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Functional, Bioactive, and Mineral Constituents of Germinated Brown Rice-based Gluten Free Cookies

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ABSTRACT

Gluten- free products are indispensable for people with celiac disease because till date the only treatment is to follow a gluten-free diet. Besides this, nowadays, people are more interested in following a healthy diet, so they are looking for nutritious food. The present investigation was therefore, carried out toformulate gluten-free cookies and to assess the functional, bioactive, and mineral composition of germinated brown rice-based cookies during storage. For the development of cookies, germinated brown rice and oat flour were blended in the ratios of 100:00, 95:5, 90:10, 85:15, 80:20, 75:25 and 70:30 percent, respectively. The prepared cookies were packed in aluminum laminates and stored under ambient storage conditions. The quality of nutri-bar was assessed for its functional, bioactive, and mineral constituents at 30-day intervals until 90 days. The highest mean water absorption capacity and oil absorption capacity of 143.21 % and 120.83% have been recorded in T_7, whereas, the highest bulk density of 0.79g/ml was observed in T_1. Treatment T_7recorded a maximum total phenolic content of 69.76 mg GAE/100g. Among minerals, the highest iron and magnesium contents have been observed in treatment T_1 (9.74 & 150.12mg/100g, respectively) however, treatment T_7 recorded maximum calcium and potassium contents (52.15 & 264.62mg/100g). Based on organoleptic evaluation, the highest mean overall acceptability score of 7.67 was recorded in T_6 (75:25:: Germinated Brown rice: Oat flour) and was adjudged as superior among all the treatments of cookies. Thus, nutritious cookies can be developed by incorporating 75 % germinated brown rice with 20% oats. Brown rice and oats possess good nutritional properties which could be utilized for formulation of baked goods.

Keywords: *Germinated brown rice, Oats, Functional parameters, Bioactive, Mineral, Sensory, water absorption capacity, phenols*

Introduction

The development of novel functional foods has been spurred by the growing consumer demand for wholesome, premium foods in both the scientific and industry sectors. Since whole grains have high nutritional content and bioactive substances that have been shown to have preventive benefits against chronic diseases, they are becoming more and more popular as ingredients in functional food recipes (1). The use of rice flour in baking is popular nowadays because of its low cost and availability.

Brown rice is unpolished rice and still has pericarp, aleurone, embryo, and endosperm which contain nutritional components and bioactive compounds. It contains dietary fibre, lipids, amino acids, vitamin E, phytosterols, phenolic compounds, gamma-aminobutyric acid (GABA), and minerals (2). However, brown rice has poor cooking properties and low organoleptic quality than white rice. The addition of brown rice to cookie dough can cause hardness in cookies. Germination is the best way of solving these undesirable properties of brown rice, which include rough eating texture, off-putting bran odour, low digestibility, and not-easy-to-cook problem (2 & 3).

During germination, rice grains go through pre-hydration and then conditioning, which is influenced by elements like temperature, duration, and relative humidity (4). These circumstances encourage the disintegration of intricate materials and the creation of novel chemicals, both of which modify the embryo (5). In addition to the enzymatic activity, this event also affects the physicochemical, functional, and nutritional makeup of the grain (6). Since different enzymes are activated during germination, a multitude of biochemical events occur. The nutritional and chemical contents of germinated rice alter as a result of these processes (7). Additionally, germination increases the amount of bioactive substances in rice, such as antioxidants including gamma-aminobutyric acid, tocopherols, ascorbic acid, and tocotrienols (8). Enzymatic activities that take place during germination have been shown to improve the organoleptic properties of grains by giving cookies their soft texture (9). Furthermore, compared to milled rice (white rice), germinated brown rice has more nutritionally sound ingredients. In comparison to brown and white rice, germinated brown rice was shown to have higher levels of protein, fat, and crude fiber (10). Furthermore, it has been noted that germinated rice cooks faster, is easier to handle, and has a better texture (11). The purpose of this study was to determine the suitability of germinated brown rice (GBR) for developing cookies and to assess the bioactive, mineral constituents, and overall acceptability of germinated brown rice and oat flour blended cookies.

