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RESEARCH ARTICLE

Ameliorative effect of multigrain on nutritional and sensorial profile of muffins

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ABSTRACT

Maize and millet are the other major cereal grains grown worldwide along with wheat grains and their incorporation in products prepared solely with wheat flours can alter nutritional and sensorial attributes of products positively. Present study has been designed to develop multigrain muffins by utilizing wheat, maize and millet in different proportions i.e., T_0 (100% wheat flour), T_1 (80% wheat flour, 10% maize and millet flour each), T_2 (60% wheat flour, 20% maize and millet flour each), T_3 (40% wheat flour, 30% maize and millet flour each), T_4 (20% wheat flour, 40% maize and millet flour each), T_5 (50% maize and millet flour each), T_6 (100% maize flour) and T_7 (100% millet flour) treatments have been prepared and investigated for their nutritional profile and sensorial characteristics (performa evaluated on 9 points Hedonic scale). Moreover, storage study of the products was carried on 0, 10, 20 and 30th day of preparation. Data has been collected and subjected to two-way ANOVA by using software Statistics 8.1. The overall mean values for crude protein (6.97%) and crude fiber (1.17%) contents proved to be improved in T_3. On the other hand, T_3 proved to be good in attaining best sensory scores in aroma and texture. Overall acceptability of T_3 remained in good condition on average basis throughout storage period of muffins. So, it has been concluded that using wheat flour in combination with the maize flour and millet flour not only improves the nutritional profile of products but also the sensorial attributes. This product would be a valuable healthy addition in the market for consumers if studied further for launching and commercialization.

Keywords: Cereals; Multigrain; Wheat; Maize; Muffins

INTRODUCTION

The functional and nutritional qualities are two essential factors that represent the significance of cereal products as an individual food (Henry et al., 2016). Bakery products may include muffins, cupcakes, bread, pastries, cakes, and biscuits. Nevertheless, most of bakery products are high in fat, calories and carbohydrates, yet low in fiber. Cereals have been commonly utilized for the improvement of pro-health qualities of bakery products. Combining multigrain such as wheat, oat, millet, maize, ragi, and many others can provide snack manufacturers with the ability to produce products with an innovative look, different consistency and color, and a helpful nutritious profile. Bakery items from multigrain may provide essential quantity of vitamins and minerals (Mandge et al., 2014). Composite flour of multigrain cereals is best suited for cookies, muffins and other baked items because of its worldwide consumption. Composite flours are being produced to mainly replace wheat flour in the manufacture of baked goods (Awolu et al., 2015).

In the manufacture of chapattis, paratha and poori, wheat has historically been used as refined flour, whole wheat meal, finds a good ingredient in the manufacture of bakery items such as muffins, cakes and bread (Nigham et al., 2013). The 75% of wheat is rendered as whole wheat flour and only 25% is used for development of bakery items. Many researchers have provided whole wheat flour with a rich source of functional ingredients such as minerals, essential amino acids, fiber, phytochemicals and fat-soluble vitamins in the whole wheat grain (Dewettinck et al., 2008). Wheat flour dough has unique viscoelastic properties. Different factors can directly effect on wheat technological quality, such as damaged starch content, protein content, the particle size of flour and enzymatic activity. Changes in the water content of the dough reduce the volume of the loaf and increase the crumb hardness of the wheat flour product (Onipe et al., 2015).

Maize and wheat flours are frequently used in many pharmaceutical industries and food preparations all over world. Maize contains many essential B vitamins and

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minerals (Ranum et al., 2014). Maize is nutritionally superior cereal to others in various ways, except in terms of protein content. Starch, which is 72-73% of the grain weight, is the main chemical component of maize (Zhang et al., 2014). Maize has a higher content of sugar, iron and fiber than wheat and rice. The use of maize flour for the preparation of baked items helps to decrease the dependency of developing countries on imported wheat (Zhang et al., 2014). Wheat flour is partial replaced with corn flour for bread manufacturing which resulted in increase in nutritional value with acceptable physical and sensory characteristics (Begum et al., 2013). Maize grain can be consumed fresh by boiling or roasting. It may also be traditionally processed by wet or dry milling into a variety of the food products (Otunola et al., 2012). It is also processed into snacks like popcorn, and kokoro (Olanipekun et al., 2015).

