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Development and Quality Evaluation of Moong and Ragi Based Multigrain biscuits

Shivangi Soni[1], R. N. Shukla[2]
[1]M.Tech. Food Tech. FPT student, [2] Associate Professor
Department of Processing and Food Engineering Sam Higginbottom Institute of Agriculture Technology and Sciences, Allahabad-211007, India

Abstract
The increasing demand for nutritious and functional foods has led to the exploration of alternative ingredients in biscuit production. This study focuses on the development and quality evaluation of multigrain biscuits incorporating Moong (Vigna radiata) and Ragi (Eleusine coracana) in various proportions. The research is to formulate multigrain biscuits by varying the proportions of Moong and Ragi flours and assess their physico-chemical and sensory qualities. The preparation of biscuits using different combinations of Moong and Ragi flour, alongside standard ingredients such as wheat flour, fat, sugar, and leavening agents. The physico-chemical characteristics of the developed biscuits, including their proximate composition, texture, and moisture content, are analysed to assess the impact of the grain proportions on the overall product quality. Sensory evaluation, including parameters such as taste, texture, appearance, and overall acceptability, is conducted to determine the consumer preference for each formulation. The study is to evaluate the shelf life of the developed multigrain biscuits. This is done by storing the biscuits under ambient conditions and periodically testing for changes in their sensory attributes, texture, and moisture content. The shelf life is determined by identifying the time period after which the biscuits begin to lose their desirable qualities. The results of this study will provide valuable insights into the potential of Moong and Ragi as functional ingredients for enhancing the nutritional value and quality of bakery products. Additionally, it will offer guidance for optimizing ingredient ratios to achieve a balanced combination of taste, texture, and shelf life, making the biscuits a viable, healthy snack alternative for consumers.

Keywords: Moong and Ragi, Proximate Composition, Physico-chemical characteristics, Multigrain biscuits, Nutritional Value and Quality

Introduction

Biscuit industry is the largest among all industries and has turnover of around Rs. 3000 crores. Biscuits cover over 70% of the total production of the baking industry. States that have larger intake of biscuits are Maharashtra, West Bengal, Andhra Pradesh, Karnataka and Uttar Pradesh. Traditionally, biscuits were made from wheat flour and there is little record of rice being used in biscuit type products, small quantity of other cereal flours or starches can be added to give special flavours or structural properties. Bakery products are sometimes used as a vehicle for incorporation of different nutritionally rich ingredients. Although, biscuits are classified in various ways based on the texture and hardness of the biscuit, on change in shape in the oven, on the extensibility or on the ways that various dough are handled prior to biscuit formation, the three main categories in which biscuit can be classified are: Sweet biscuits, semi-sweet biscuits, salt biscuits. Sweet biscuits are produced mainly from soft and short dough and have a high water and fat content. Semi-sweet biscuit are also known as tea biscuits. These are produced from hard dough and characterized with low fat and sugar. Salt biscuits include crackers and puffed biscuits. These biscuits are prepared from generally fermented dough or may be unfermented hard dough and have low amount of fat and sugar. The principal ingredients used in the manufacture of biscuits are flour, sugar and fat. Biscuits are made from weak wheat flour obtained from soft wheat having moisture content of about 12% protein content in the range of 7-9% and a starch content of about 70-75%. The main function of flour is to form dough during mixing and holding the ingredients uniformly, to form the structure of biscuits, to retain the gases during fermentation as well as baking. The principal sugar used in biscuit making in sucrose. The main function of sugar is: It imparts sweet taste to biscuit, it has softening action to gluten, it improves colour and flavour of biscuits through Millard type of reactions when reducing sugars are used.

Wheat is considered a highly nutritious food that supports health, being a good Source of protein, carbohydrates, minerals, B-group vitamins, and dietary fibre. The Grain’s nutritional components are unevenly distributed across its parts: the Endosperm is primarily composed of starch, the bran is rich in dietary fiber, and the Germ contains proteins and lipids.

Nutritional Value of Finger Millet: Finger millet grain has a carbohydrate content of 81.5%, protein 9.8%, crude fibre 4.3%, and mineral 2.7% which is comparable to other cereals like rice, wheat, maize and millets. Its crude fibre and mineral content is remarkably higher than those of wheat (1.2% fibre, 1.5% minerals) and rice (0.2% fibre, 0.6% minerals); its protein profile is relatively well balanced; as it contains more lysine.

Sorghum (Sorghum bicolour L. Moench) is the fifth most produced cereal and, in most countries, is mainly used as animal feed. However, due to the interesting nutritional content of this cereal, it can be successfully used to improve the nutritional content of starch-based products that are commonly developed with non-wholemeal flours like wheat, rice and corn. Studies indicate sorghum to diversify the diet and promote human health through its nutritional composition and potential as a functional food.

Chickpeas are used in many dishes, and chickpea flour is also popular. It has a lower glycaemic index than wheat flour, which is important to diabetics and people with insulin resistance. People consuming a diet rich in chickpeas (as cooked seeds and bread or biscuits made from wheat and chickpea flour blend) have significantly lower fluctuations in blood glucose levels and lower insulin levels. Therefore, increasing the intake of chickpea products may be beneficial.

Mung bean, which is abundant in easily digestible protein (24%) and adds diversity to cereal-based diets, is a popular choice. moong bean contain high levels of energy, dietary fibre, protein, minerals, and vitamins, all of which are beneficial to human health.

Materials and Methods

The all experiment and trails was conducted in the Department of Processing & Food Engineering at Food Analysis Laboratory, Vaugh Institute of Agricultural Engineering & Technology. Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj.

Raw materials selected were wheat flour, Finger Millet Flour, Moong flour, Sorghum flour, Chickpea flour, Sugar, Baking Powder, Baking Soda, Fortune refined oil were brought from local Prayagraj stores.