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Materials and Methods

Procurement of Raw Materials

Brown rice (Pusa basmati 1121) was procured from M/S Jatinder Rice Mill, R.S. Pura, Jammu. For the development of gluten free cookies, oats, milk powder, sugar, and butter were used. All the raw materials were procured from the local market of Jammu and were taken to the Food Processing and Training Centre of the Division of Post Harvest Management, SKUAST-Jammu for further processing.

Processing of Raw Materials

Germinated brown rice

The procured brown rice grains were cleaned manually and sorted to remove any foreign matter. The rice grains were then washed and soaked in water for 12 hours at 28±2ºC, followed by incubation at 28±2ºC for the time interval of about 48 hours. After that, the germinated brown rice samples were dried in a tray dryer at 50±3ºC until the moisture content dropped below 12 per cent (12). The germinated samples were then milled by using a laboratory flour mill followed by sieving using 80-100 mesh sieve. The sieved sample was packed in airtight containers till further use.

Standardization of gluten-free cookies

For the development of gluten-free cookies, brown rice, and oats were mixed in different proportions as per the treatment combinations: T_1 (!00% Germinated brown rice), T_2 (95:5:: Germinated brown rice: Oats), T_3 (90:10:: Germinated brown rice: Oats), T_4 (85:15:: Germinated brown rice: Oats), T_5 (80:20:: Germinated brown rice: Oats), T_6 (75:25:: Germinated brown rice: Oats), T_7 (70:30:: Germinated brown rice: Oats). The gluten-free biscuits were prepared from germinated brown rice flour and oat flour along with other basic ingredients (13). Treatments were standardized using varying concentrations of germinated brown rice flour and oat flour along with other basic ingredients like shortening (vegetable fat), sugar, baking powder, milk powder and water. The powdered sugar and fat were creamed with flat beater for five minutes. The milk powder was made into a suspension in water and transferred to the cream. The contents were mixed and sieved flours were added to the cream and kneaded to form a dough. The dough was then sheeted to a thickness of 3.5 mm and cut into cookies with the help of a circular mold (51mm diameter). It was then baked at 180ºC for 15 minutes on a greased tray. After baking, cookies were cooled at room temperature and were wrapped tightly in laminated pouches, sealed and stored under ambient conditions (32±2°C) for a period of 90 days. The fresh as well as stored samples were analyzed periodically at an interval of 0, 30, 60 and 90 days of storage for bioactive, mineral constituents and overall acceptability.

For estimation of water absorption capacity of 1 g sample was mixed in centrifuge tubes with 10 ml distilled water (14). The sample was stirred intermittently over a period of 30 minutes and centrifuged at 2000 rpm for 10 minutes. The aqueous supernatant obtained after centrifugation was decanted and the test tubes were inverted and allowed to drain for 5 minutes on paper towel. By weighing the residue, water absorption capacity was calculated and expressed as a percentage of water absorbed per gram of sample. The oil absorption capacity of samples was determined by mixing 1.0 g of sample with 10 ml sunflower oil in centrifuge tubes (15). The sample was stirred intermittently over 30 minutes and centrifuged at 2000 rpm for 10 minutes. The aqueous supernatant obtained after centrifugation was decanted and the test tubes were inverted and allowed to drain for 5 minutes on a paper towel. By weighing the residue, oil absorption capacity was calculated and expressed as a percentage of oil absorbed per gram of sample. The flour samples (100 gm each) were gently filled in 500 ml graduated cylinder, previously tarred. The bottom of the cylinder was gently tapped on a laboratory bench several times until there was no further diminution of the sample level after filling to 500 ml mark. Bulk density was calculated as weight of the sample per unit volume of sample (g/ml).

Total phenolic content was determined by Folin-Ciocalteau assay (16) which is an electron transfer-based assay. The absorbance was measured at 765 nm against a reagent blank using a UV-visible spectrophotometer (Model UV4, Unicam and Cambridge, UK). Gallic acid was used as the calibration standard and the results were calculated as mg of Gallic acid equivalents (mg GAE/100g) of samples. Free radical scavenging activity of samples was determined by DPPH (1, 1, diphenyl - 2 picrylhydrazyl) method. The absorbance was determined at 517 nm using blank as 80 percent methanol. The free radical scavenging activity was evaluated by comparing the absorbance of the sample solution with the control solution to which distilled water was added instead of sample (17).