Millets contain abundant phytochemicals and micronutrients and due to these nutritional benefits, millets are termed as "nutri-cereals" (Singh et al., 2012). As compared to other cereal grains, millets are less costly and millet fortification is a cost-effective approach that can take advantage of the deficiency and is a viable strategy to increase the consumption of fortified millet products. The supply of nutrients and the production of products can also be improved by fortifying millets (Singh et al., 2012). Among cereals, millets are unique due to their higher amount of calcium, dietary fiber, polyphenols and protein. Millets are found to have higher quantity of minerals when compared to wheat (Devi et al., 2011). Millet is often starchy, and good sources of vitamin b complex are the bran layer of millet (Odusola et al., 2013). For human consumption, millet is commonly used in the form of roti and other food preparations. Millet is also used to prepare different traditional foods and beverages such as dosa, porridges, breads, babies and snack foods, especially in bread, cookies and crackers that target the nutritional requirements of the customer (Rai et al., 2015).

Muffins are cereal products that include essential macronutrients and can be easily supplemented and enriched by changing the ingredients (Singh et al., 2012). Studies carried out to use multigrain in bakery products are very limited the main purpose of replacing wheat flour in bakery products with other cereals (millet and maize) is to bring more practical and nutritious value to bakery products while helping to encourage locally grown crops. Adding such substitutes has influenced the consistency of baking and the overall acceptance of the customer in turn. It has always been a major challenge to define the correct proportion of such substitute items in the baking industry. Precise proportions of different grains for various bakery applications have not been explored or finalized due to complexity and diversity of bakery process and products. Hence, it is important to understand and explore the impact of replacing wheat flour with other grains on finished product properties to recognize best proportions (Zhang et al., 2014).

Objectives

Keeping in view potential of other cereals to replace wheat flour in bakery product as well as to promote locally grown crops, present study is designed to achieve the following objectives:

- Preparation of multigrain muffins and evaluation of their proximate composition and sensorial characteristics.
- Studying the effect of storage period on different nutritional and sensory aspects of multigrain muffins.

MATERIALS AND METHODS

To achieve the objectives of designed study following materials and methods had been followed:

Procurement of raw material

The study was carried out using wheat, corn and millet flour in various combinations to create multigrain muffins. The raw materials like wheat, corn and millet flour as well as all other ingredients required for muffins, was taken locally marketing from Faisalabad.

Preparation of muffins

Ingredients for control muffins, of flour (100g), baking powder (6g), granulated sugar (150g), whole milk (200Ml), salt (0.5g), 1 large egg and butter (20g) were used by (Romjaun et al., 2013). Treatment plan for preparation of muffins (select on trial basis) with different cereal combinations is shown in Table 1. and the muffins were prepared as described by Rajiv et al. (2011), with some modifications.

Storage study

After preparation, muffins were wrapped in linear low density polyethylene (LLDPE) and stored at room temperature for 30 days (Sharma et al., 2016).

Table 1: Treatment plan for preparation of multigrain muffins

Treatments	Wheat flour (g)	Corn flour (g)	Millet flour (g)
T_0	Control (100)	0	0
T_1	80	10	10
T_2	60	20	20
T_3	40	30	30
T_4	20	40	40
T_5	0	50	50
T_6	0	100	0
T_7	0	0	100

Analysis of multigrain muffins

Proximate composition

Moisture content

The moisture content of each sample was determined by drying sample in an oven at a temperature of 105 ± 5 °C till to a constant weight according method described in the AACC (2009).

Crude protein content

The nitrogen content was determined in each sample by Kjeldahl's method as described in AACC (2009). Percent crude protein was calculated by multiplying the nitrogen with factor 6.25.

Crude fat content

The fat contents were determined by using petroleum ether as solvent in soxhlet apparatus according to the method described in the AACC (2009).

Crude fiber content

For determination of crude fiber content, the defatted and dried samples was digested with 1.25 % H_2SO_4 followed by 1.25 % NaOH solution as described in AACC (2009).

Sensory analysis

The evaluation of muffins was carried out for various sensory attributes like color, aroma, taste, texture and over all acceptability. Sensory performa had been developed and subjected to a panel of sensory experts for evaluating the product sensory characters though 9-points Hedonic scale (Singh et al., 2020). Each treatment was evaluated for sensory characters on 0, 10th, 20th and 30th day of storage.

Statistical analysis

Data collected and subjected to statistical analysis for determination of level of significance through two factor factorial test. Software used for this statistical study was Statistics 8.1. (Montgomery et al., 2013).