Experimental Plan

Sr. No.	Parameters	Level	Description
1.	Product	1	Multigrain biscuits
2.	Ingredients	5	Wheat, Chickpea, Ragi, Moong, Sorghum
3.	Samples	4	$T_0, T_1, T_2, T_3,$
4.	Processing	10	Cleaning, Grinding, Sieving, Mixing, Sheeting, Molding, Baking, Cooling, Packaging, Storage
5.	Physico-chemical analysis	6	Moisture, Protein, Carbohydrate, Fat, Ash, pH,
6.	Sensory analysis	6	Colour, Texture, Taste, Flavour, Appearance, Overall acceptability
7.	Statistical analysis	1	ANOVA
8.	Packaging material	1	LDPE
9.	Storage condition	1	Ambient condition

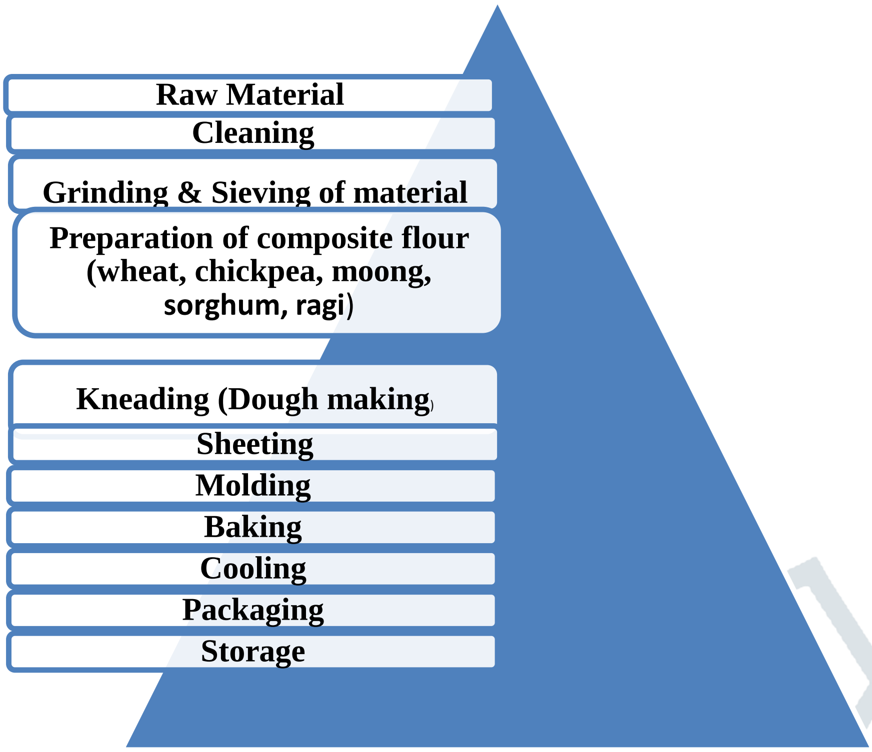
Formulation Table

Formulation Table for Multigrain Biscuits

Sr. No.	Ingredients	T_0	T_1	T_2	T_3
1.	Wheat flour	50	50	50	50
2.	Chickpea flour	20	20	20	20
3.	Moong flour	20	15	10	5
4.	Ragi flour	-	5	10	15
5.	Sorghum flour	10	10	10	10

Methodology

Flow sheet of preparation of multigrain biscuits:-



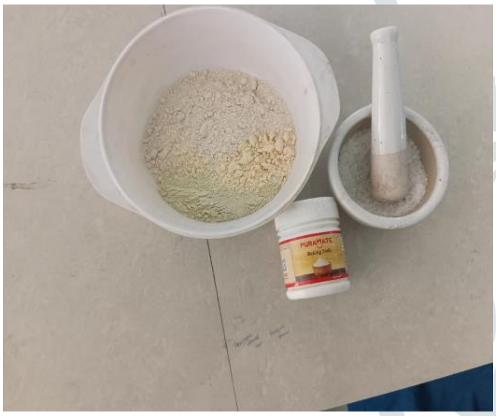


Fig 2. Composition of flours

Fig 1. Raw biscuits

Fig 4. Baked biscuits

Fig 3. Storage condition

PHYSICO-CHEMICAL ANALYSIS

Moisture

The moisture content was determined by taking a known weight of biscuit in a Petri dish and drying in an oven at 110 ± 5°C to a constant weight. The per cent loss in the weight was calculated and expressed as per cent of moisture on fresh weight basis AOAC, 2005.

$$\text{Moisture (\%)} = \frac{(\text{weight of fresh sample} - \text{weight of dried sample}) * 100}{\text{Weight of fresh sample}}$$

Ash

Total ash was determined gravimetrically by taking known weight of fresh and dried samples in tarred silica crucibles. The oven dried samples after moisture determination were slowly heated over hot plate until the bulk of organic matter was burnt. The crucibles were then placed in a muffle furnace for ashing at 550±2°C to obtain a carbon free white ash with a constant weight AOAC, 2005. The ash content of samples was then calculated and expressed as per cent on fresh weight basis as given below:

$$\textbf{Ash (\%)} = \frac{\textbf{weight of ash}}{\textbf{Weight of sample}} * 100$$

Crude Fibre

0.5-1g of sample (triplicate) was weighed in crucibles for Raw Fibre Analyser (Velp Scientifica). 150 ml H_2SO_4 was added up to 150 ml notch and boiled for 30 min from onset of boiling. Sulphuric acid

Was drained followed by washing with 30 ml of hot water. 150 ml of KOH and 3-5 drops of antifoaming reagent (H_2O_2) was added and boiled for 30 min. Then washing was done with hot water followed by cold water and acetone (25 ml). The crucibles were removed and dried in oven at 105˚C for an hour up to constant weight. This weight represents crude fibre plus ash content (F1). Crucibles were placed in muffle furnace and heated up to 550˚C for 3 hour AOAC, 2005.