The mineral contents were determined after the ash content determination. The ash residue of each formulation was digested with perchloric acid and nitric acid (1:4) solution (18**)**. The samples were used separately to determine the mineral content of calcium, iron, potassium and magnesium in the sample by using an Atomic Absorption spectrophotometer (Spectra AA 220, USA Varian).

The samples were analyzed on the basis of overall acceptability by semi-trained panel (9-10 judges) using 9 point Hedonic scale assigning scores 9-like extremely to 1-dislike extremely. A score of 5.5 and above was considered acceptable (19).

Statistical analysis

The results obtained were statistically analyzed employing completely randomized design and CRD factorial for interpretation of the results through analysis of variance using OPSTAT v.8.6 software.

Results and Discussion

Functional Properties

Water absorption capacity

The water absorption capacity measures the volume occupied by the granule or starch polymer after swelling more than water and determines the ability of the flour to absorb water and swell for improved consistency in food (20). The highest mean water absorption capacity of 143.21 per cent was recorded in T_7 whereas, T_1 showed lowest mean water absorption capacity of 130.87 per cent (Fig 1). As is evident from the data the increase in mean water absorption capacity among treatments might be due to an increase in proportions of oats which possessed higher water absorption capacity as compared to germinated brown rice. It might also be due to the molecular structure of rice which inhibited water absorption capacity and availability of polar amino acids that gave lower values of water absorption capacity in samples having higher percentage of brown rice (21). Water absorption capacity of gluten-free cookies decreased significantly from 137.18 to 136.87% during storage period of 90 days. The treatment and storage had a significant effect on water absorption capacity of cookies with a significant interaction between treatment and storage at 5 percent level of significance.

The decrease in water absorbtion capacity might be due to the decrease in crude fibre content and increase in hydrophobic amino acid residues during storage (22).

Oil absorption capacity

Oil absorption capacity of food is an important parameter determining the ability of proteins to physically bind fat by capillary action and plays role in flavour retention and enhances the mouthfeel of food (23). The maximum mean oil absorption capacity of 120.83 per cent was recorded in treatment T_7 whereas T_1 recorded minimum mean oil absorption capacity of 81.25 per cent (Fig 1). The increase in mean oil absorption capacity might be due to increase in proportions of oats which possessed higher oil absorption capacity as compared to germinated brown rice. The presence of high protein content and non-polar amino acids in oats might be responsible for increased oil absorption capacity in cookies (24). During storage period of 90 days, mean oil absorption capacity of gluten-free cookies increased from 100.91 to 101.19%. Oil absorption capacity of cookies varied significantly with treatment and storage with a significant interaction between treatment and storage at 5 per cent level of significance. During storage period of 90 days, the increase in oil absorption capacity might be due to increase in hydrophobic/non-polar amino acid residues which form complex structures (25).

Bulk density

A perusal of data in Fig. 1 revealed that among treatments, the lowest mean bulk density of 0.58 g per ml was recorded for T_7, gluten-free cookies corresponding to T_1 exhibited highest mean bulk density of 0.79 g per ml. Among treatments, the mean bulk density of gluten-free cookies decreased from 0.79 to 0.58 g per ml which might be due to lower bulk density possessed by oats as compared to germinated brown rice. The bulk density of cookies varied significantly with treatment and storage. During storage period of 90 days, the mean bulk density value decreased from 0.79 to 0.58g per ml. The increase in moisture content and the associated change in particle size might be responsible for decrease in bulk density values (22).

Bioactive Constituents

Among treatments, T_1 depicted the lowest mean total phenolic content of 62.32 mg GAE per 100 g, whereas treatment T_7 recorded highest mean total phenolic content of 69.76 mg GAE per 100 g (Table 1). The mean total phenolic content decreased significantly from 66.20 to 65.87 mg GAE per 100 g during a storage period of 90 days. This decrease in total phenolic content might be attributed to the dilution of total phenolic compounds due to an increase in moisture during storage (26).