RESULTS AND DISCUSSIONS

Proximate composition of multigrain muffins

Mean values regarding the moisture content has been presented in Table 2. Analysis of variance for moisture content score of multigrain muffins are presented highly significant results P≤0.01. The overall mean for moisture content ranged from 21.10% to 26.33%. During the storage time period (0 to 30 days) T_1 showed good scores on 0, 10 and 20 days of storage intervals. Whereas T_0 showed lowest moisture score. However, with respect to storage days, highest moisture score was found at 0 day and its value increased in all treatments as storage time proceeds to 30 days. Similar findings have also been reported earlier Rehman et al. (2016) in which moisture content ranged from 19.20% to 29.00%.

The mean values regarding the crude protein has been shown in Table 3. Analysis of variance for crude protein score of multigrain muffins showed highly significant results p≤0.01. The crude protein content ranged from 6.28% to 7.79%. During the storage time period (0 to 30 days) T_7 acquired good scores on 0, 10 and 20 days of storage intervals and T_7 showed good score on the 30 day of storage time period these treatments indicates the best storage of muffins. Whereas T_0 showed lowest crude protein score. However, with respect to storage, highest crude protein score was found at 0 day and its value decreased in all treatments as storage time proceeds to 30 days. Similar findings have been reported earlier Li et al. (2017) in which crude protein content ranged from 5.0% to 8.9%.

The mean values regarding the crude fat of multigrain has been displayed in Table 4. Analysis of variance for crude fat score of multigrain composite flours muffins showed highly significant results p≤0.01. The crude fat content ranges from 8.87% to 12.88%. During the storage time period (0 to 30 days) T_1 acquired good scores on 0, 10, 20 and 30 days of storage intervals and T_0 shows good score on the 30 day of storage time period these treatments indicates the best storage of muffins. Whereas T_7 showed lowest crude fat score. However, with respect to storage, highest crude fat score was found at 0 day and its value decreased in all treatments as storage time proceeds to 30 days. Similar findings have been reported earlier Segura et al. (2011) in which crude fat ranged from 4.28% to 16.91%.

The mean values regarding crude fiber are presented in Table 5. Analyses of variance for crude fiber score of multigrain composite flours muffins showed highly significant results p≤0.01. The crude fiber content ranges from 21.10% to 25.98%. During the storage time period (0 to 30 days) T_1 acquired good scores on 0, 10 and 20 days of storage intervals and T_0 shows good score on the 30 day of storage time period these treatments indicates the best storage of muffins. During this study, with respect to treatments, T_5 showed highest crude fiber score. Whereas T_0 showed lowest crude fiber score. However, with respect to storage, highest crude fiber score was found at 0 day and its value decreased in all treatments as storage time proceeds to 30 days. Similar findings have been reported earlier Olaoye et al. (2008) in which crude fiber contents ranged from 20.05% to 16.27%.

Sensory evaluation

The mean values regarding aroma score of multigrain muffins has been displayed in Table 6. Analysis of variance for aroma of multigrain composite flours muffins showed highly significant results p≤0.01. The aroma score ranged

Table 2: Effect of treatments and days on crude moisture means of multigrain muffins

Treatments	Days				Means
	0	10	20	30	
T_0	21.19^{c}	21.12^{a}	21.07^{b}	21.00^{d}	21.10^{c}
T_1	23.16^{b}	23.29^{a}	23.30^{a}	23.10^{b}	23.21^{bc}
T_2	23.82^{a}	23.86^{a}	23.21^{b}	23.84^{a}	23.68^{bc}
T_3	24.95^{a}	24.92^{b}	24.94^{b}	24.95^{a}	24.94^{b}
T_4	25.74^{d}	25.89^{a}	25.86^{a}	25.89^{b}	25.84^{ab}
T_5	26.15^{c}	26.37^{a}	26.49^{a}	26.29^{b}	26.33^{a}
T_6	25.60^{c}	25.86^{b}	26.01^{a}	25.96^{b}	25.86^{ab}
T_7	25.87^{a}	25.93^{c}	25.90^{b}	26.23^{a}	25.98^{ab}
Means	24.37^{b}	24.47^{a}	24.41^{ab}	24.43^{a}	

