638; for taste and aroma it varied from 6.401 to 8.516 and for overall acceptability it varied from 6.112 to 8.035. Trial T13 showed best results for all the sensory parameters, as it had the highest mean value than the rest of the variants.

- The textural properties of control cookies hardness was 19.811 (N) and the optimized sample of cookies had 15.142 (N). The level of honey had an impact on the textural properties of cookies.

- Antioxidant activity of optimized cookies 24.50 % and control cookies 22.65 %. The antioxidant activity was based on the level of honey as the level of the honey was increased, the antioxidant property of the chia seed based cookies also increased. The optimized trial T15 had the highest antioxidant activity which corresponds to the fact that it had the highest amount of honey incorporated into it.

- According to sensory , textural and antioxidant attributes and protein content trial T13 was found to be having the highest sensory acceptability , the textural properties were better than control sample of cookies , it also showed the highest antioxidant activity . Thus, trial T13 can be taken as the optimized product on the basis of sensory, textural and antioxidant properties. The optimized product (Trial T13) had composition of honey25g, butter 20g, whole wheat flour 33.165g, skim milk powder 5.0g, baking powder 1.0g, baking soda 1.0g, salt 1.0g respectively.

- The optimized chia seed based cookies had a proximate composition of protein 8.38%, fat 32.6%, moisture 6.0% ash 2.0%, and crude fiber 1.69% and DPPH inhibition 24.50%.

- From present study it can be inferred that the developed chia seed flour based cookies had high sensory and textural properties along with the good functional properties. It can be also concluded that honey can be incorporated into many products, on such is cookies to increase its nutritional and antioxidant potential and making it beneficial for health.

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APPENDICES

Appendix-I

Appendix I; Ap.1

Sensory Evaluation Card

PRODUCT-CHIA SEED FLOUR BASED COOKIES

DATE……

TIME…..

NAME OF THE PANELIST:……..

Instruction: Given below are the sample of **"Chia Seed Flour Based Cookies"**. You are requested to judge the sample on the 9 point hedonic scale for the parameters listed below:

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

SAMPLE CODE	BODY AND TEXTURE	COLOUR AND APPEARANCE	AROMA AND TASTE	OVERALL ACCEPTABILITY
A				
B				
C				
D				

Remarks **Signature**