The data about antioxidant activity of gluten-free cookies (Table 1) revealed that treatment and storage had a significant effect on antioxidant activity. Among treatments, treatment T_1 recorded the highest mean antioxidant activity of 51.71 per cent, whereas treatment T_7 recorded the lowest mean antioxidant activity of 40.90 per cent. Moreover, a significant interaction between treatment and storage was recorded at 5 per cent level of significance. The mean value of antioxidant activity decreased significantly from 46.40 to 46.09 per cent during 90 days of storage period which might be due to the dilution of antioxidant components by increased moisture and also due to possible oxidation of antioxidant compounds under favorable conditions during storage (26).

Minerals

Germinated brown rice and oats are good sources of minerals viz., iron, calcium, magnesium, and potassium which are present in distinct amounts. The mean iron and magnesium content was found to be higher in gluten-free cookies formulated from higher levels of germinated brown rice in contrast to cookies formulated from supplementation of oats (Fig 2). The highest mean iron and magnesium content of 9.74 mg/100 g and 150.12 mg/100 g were recorded in treatment T_1, whereas the lowest mean iron and magnesium content of 9.15 mg/100 g and 132.74 mg/100 g were recorded in treatment T_7, respectively. The highest mean calcium and potassium content of 52.15 mg/100 g and 264.62 mg/100g were recorded in treatment T_7 whereas, the lowest mean calcium and potassium content of 44.35 mg/100 g and 229.31 mg/100 g were recorded in treatment T_1, respectively (Fig. 2). A significant effect of treatment and storage and non-significant interaction was observed at 5 per cent level of significance. During the storage period of 90 days, the mean iron, calcium, potassium and magnesium content of cookies decreased significantly from 9.52 to 9.31 mg/100 g, 48.35 to 48.10 mg/100 g, 247.09 to 246.87 mg/100 g and 141.51 to 141.30 mg/100 g, respectively. The decrease in minerals might be due to the interaction between minerals and other compounds like carbohydrates and proteins (product of Maillard reaction) thus reducing the bioavailability of minerals (27).

Sensory evaluation

Among all the treatments, the overall acceptability scores were rated highest in T_6 (75:25:: Germinated Brown rice: Oat flour) with mean score of 7.67 (Fig. 3) which was followed by 7.59 in treatment T_5. The decrease in overall acceptability scores of gluten free cookies beyond 75 per cent of germinated brown rice might be attributed to its higher quantity of volatile matter which resulted in a higher hexanal concentration which produces unpleasant taste (28). Significant decrease in overall acceptability scores was observed with the progression in storage period from 7.63 to 7.29. The decrease in sensory scores for different characteristics of the product, irrespective of treatments during storage might be attributed to non-enzymatic browning reaction (Maillard reaction) (29).

Conclusion

Recent studies on the development of gluten-free food are garnering international attention. These studies recommend replacing basic ingredients, either whole or in part, with value-added raw materials to achieve the right nutritional improvements. Therefore, cookies were developed by blending germinated brown rice with oat flour in an attempt to create gluten-free food items with improved nutritional value. Significant variations were observed between the control and oat flour-substituted cookies. Sensory evaluation showed that cookies made with 75 % germinated brown rice and 25% oat flour improved were better as compared to control. Hence, the market's introduction of convenience products made from germinated brown rice and oat flour would likewise improve the diversity of functional products and provide growers with profitable sales.

Future scope of the study: Brown rice is a good source of bioactive components which serve as a functional food. Further studies on the packaging material that retains the best flavor, color, and nutritional content of developed products is needed.

Subsequently, the germinated brown rice can also be incorporated into various food products to improve their nutritional content and organoleptic acceptability.