T_0= 100% whole wheat flour
T_1= 80% whole wheat flour, 10% corn flour , 10% millet flour
T_2= 60% whole wheat flour, 20% corn flour, 20% millet flour
T_3= 40% whole wheat flour, 30% corn flour, 30% millet flour
T_4= 20% whole wheat flour, 40% corn flour, 40% millet flour
T_5= 50% corn flour, 50% millet flour
T_6= 100% corn flour
T_7= 100% millet flour

Table 3: Effect of treatments and days on crude protein means of multigrain muffins

Treatments	Days				Means
	0	10	20	30	
T_0	6.74^{ij}	6.46^{k}	6.17^{m}	5.77^{n}	6.28^{h}
T_1	7.10^{h}	6.77^{i}	6.27^{l}	6.14^{m}	6.57^{g}
T_2	7.27^{g}	7.16^{h}	6.77^{i}	6.17^{m}	6.84^{e}
T_3	7.50^{f}	7.17^{h}	6.77^{i}	6.47^{k}	6.97^{d}
T_4	7.95^{c}	6.68^{j}	6.17^{m}	5.77^{n}	6.64^{f}
T_5	8.07^{b}	7.85^{d}	7.17^{h}	6.77^{i}	6.74^{c}
T_6	8.14^{b}	8.08^{b}	7.79^{d}	7.17^{h}	7.79^{a}
T_7	8.64^{a}	7.67^{e}	7.17^{h}	6.77^{i}	7.56^{b}
Means	7.67^{a}	7.23^{b}	6.78^{c}	6.37^{c}	

T_0= 100% whole wheat flour
T_1= 80% whole wheat flour,10% corn flour,10% millet flour
T_2= 60% whole wheat flour, 20% corn flour, 20% millet flour
T_3= 40% whole wheat flour, 30% corn flour, 30% millet flour
T_4= 20% whole wheat flour, 40% corn flour, 40% millet flour
T_5= 50% corn flour, 50% millet flour
T_6= 100% corn flour
T_7= 100% millet flour

Table 4: Effect of treatments and days on crude fat means of multigrain muffins

Treatments	Days				Means
	0	10	20	30	
T_0	13.73^{a}	13.26^{b}	12.85^{cd}	11.67^{d}	12.88^{a}
T_1	13.04^{bc}	12.93^{bc}	11.74^{e}	11.17^{fg}	12.22^{b}
T_2	12.55^{d}	11.85^{e}	11.25^{f}	10.85^{g}	11.62^{c}
T_3	11.72^{e}	11.17^{fg}	10.85^{g}	10.17^{h}	10.97^{d}
T_4	10.23^{h}	10.07^{hi}	9.74^{ij}	9.17^{j}	9.80^{g}
T_5	11.03^{fg}	10.84^{g}	9.74^{ij}	9.17^{k}	10.19^{f}
T_6	11.86^{e}	11.57^{b}	10.17^{h}	9.10^{k}	10.50^{e}
T_7	9.87^{jk}	9.26^{k}	8.67^{l}	8.17^{m}	8.87^{h}
Means	11.69^{a}	11.28^{b}	10.62^{c}	9.93^{d}	

T_0= 100% whole wheat flour
T_1= 80% whole wheat flour, 10% corn flour, 10% millet flour
T_2= 60% whole wheat flour, 20% corn flour, 20% millet flour
T_3= 40% whole wheat flour, 30% corn flour, 30% millet flour
T_4= 20% whole wheat flour, 40% corn flour, 40% millet flour
T_5= 50% corn flour, 50% millet flour
T_6= 100% corn flour
T_7= 100% millet flour

Table 5: Effect of treatments and days on crude fiber means of multigrain muffins

Treatment	Days				Means
	0	10	20	30	
T_0	1.02^{q}	1.01^{q}	1.01^{q}	1.00^{q}	1.01^{f}
T_1	1.13^{ijk}	1.08l^{mn}	1.04^{opq}	1.01^{q}	1.06^{e}
T_2	1.22^{fg}	1.18^{gh}	1.10^{klm}	1.02^{pq}	1.13^{d}
T_3	1.32^{d}	1.21^{fg}	1.1^{jkl}	1.06^{nop}	1.17^{c}
T_4	1.68^{a}	1.45^{c}	1.17^{hi}	1.07^{mno}	1.34^{a}
T_5	1.45^{c}	1.34^{d}	1.17^{hi}	1.07^{mno}	1.25^{b}
T_6	1.23^{ef}	1.17^{hi}	1.07^{mno}	1.02^{pq}	1.12^{d}
T_7	1.51^{b}	1.26^{e}	1.14^{ij}	1.07^{mno}	1.24^{b}
Means	1.32^{a}	1.21^{b}	1.10^{c}	1.04^{d}	