Reweigh after cooling in desiccator (F2).

$$\textbf{Crude fibre (\%)} = \frac{F1-F2}{F0} * 100$$

Crude Protein

Crude Protein Crude protein was determined by the Khjeldahl method which is based on the determination of amount of reduced nitrogen (NH_2 and NH) present in the sample. The three basic steps involved in this method were i.e. digestion, distillation and titration. About 0.125-1 g of finely ground sample was weighed. Weighed sample was put in digestion tube and catalyst tablet was added in it. About 10-20 ml of concentrated sulphuric acid was measured and added in digestion tube to digest the sample. When sample boiled with conc. sulphuric acid, most of the nitrogenous compounds present were converted into ammonium sulphate (digestion). Ammonium sulphate thus formed, was decomposed with an alkali (NaOH), and liberated ammonia was absorbed in the excess of neutral boric acid solution which was then titrated against standardized acid (0.1 N HCl).Crude protein content (%) in the sample was then calculated by multiplying per cent nitrogen with the factor of 6.25 AOAC, 2005.

$$\textbf{Nitrogen (\%)} = \frac{\text{(sample titre – Blank titre)} * \text{Normality of Hcl} * 14}{\text{Weight of sample} * 1000} * 100$$

Crude protein (%) = Nitrogen % * 6.25

Crude Fat

3 to 10g weighed sample was initially hydrolysed with 50 ml of HCl (8N) in conical flask. The conical flask was kept in water bath (80˚C) for 1 hr. After that boiled distilled water (100 ml) was added in flask and then filtered. Residues with filter paper were taken to estimate the fat in thimble and the thimbles were introduced into extraction equipment. Oil was extracted using petroleum ether (40-60oC BP) as a solvent in Soxtec Oil Extraction Apparatus (M/s Velps Scientifica, SRL Italy) pre-programmed (temperature 130˚C, washing time 60 minutes, Recovery time 15 minutes). After two hours of extraction process, the ether extract was collected and poured into beaker. The beaker was kept in hot air oven at 70 °C for one hour for removal of remaining solvent before being finally weighed for fat content AOAC, 2005. Fat content was calculated as per following formula:

$$\textbf{Crude fat (\%)} = \frac{W2-W1}{W} * 100$$

Carbohydrate

Carbohydrate The total carbohydrate content as per cent dry weight basis was determined by mathematically working out other parameters and then deducting them from 100 as follows AOAC, 2005.

Total carbohydrate (%) = 100 – (% moisture content + % ash content + % crude protein + % crude fat + % crude fibre).

Ingredients used in preparation of biscuits

Ingredient	Quantity (g)
Composite flour (wheat, chickpea, moong, ragi, sorghum)	100
Sugar	25
Shortening	18
Ammonium bicarbonate	1.5
Sodium bicarbonate	1.5
Milk	15-20 ml

Weight, diameter, thickness, and top grain development

The Weight (g), diameter (mm) and thickness (mm), of cookies were calculated as per A.A.C.C. 1976 methods. Weight in terms of grams (g) was measured using electronic weighing balance. The thickness and diameter of biscuits were measured with a Vernier calliper micrometer after baking; the spread ratio values were estimated as the ratio of diameter to thickness. Top grain development was visually assessed as a function of number of cracks formed over the surface of biscuits.

Organoleptic evaluation

Sensory evaluation of the developed value added products was done in the Department of Processing and Food Engineering. Developed value added products were evaluated by 5 judges from the Department for evaluating the sensory qualities. Judges were asked to score the products for each and every quality attributes and overall acceptability using a score card of nine point Hedonic rating scale. Organoleptic evaluation of developed biscuits was carried out using 9 point hedonic scale ranges from like extremely to dislike extremely with 3 semi-trained judges with respect to colour and appearance, taste, flavour, texture and overall acceptability.

Sensory evaluation of the developed value added products

9	Like Extremely
8	Like Moderately
7	Like Slightly
6	Neither Like nor Dislike
5	Dislike Slightly
4	Dislike Moderately
3	Dislike Moderately
2	Dislike Very Much
1	Dislike Extremely

Estimation of theoretical energy value of the product

Theoretical energy value of the prepared cookies was calculated on the basis of proximate chemical composition taking conversion values for protein, fat and carbohydrate as 4, 9 and 4 Kcal respectively.

STORAGE STUDY OF MILLET BASED MULTIGRAIN MIX

Storage study of millet based multigrain mixes were done using three packaging materials such as PP pouch (100 gauge), LDPE pouch (200 gauge) and plastic bottle (Tarson) at interval of 0, 15, 30, 60, 90 days.

Free fatty acid

Free fatty acid was determined as per the method of AOAC 1992.

Reagents

1. 95% ethanol.
2. 1% phenolphthalein indicator (1g of indicator was dissolved in 100 ml 95% ethanol).
3. 0.1 N potassium hydroxide- 5.61 g of potassium hydroxide was dissolved in 1000 ml of distilled water.

Procedure

10g of sample was transferred in 250ml volumetric flask in which 50ml 95% ethanol was added. The solution was titrated against standard 0.1N KOH with constant shaking until end point (appearance of persistent pink colour). The value of free fatty acid in the sample was calculated by the formula.

Calculation

Free Fatty Acid (% Oleic acid) = $\mathbf{56.1\ x\ Normality\ of\ alkali\ x\ Volume\ of\ alkali\ ml}$

Storage studies

The storage study of biscuits under experiment was carried for 90 days at an interval of 30 days for its sensory quality. The biscuits were stored in Low Density Polyethylene (LDPE) pouches; Polyethylene Terephthalate (PET) jar and aluminium foil pouches.

RESULTS AND DISCUSSION

This chapter deals with the result obtained during the experiment of the research work Development and quality evaluation of multigrain biscuits and has been evaluated by studying their physical, chemical, and sensory characteristics of biscuits. The cost of high fiber and high protein biscuits was also calculated. The data obtained were analyzed statistically to determine the level of significance of variation in observation caused by the changes in blends and biscuits formulations.

Development of multigrain biscuits

Different standardization trials were conducted to develop most acceptable protein and fiber rich functional biscuits by substituting defatted wheat flour, moong flour, ragi flour, Sorghum flour and chickpea flour at different levels.

Biscuits were preparing dousing creamery method for making biscuits dough. The ingredients used in cookies were wheat flour, moong flour, ragi flour, Sorghum flour, Chickpea flour, sugar, shortening, sodium chloride, sodium bicarbonate ammonium bicarbonate. The dough was sheet be thickness of 1.5mm with the help of flat rolling board. The sheeted dough was cut into fine circular shape using a wooden cutter. The cut were dough transfer to greased baking tray. The biscuits were baked in an electric oven maintained 180°C for 12-13 min. The biscuits were cooled for about 30 min, packed into LDPE bags for further analysis.