Conlict of interest: The authors declare no conlict of interest

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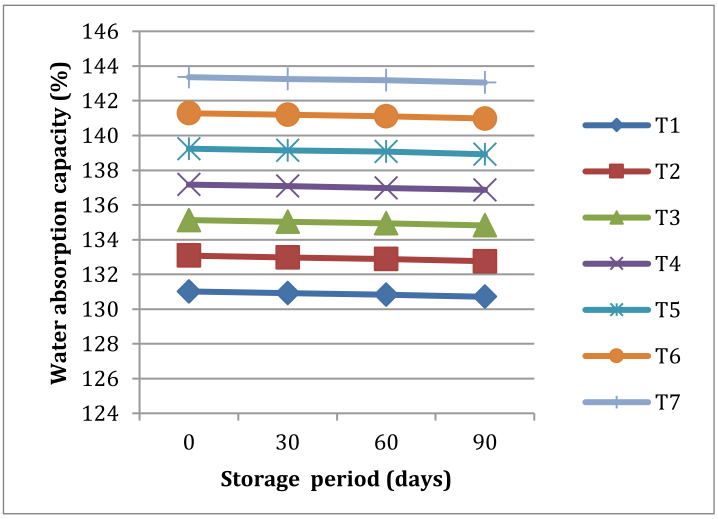
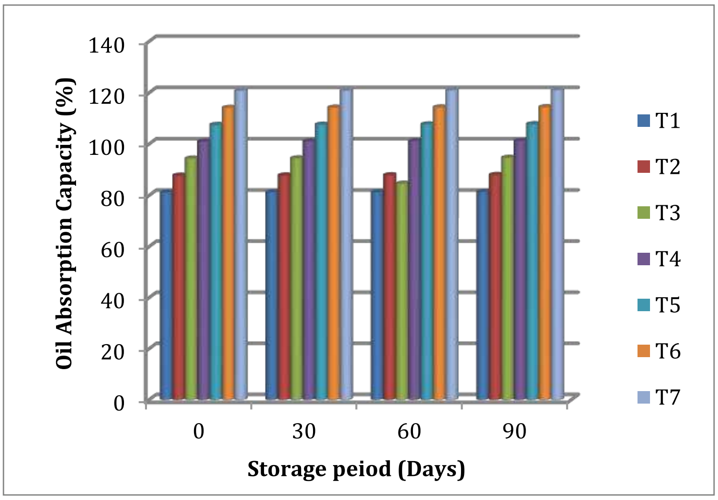
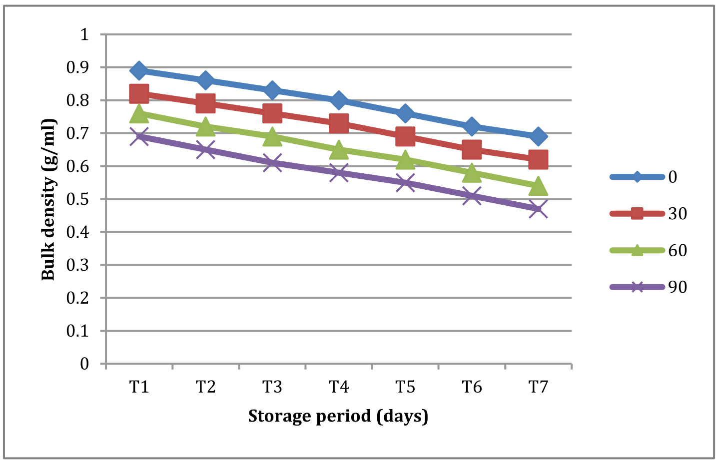


I) Water absorption Capacity (%)