T_0= 100% whole wheat flour
T_1= 80% whole wheat flour, 10% corn flour, 10% millet flour
T_2= 60% whole wheat flour, 20% corn flour, 20% millet flour
T_3= 40% whole wheat flour, 30% corn flour, 30% millet flour
T_4= 20% whole wheat flour, 40% corn flour, 40% millet flour
T_5= 50% corn flour, 50% millet flour
T_6= 100% corn flour
T_7= 100% millet flour

from 4.63 to 7.67. During this study, with respect to treatments, T_1 showed highest aroma score followed by T_0. Whereas T_7 showed lowest aroma score. However, with respect to storage, highest aroma score was found at 0 day and its value decreased in all treatments as storage time proceeds to 30 days. Similar findings have been reported earlier (Dhillon, 2018) in which the aroma score ranges from 6.2 to 8.00.

The mean values regarding the color of multigrain muffins are displayed in Table 7. Analysis of variance for color score of multigrain composite flours muffins showed highly significant results $p \leq 0.01$. The color score ranged from 5.02 to 7.58. During the storage time period (0 to 30 days) T_1 good acquired cores on 0, 10 and 20 days of storage intervals and indicates the best storage of muffins. During this study, with respect to treatments, T_1 showed highest color score followed by T_0. Whereas T_6 showed lowest color score. However, with respect to storage, highest color score was found at 0 day and its value decreased in all treatments as storage time proceeds to 30 days. Similar study has been reported earlier Begum et al. (2013) in which color score ranges from 4.8 to 8.4.

The mean values regarding taste score of multigrain muffins has been revealed in Table 8. Analysis of variance of taste score of multigrain composite flours muffins showed highly significant results $p \leq 0.01$. The taste score ranged from 4.43 to 7.62. During the storage time period (0 to 30 days) T_1 acquired good scores on 0, 10 and 20 days of storage intervals and T_1 shows good score on the 30 day of storage time period these treatments indicates the best storage of muffins. During this study, with respect to treatments, T_1 showed highest taste score followed by

T_0. Whereas T_7 showed lowest taste score. However, with respect to storage, highest taste score was found at 0 day and its value decreased in all treatments as storage time proceeds to 30 days. Similar study have been reported earlier (Olagunju, 2019) in which taste score ranges from 4.86 to 7.65.

The mean values of texture score of multigrain composite flours muffins are presented in Table 9. Analysis of variance of texture score of multigrain composite flours muffins showed highly significant results $p \leq 0.01$. The texture score ranged from 4.58 to 7.28. During the storage time period (0 to 30 days) T_0 acquired good scores on 0, 10, 20 and 30 days of storage intervals and indicates the best storage of muffins. During this study, with respect to treatments, T_0 showed highest texture score. Whereas T_6 showed lowest texture score. However, with respect to storage, highest texture score was found at 0 day and its value decreased in all treatments as storage time proceeds to 30 days. Similar study have been reported earlier (Pooja, 2019) in which texture score ranges from 6.5 to 8.3.

The mean values regarding overall acceptability are revealed in Table 10. Analysis of variance for overall acceptability score of multigrain composite flours muffins showed highly significant results $p \leq 0.01$. The overall acceptability score ranged from 5.05 to 7.50. During the storage time period (0 to 30 days) T_1 acquired good scores on 0, 10 and 20 days of storage intervals and T_1 shows good score on the 30 day of storage time period these treatments indicates the best storage of muffins. During this study, with respect to treatments, T_0 showed highest overall acceptability score followed by T_3. Whereas T_7 showed lowest overall acceptability score. However, with respect

Table 6: Effect of treatments and days on aroma score of multigrain muffins

Treatments	Days				Means
	0	10	20	30	
T_0	8.22^{a}	8.15^{a}	7.50^{abc}	6.50^{de}	7.59^{ab}
T_1	8.15^{a}	8.05^{ab}	7.50^{abc}	7.00^{cd}	7.67^{a}
T_2	7.95^{ab}	7.50^{abc}	6.85^{cd}	6.50^{de}	7.20^{b}
T_3	7.50^{abc}	7.25^{bcd}	7.00^{cd}	5.00^{hi}	6.68^{c}
T_4	6.50^{de}	6.00^{ef}	5.00^{hi}	4.00^{j}	5.37^{de}
T_5	6.00^{ef}	5.87^{efg}	5.50^{fgh}	5.00^{hi}	5.59^{d}
T_6	5.50^{fgh}	5.25^{fghi}	5.15^{ghi}	4.75^{hij}	5.16^{e}
T_7	5.00^{hi}	4.75^{hij}	4.63^{ij}	4.15^{j}	4.63^{f}
Means	6.85^{a}	6.60^{a}	6.14^{b}	5.36^{c}	