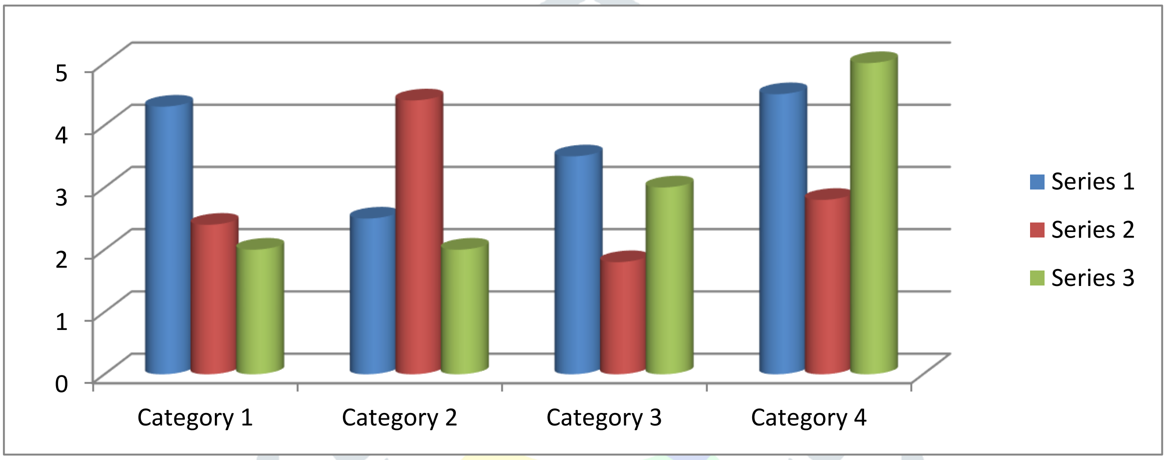
Physio- chemical and Microbiological Characteristics

Physical Analysis of multigrain biscuits Physical analysis of biscuits is important as an objective judgment of quality. Physical analysis of cook is important as an objective judgment of quality. The result of the physical analysis of the functional biscuits is shown in Table, which shows width & spread factor of functional biscuits decreases with increasing level of substitution whereas thickness increases with increasing the concentration. The result obtained agreed with result reported by **Bunde, *et al.*, 2010.**

Effect of different treatments on mean score for physical analysis of biscuits.

Treatments	Diameter (mm)	Thickness (mm)	Spread Ratio
T_0	47.2	8.6	52.3
T_1	43.6	10.2	50.8
T_2	46.0	7.9	56.1
T_3	45.8	10.0	51.2

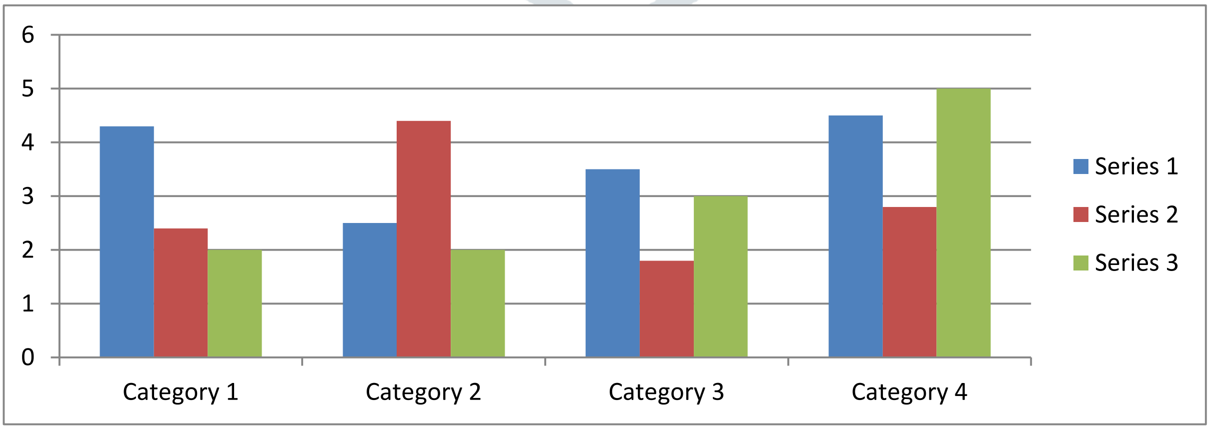
The data regarding means for effect of various treatments on diameter of biscuits shown in Table 4.1 and presented in Fig 4.3 showed a decreasing trend with the proportionate increase of supplementation. The results elucidated that to exhibits maximum diameter 46.0mm, followed by TI (47.2 mm) while minimum diameter (43.6mm) was observed inT1. The diameter of biscuits decreases from 47.2 to 45.8 with increasing the level of substitution; this may be due to the high fiber content of composite wheat flour than control flour. Dietary fiber additions, in general had pronounced effects in dough properties yielding higher water absorption, mixing tolerance, tenacity & smaller extensibility in comparison with those obtained without fiber addition **Gomez *et al.*, 2003; Elleuch *et al.*, 2011.**



Graphical representation of biscuit Diameter (mm)

Thickness of developed Biscuits

The data regarding means for effect of various treatments on thickness of Biscuits shown in Table. The thickness of biscuits prepared from different treatment ranged from 8.6 to 10.0 The result elucidated that T_1 has maximum thickness 8.15 while minimum thickness was observed in control treatment T_2 (7.9). The results of present study are quite close to the observations reported earlier by numerous researchers. **Sharif *et al.*, 2009** study that thickness of biscuits increases with proportionate increase of defatted rice bran and with supplementation of wheat flour.



Graphical representation of biscuit Thickness (mm)

Spread Ratio of developed multigrain biscuits

Spread ratio (diameter/thickness) is one of the most important properties in evaluating the quality of Biscuits. Greater spread ratios are desirable and indicate a better Biscuits quality **Seker *et al.*, 2010.**

Mean score of spread factor of the Biscuits have been shown in Table 4.1. There was a decreasing trend in the spread ratio of Biscuits with the proportionate increase of supplementation. The spread factor of Biscuits prepared from different treatments ranged from 64.60 to 48.84. The maximum value (64.60) for spread ratio was observed in T_0 (biscuits with 0% fortification) whereas minimum (48.84) in biscuits prepared from 40% supplementation of Wheat flour.