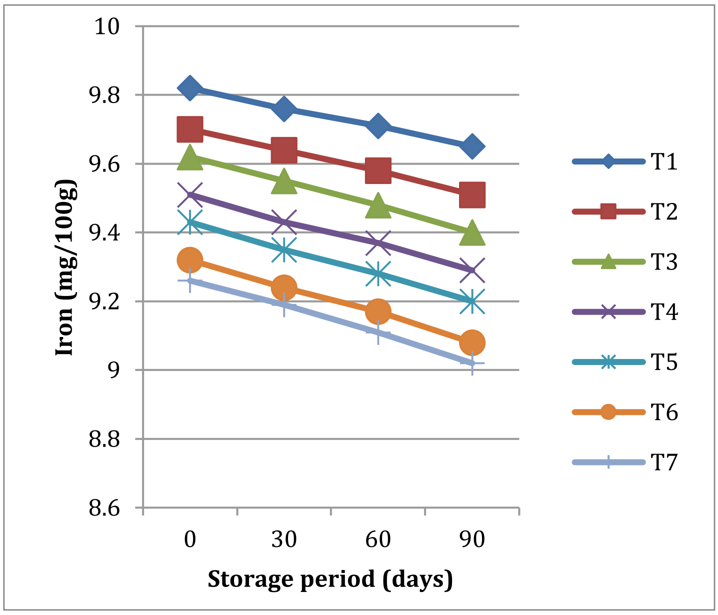


ii) Oil absorption capacity (%)

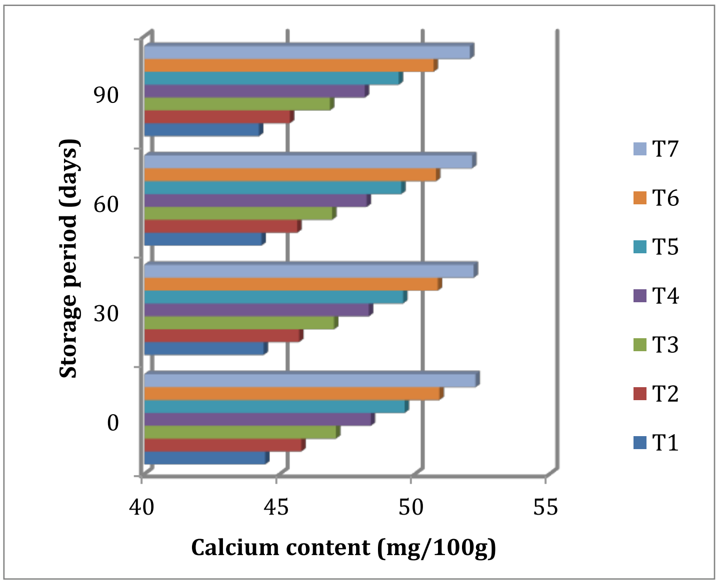


iii) Bulk density (g/ml)

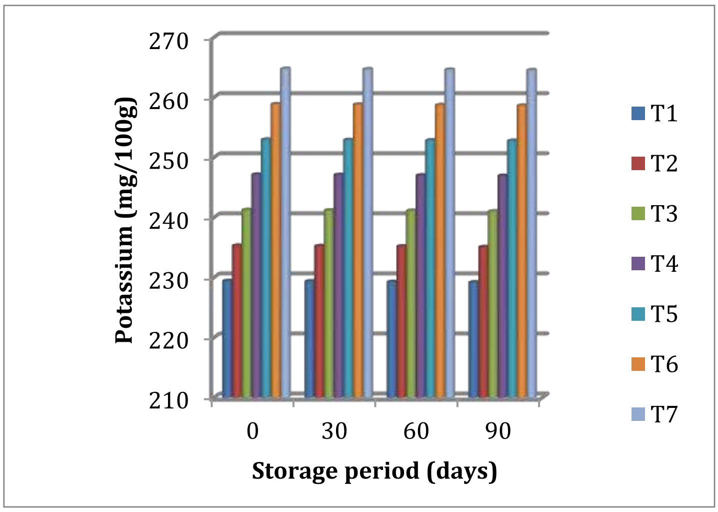
Figure 1: Functional parameters of germinated brown rice and oat flour blends