T_0= 100% whole wheat flour
T_1= 80% whole wheat flour, 10% corn flour, 10% millet flour
T_2= 60% whole wheat flour, 20% corn flour, 20% millet flour
T_3= 40% whole wheat flour, 30% corn flour, 30% millet flour
T_4= 20% whole wheat flour, 40% corn flour, 40% millet flour
T_5= 50% corn flour, 50% millet flour
T_6= 100% corn flour
T_7= 100% millet flour

Table 7: Effect of treatments and days on color score of multigrain muffins

Treatments	Days				Means
	0	10	20	30	
T_0	8.55^{a}	8.51^{a}	7.00^{def}	6.00^{ghi}	7.51^{a}
T_1	8.50^{a}	8.33^{A}	7.02^{def}	6.50^{efgh}	7.58^{a}
T_2	8.00^{ab}	7.84^{abc}	7.00^{def}	6.33^{fgh}	7.29^{a}
T_3	7.50^{bcd}	7.33^{bcd}	7.15^{cde}	5.50^{ij}	6.87^{b}
T_4	6.00^{ghi}	5.50^{ij}	5.00^{jk}	4.50^{k}	5.25^{de}
T_5	7.00^{def}	6.75^{defg}	6.50^{efgh}	5.50^{ij}	6.43^{c}
T_6	5.50^{ij}	5.33^{ij}	5.00^{jk}	4.25^{k}	5.02^{e}
T_7	6.00^{ghi}	5.75^{hij}	5.50^{ij}	5.00^{jk}	5.56^{d}
Means	7.13^{a}	6.91^{a}	6.27^{b}	5.44^{c}	

T_0= 100% whole wheat flour
T_1= 80% whole wheat flour, 10% corn flour, 10% millet flour
T_2= 60% whole wheat flour, 20% corn flour, 20% millet flour
T_3= 40% whole wheat flour, 30% corn flour, 30% millet flour
T_4= 20% whole wheat flour, 40% corn flour, 40% millet flour
T_5= 50% corn flour, 50% millet flour
T_6= 100% corn flour
T_7= 100% millet flour

Table 8: Effect of treatments and days on taste score of multigrain muffins

Treatments	Days				Means
	0	10	20	30	
T_0	8.25^{ab}	8.21^{ab}	7.82^{ab}	6.23^{efg}	7.62^{a}
T_1	8.50^{a}	8.25^{ab}	7.95^{ab}	6.50^{ef}	7.80^{a}
T_2	8.00^{ab}	7.75^{abc}	6.25^{efg}	6.00^{fgh}	7.00^{b}
T_3	7.50^{bcd}	7.00^{cde}	6.87^{de}	5.50^{ghi}	6.71^{b}
T_4	6.00^{fgh}	5.75^{fghi}	5.50^{ghi}	4.00^{l}	5.31^{c}
T_5	6.00^{fgh}	5.50^{ghi}	5.25^{hij}	4.50^{jkl}	5.31^{c}
T_6	6.00^{fgh}	5.75^{fghi}	5.50^{ghi}	5.00^{ijk}	5.56^{c}
T_7	5.00^{ijk}	4.50^{jkl}	4.25^{kl}	4.00^{l}	4.43^{d}
Means	6.90^{a}	6.58^{b}	6.17^{c}	5.21^{d}	

T_0= 100% whole wheat flour
T_1= 80% whole wheat flour, 10% corn flour, 10% millet flour
T_2= 60% whole wheat flour, 20% corn flour, 20% millet flour
T_3= 40% whole wheat flour, 30% corn flour, 30% millet flour
T_4= 20% whole wheat flour, 40% corn flour, 40% millet flour
T_5= 50% corn flour, 50% millet flour
T_6= 100% corn flour
T_7= 100% millet flour