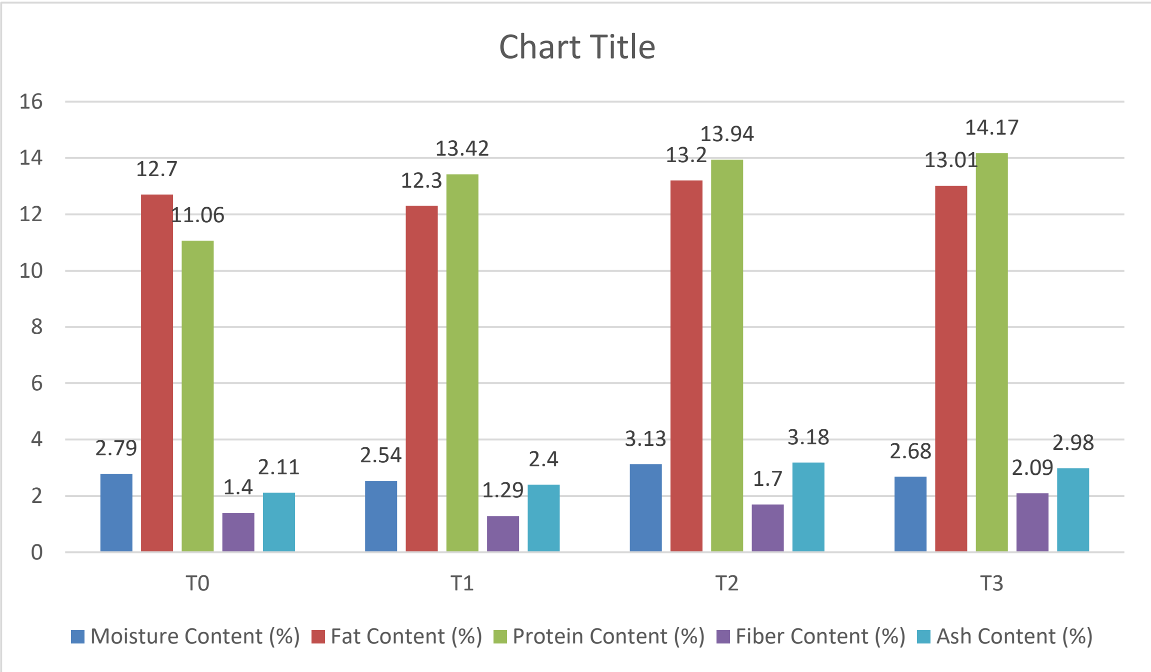
Interaction effect of different ratio of composite flour with Wheat flour and on spread factor of functional biscuits has been shown in Table 4.1. Spread ratio of biscuits decreases with increase in supplementation of Wheat flour. This reduction in the spread factor of the biscuits attributed to the proteins & fiber present in the composite flour because protein & fiber has more binding power and it binds water and restricts the spread of the biscuits.

Chemical Analysis of Biscuits

The chemical analysis of the Biscuits has been presented in Table 4.2 indicated that all the Biscuits contained favorable proportion of protein and fiber.

Chemical analysis of multigrain biscuits

Treatment	Moisture Content (%)	Fat Content (%)	Protein Content (%)	Fibre Content (%)	Ash Content (%)
T_0	2.79	12.7	11.06	1.4	2.11
T_1	2.54	12.3	13.42	1.29	2.40
T_2	3.13	13.2	13.94	1.7	3.18
T_3	2.68	13.01	14.17	2.09	2.98

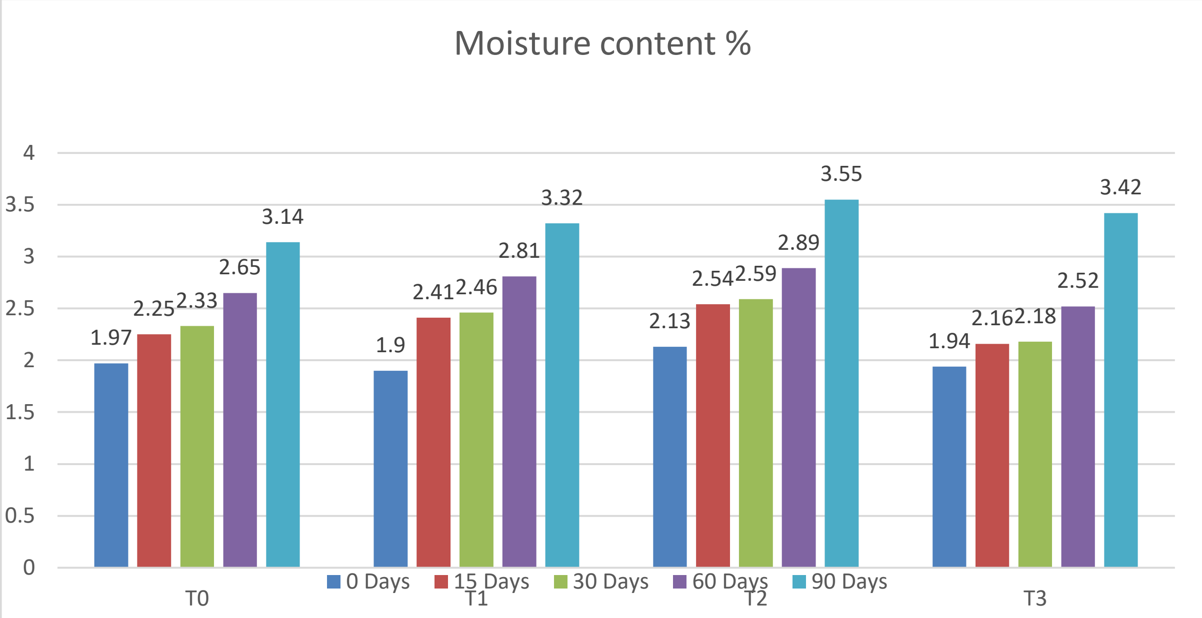


Graphical representations of physio-chemical parameters

The effect of moisture content scored for the sample To Table shows significant change. T_2 and T_3 treatment sample sharply increase its moisture content as compare to other. The moisture content of biscuits increased with increase in attributed to high water binding capacity baking powder which retain higher moisture content in ultimate products the moisture content is also increasing during decreasing. Similar result obtained by researcher who incorporate wheat flour in preparation of the biscuits and found increased moisture content of the wheat flour based biscuits **Mishra & Kalpana, 2003.** From the ANOVA Table A6 it is evident that the calculated value of F due to treatment is greater than the tabulated value at 5 percent probability level. Therefore, it can be concluded that effect on moisture content of sample To. T1, T2, and T_3, was observed as shown in table.