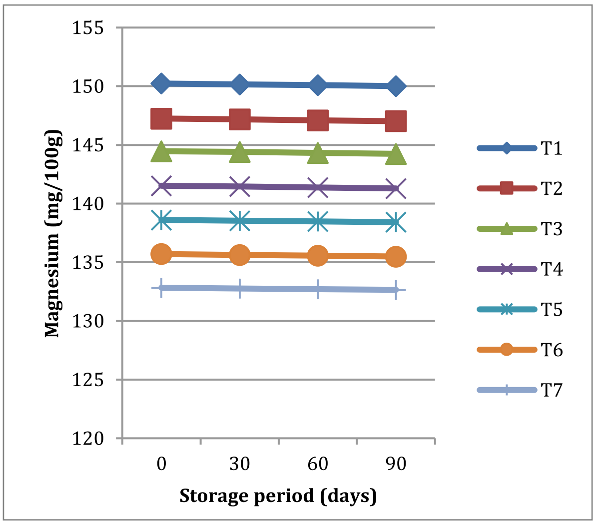
A) Iron content



B) Calcium content



C) Potassium content



D) Magnesium content

Figure 2: Mineral composition of germinated brown rice based gluten free cookies

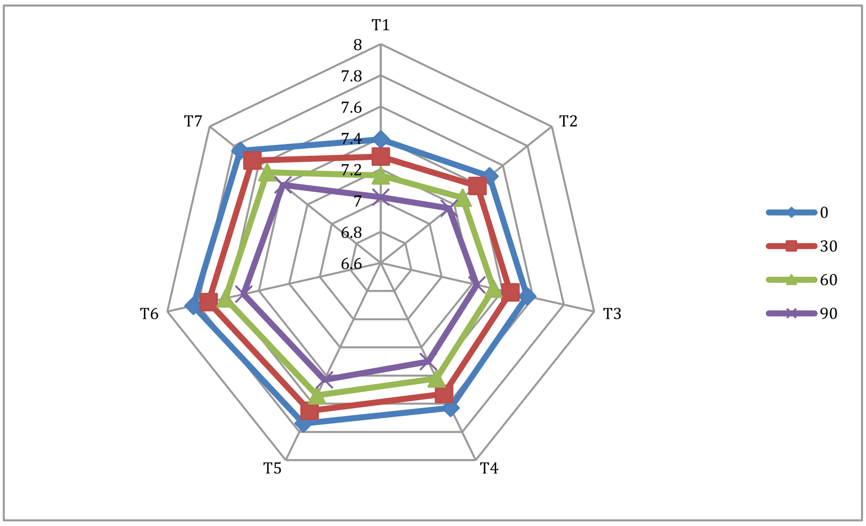


Figure 3: Effect of blending and storage on overall acceptability (Hedonic score) of gluten free cookies

Table 1. Total phenolic (mg GAE/100g) and Antioxidant activity (%) of germinated brown rice based cookies

Treatment	Total phenolic content (mg GAE/100g) Storage period (days) 0	30	60	90	Mean (Treatment)	Antioxidant activity (%) Storage period (days) 0	30	60	90	Mean (Treatment)
T_1 (100:00:: GBR: OF)	62.45	62.37	62.28	62.17	62.32	51.84	51.76	51.67	51.56	51.71
T_2 (95:5:: GBR: OF)	63.71	63.62	63.53	63.42	63.57	50.01	49.92	49.81	49.70	49.86
T_3 (90:10:: GBR: OF)	64.97	64.88	64.78	64.65	64.82	48.20	48.12	48.01	47.89	48.06
T_4 (85:15:: GBR: OF)	66.19	66.10	65.98	65.87	66.04	46.18	46.09	45.98	45.86	46.03
T_5 (80:20:: GBR: OF)	67.40	67.32	67.21	67.10	67.26	44.65	44.56	44.43	44.31	44.49
T_6 (75:25:: GBR: OF)	68.72	68.61	68.50	68.38	68.55	42.87	42.78	42.69	42.56	42.73
T_7 (70:30:: GBR: OF)	69.94	69.85	69.74	69.52	69.76	41.06	40.97	40.86	40.72	40.90
Mean (Storage)	66.20	66.11	66.00	65.87		46.40	46.31	46.21	46.09	
Effects C.D$_{(p\leq0.05)}$ Treatment (T) 0.04 Storage (S) 0.03 Treatment x Storage 0.07						Effects C.D$_{(p\leq0.05)}$ Treatment (T) 0.03 Storage (S) 0.02 Treatment x Storage 0.06				

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