Table 9: Effect of treatments and days on texture score of multigrain muffins

Treatments	Days				Means
	0	10	20	30	
T_0	7.82^{a}	7.75^{ab}	7.00^{bcde}	6.58^{defg}	7.28^{a}
T_1	7.50^{abc}	7.33^{abcd}	7.00^{bcde}	6.00^{fghi}	6.95^{ab}
T_2	7.00^{bcde}	6.85^{cde}	6.50^{efgh}	6.25^{efghi}	6.65^{bc}
T_3	7.00^{bcde}	6.75^{cdef}	6.50^{efgh}	5.00^{jkl}	6.31^{c}
T_4	6.50^{efgh}	6.00^{fghi}	5.75^{hij}	5.00^{jkl}	5.81^{d}
T_5	6.00^{fghi}	5.00^{jkl}	4.50^{lm}	4.00^{m}	4.87^{e}
T_6	5.00^{jkl}	4.85^{kl}	4.50^{lm}	4.00^{m}	4.58^{e}
T_7	6.00^{fghi}	5.85^{ghi}	5.50^{ijk}	5.00^{jkl}	5.58^{d}
Means	6.60^{a}	6.29^{b}	5.90^{c}	5.22^{d}	

T_0= 100% whole wheat flour
T_1= 80% whole wheat flour, 10% corn flour, 10% millet flour
T_2= 60% whole wheat flour, 20% corn flour, 20% millet flour
T_3= 40% whole wheat flour, 30% corn flour, 30% millet flour
T_4=20% whole wheat flour, 40% corn flour, 40% millet flour
T_5= 50% corn flour, 50% millet flour
T_6= 100% corn flour
T_7= 100% millet flour

Table 10: Effect of treatments and days on overall acceptability score of multigrain muffins

Treatments	Days				Means
	0	10	20	30	
T_0	8.21^{a}	8.15^{ab}	7.33^{cdef}	6.32^{ghi}	7.50^{a}
T_1	8.162^{ab}	7.99^{abc}	7.36^{bcdef}	6.50^{ghi}	7.50^{a}
T_2	7.73^{abcd}	7.48^{abcde}	6.65^{fgh}	6.27^{ghij}	7.03^{b}
T_3	7.37^{bcdef}	7.08^{defg}	6.88^{efgh}	5.25^{lmno}	6.64^{b}
T_4	6.25^{hijk}	5.81^{ijkl}	5.31^{lmno}	4.37^{p}	5.43^{cd}
T_5	6.25^{hijk}	5.78^{ijklm}	5.43^{klmn}	4.75^{nop}	5.55^{c}
T_6	5.50^{jklmn}	5.29^{lmno}	5.03^{lmnop}	4.50^{op}	5.08^{d}
T_7	5.50^{jklmn}	5.21^{lmno}	4.97^{mnop}	4.53^{op}	5.05^{d}
Means	6.87^{a}	6.60^{a}	6.12^{b}	5.31^{c}	

T_0= 100% whole wheat flour
T_1= 80% whole wheat flour, 10% corn flour, 10% millet flour
T_2= 60% whole wheat flour, 20% corn flour, 20% millet flour
T_3= 40% whole wheat flour, 30% corn flour, 30% millet flour
T_4= 20% whole wheat flour, 40% corn flour, 40% millet flour
T_5= 50% corn flour, 50% millet flour
T_6= 100% corn flour
T_7= 100% millet flour

to storage, highest overall acceptability score was found at 0 day and its value decreased in all treatments as storage time proceeds to 30 days. Similar studies have been reported earlier (Odunlade, 2017) in which the overall acceptability ranges from 4.4 to 8.7.

CONCLUSION

It has been concluded that treatments T_3 (40% wheat flour, 30% maize and millet flour each) and T_4 (20% wheat flour, 40% maize and millet flour each) have abilities to provide great nutrient level with high scores for sensory attributes. The flours from other grains incorporated in muffins proved to be a source of more nutrients and improved overall acceptability. These muffins can be consumed by persons with more ease who are unable to digest wheat products due to certain reasons. Product developed in present study helped to utilize neglected grains (maize and millet) efficiently. So these are healthier options as compared to standard muffin.

Authors contribution

All work done has been completed by corresponding author and coauthors Author MR designed the experiments and plan all the study. MAS and BS conducted the experiments. MR, MAS and BS performed the storage study and analyzed the data. MR and MAS wrote the manuscript and ST done the proof reading. MR revised the manuscript. All authors provided the financial support. All authors have read and agreed to the published version of the manuscript.

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