Effect of moisture content of storage period

Treatment	Moisture Content				
	0 Days	15 Days	30 Days	60 Days	90 Days
T_0	1.97	2.25	2.33	2.65	3.14
T_1	1.90	2.41	2.46	2.81	3.32
T_2	2.13	2.54	2.59	2.89	3.55
T_3	1.94	2.16	2.18	2.52	3.42



Graphical representation of Moisture Content on storage period

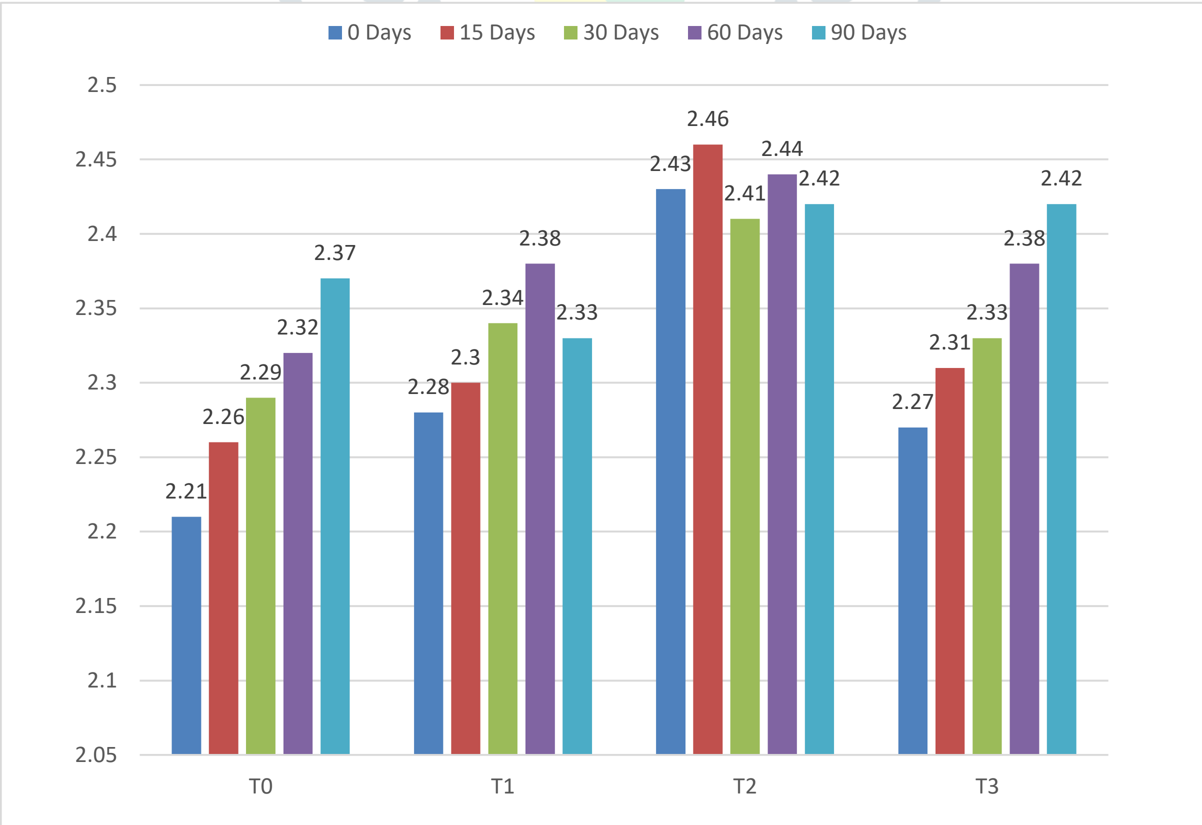
Ash content of developed incorporated biscuits.

Ash content indicated an estimate of the total mineral content in a given quantity of food substance. Mean score for ash content of different treatment has shown in table 4.2 and presented Fig 4.7, revealed the lowest ash content was observed in

Effect of Ash content on storage period

Treatments	Ash content (%)				
	0 Days	15 Days	30 Days	60 Days	90 Days
T_1	2.21	2.26	2.29	2.32	2.37
T_2	2.28	2.30	2.34	2.38	2.33
T_3	2.43	2.46	2.41	2.44	2.42
T_4	2.27	2.31	2.33	2.38	2.42

Ash content



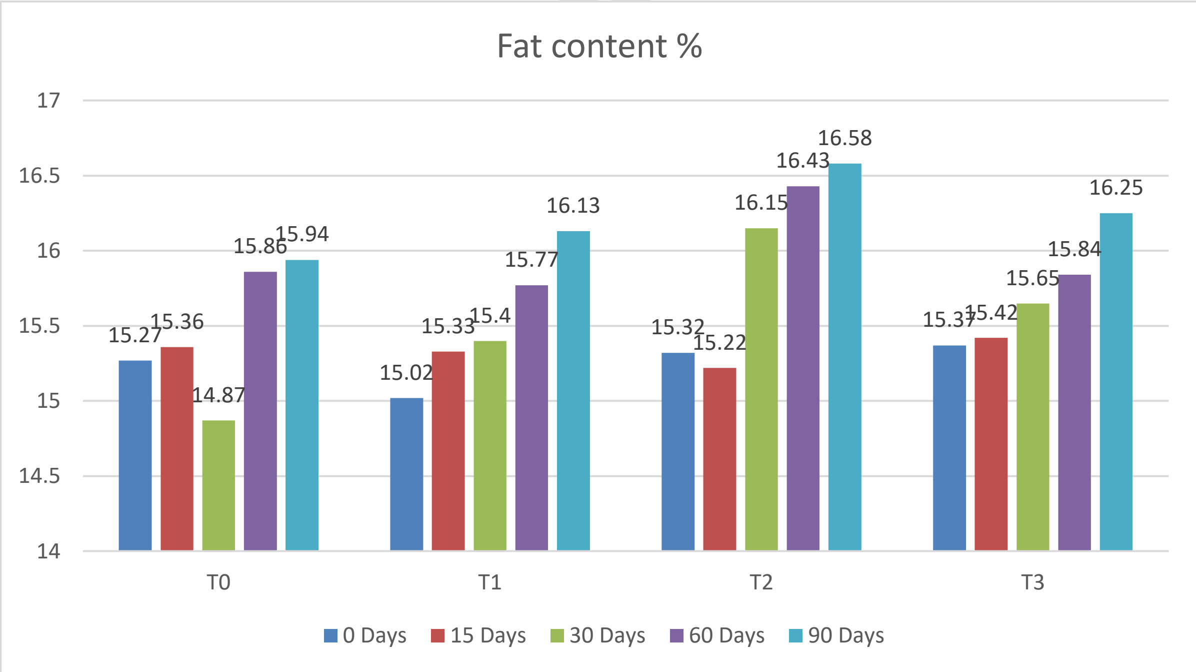
Graphical representation of Ash content on storage period

Fat content of developed multigrain biscuits

The percent fat score for to be 15.33% in 0 Days. Ti scored 14.92 percent, similarly the fiat content of sample T2, T3 and Ta decreases. The result in present study showed that the fat content of prepared biscuits. There was a significant decrease in fat deterioration during increase the moisture content may be due to activity of lipase enzyme which split off the fat into free fatty acids and glycerol in the presence of catalyst like moisture, light and heat.

Effect of Fat content on storage period

Treatments	Fat Content (%)				
	0 Days	15 Days	30 Days	60 Days	90 Days
T_0	15.27	15.36	14.87	15.86	15.94
T_1	15.02	15.33	15.40	15.77	16.13
T_2	15.32	15.22	16.15	16.43	16.58
T_3	15.37	15.42	15.65	15.84	16.25



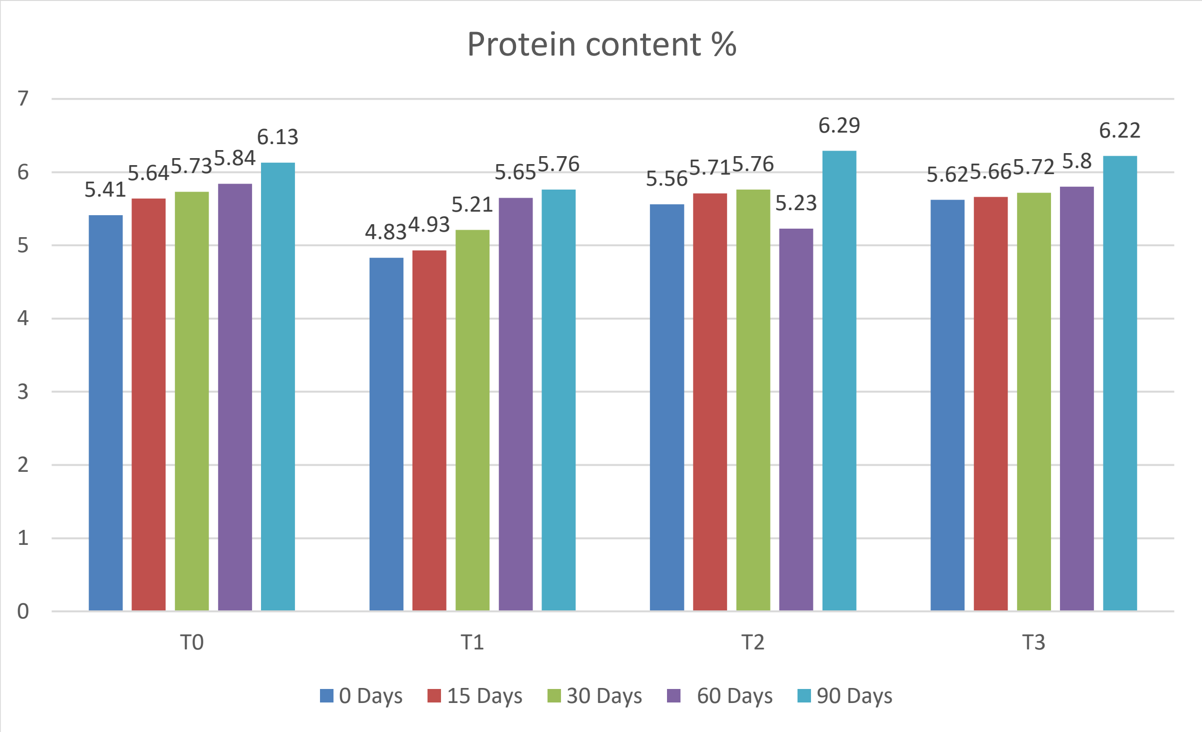
Graphical representation of fat content on storage period

Protein content of developed multigrain biscuits

It was clearly revealed from the table as the storage period was increased from 0 days to 90 days from sample T_0 to T_3 protein content was increased its was due to longer duration of the product Wheat flour is high quality protein complement, whose incorporation enhances the quantity and quality of protein content of food product which increase its potential for the formation of functional Biscuits. Based on ANOVA, all the factors were found to have significant effect.

Effect of protein content on storage period

Treatments	**Protein Content (%)**				
	0 Days	**15 Days**	**30 Days**	**60 Days**	**90 Days**
T_0	5.41	5.64	5.73	5.84	6.13
T_1	4.83	4.93	5.21	5.65	5.76
T_2	5.56	5.71	5.76	6.23	6.29
T_3	5.62	5.66	5.72	5.80	6.22



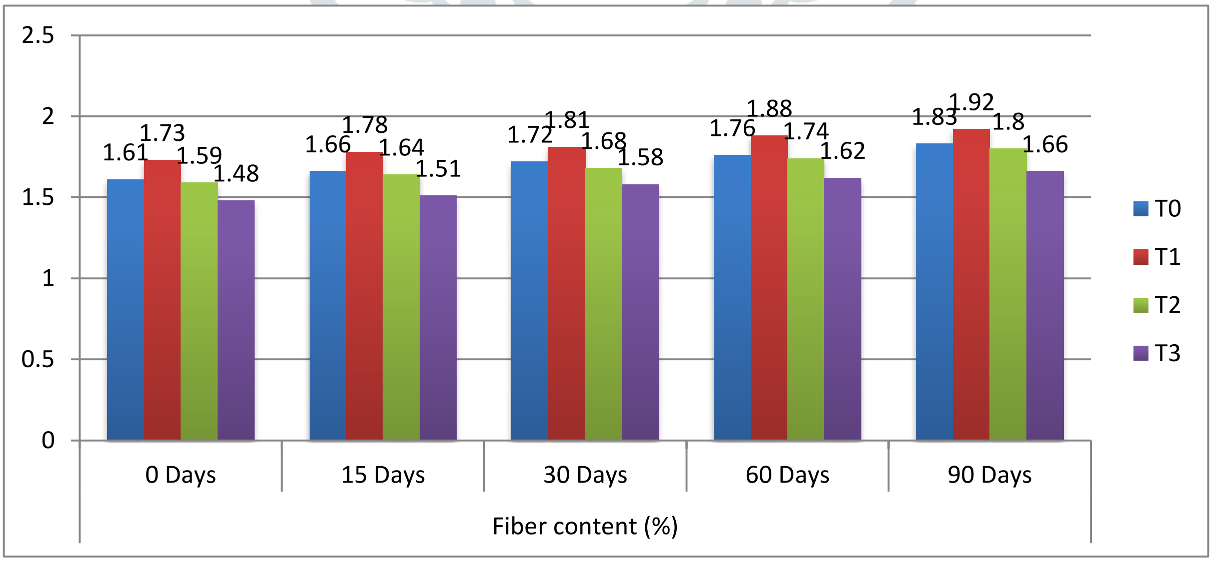
Graphical representation of protein content on storage period

Fiber content of developed biscuits.

The fiber content of the product biscuits was increased from 0 days to 90 days that is in T_0 is 1.61 and in T_3 is 1.48 is decreases is due to significant higher dietary fiber content.

Effect of fiber content on storage period

Treatment	Fiber content (%)				
	0 Days	15 Days	30 Days	60 Days	90 Days
T_0	1.61	1.66	1.72	1.76	1.83
T_1	1.73	1.78	1.81	1.88	1.92
T_2	1.59	1.64	1.68	1.74	1.80
T_3	1.48	1.51	1.58	1.62	1.66



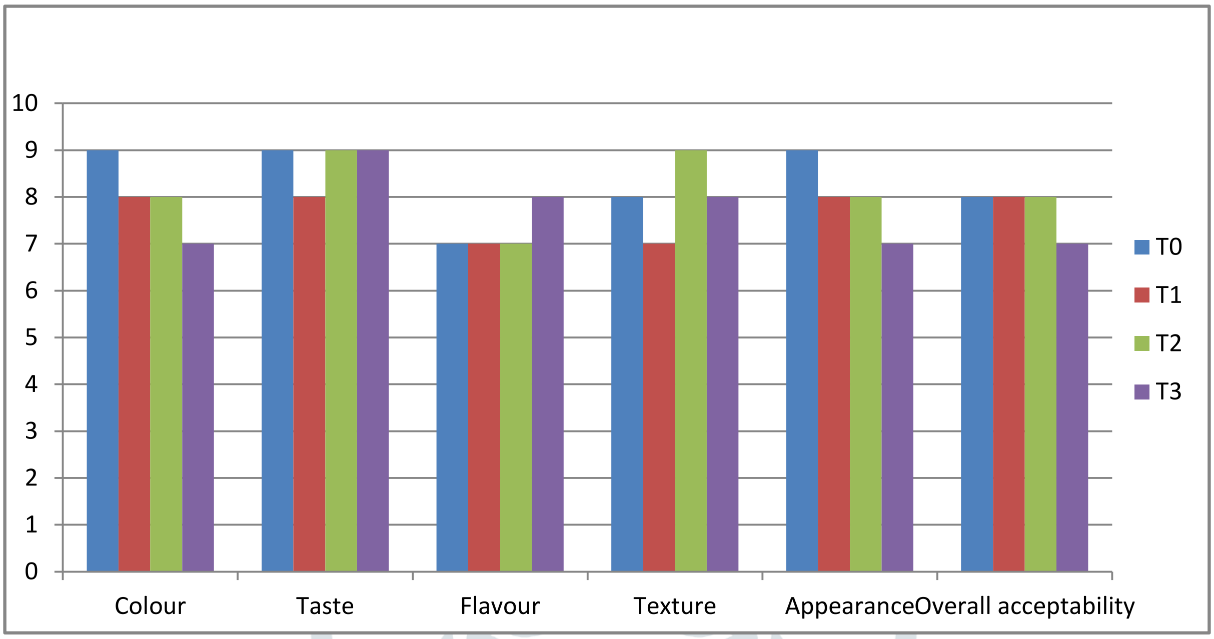
Graphical representation of Fiber content on storage period

Sensory evaluation

Sensory attributes including color, aroma, taste and overall acceptability is determined by hedonic rating tastes as recommended by Hedonic rating taste is used for evaluation of sensory characteristics. This test is used for acceptability by consumer for the product. The color of T_0 was more attractive than T_1 and T_2. The taste was almost same. Flavor and overall acceptability were higher of sample B than others, than sample A during the 0 days. The data presented in Table 4.8 indicate that the average rating for color, taste, flavor, texture, appearance and overall acceptability of multigrain biscuits was found that 8.26, 8.70, 8.22 and 7.92 respectively.

Sensory Evaluation of the multigrain biscuits

Treatment	Colour	Taste	Flavour	Texture	Appearance	Overall acceptability
T_0	9	9	7	8	9	8
T_1	8	8	7	7	8	8
T_2	8	9	7	9	8	8
T_3	7	9	8	8	7	7



Graphical representation of sensory evaluation of multigrain biscuits

Conclusion

Functional foods are foods that have a potentially positive effect on health beyond basic nutrition. In contrast to conventional foods, functional foods, however, have demonstrated physiological benefits and can reduce the risk of chronic disease beyond basic nutritional functions. Functional food provides the body with the required amount of vitamins, fats, proteins, carbohydrates, etc., needed for its healthy survival. Hardness of baked biscuits was measured in terms of breaking strength using Texture Analyzer (TAHD plus, stable Micro systems). Breaking strength of biscuits was placed on the platform such that they are supported at two points and the blades were attached to the crosshead of the instrument. The Texture profile analysis instrument, measuring the physical product characteristic such as hardness, factorability, adhesiveness, extensibility of product. Sensory evaluation was carried out by a panel of ten semi trained panel members. Hedonic rating test was employed using 9-point hedonic scale. Sensory parameters such as color, taste, texture and overall acceptability were evaluated. Functional biscuits gave the highest thickness. The spread ratio is concerned as one of the most important quality parameters of biscuits since it correlates well with texture, grain fineness, bite and overall mouth feel of the biscuits.

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