

Optimisation of Process for Development of Nutritionally Enriched Multigrain Bread

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Abstract

The main aim for the development of multigrain breads was to meet the increasing demand of healthy diet with reference to economy. The multigrain breads were developed by replacing wheat flour by 5, 10, 15, 20 and 30% of oat, barley, maize and rice flours and 1% flax seeds were incorporated in bread making to increase its pharmaceutical value. A prominent change was observed in case of protein content by altering the substitution levels. Similarly fat, fibre and ash also vary by varying the flour ratios. The colour analysis showed certain change in L*, a* and b* values. More the fibre content was introduced in the samples, more the brown colour appeared. The texture profile analysis (hardness, springiness, chewiness & cohesiveness) increased by increasing the percentage of composite flours in the blends. Physical characteristics (bread volume, dough expansion and specific volume) increased by decreasing the percentage of blends in the bread samples and vice versa.

Keywords: Multigrain; Composite flours; Proximate analysis; Colour analysis; Bread optimization

Introduction

India is a developing country with a large segment of population depending upon wheat, rice and maize as staple food which provide calories and proteins. Traditionally only wheat has been used as a whole wheat meal (*atta*) in production of chapattis, paratha and poori whereas refined flour (*maida*) finds great application in manufacture of bakery foods like bread and cookies [1]. 75 per cent wheat is produced as whole wheat flour and only 25 per cent is used in preparation of bakery goods [2]. It has been proved that regular consumption of single items affect health directly e.g. regular consumption of wheat causes lysine deficiency while gluten protein may cause allergic reactions in some people. Diet should be balanced besides being it should be wholesome, appetizing, palatable and satisfying. It has been proved that right food can cure several diet related disorders. With increasing consumer awareness, improved educational status and standard of living, knowledge about natural foods, change in food habits and increased cost of medicines, there is an increased trend in consumption of healthy foods and hence alternate wheat flour and meal serves as excellent source to provide functional ingredients from other natural sources in our diet. The multigrain products feature a combination of grains such as wheat, oat, barley, maize, rice, flax etc. and provide opportunity for snack manufacturers to develop products within an imaginative appearance, featuring new texture and colour with a beneficial nutritional profile [2]. Multigrain products must be of course whole grain to offer maximum nutritional benefits. The use multi-grains are well established in other food sectors particularly bakery and breakfast cereals [3]. They make a positive contribution to the taste and texture of products and consumer readily accept the health benefits. Multigrain products can contribute to a healthy digestive system, help in weight control, reduce the risk of diabetes reduce the risk of cardiac failures and prevent the chances of bowel cancer. The flax seeds are commonly consumed in one of the three forms, whole seed, ground or powder form and flax seed oil. Most of the benefits reported from flax seeds are believed due to the presence of alpha linolenic acids (ALA), lignans and fibre [4]. Flax seeds are reported to have lot of health benefits e.g. flax seeds are most commonly used as laxative, flax seed oil is used for various conditions like arthritis, both flax seed and flax oil have been used to prevent high cholesterol levels and reduce the

risk of cancer [5]. Bread is an ideal functional product, since it is an important part of our daily diet. Bread is consumed in large quantity in world in different types and forms depending upon cultural habits [6]. Bread is usually made from wheat flour dough that is cultured with yeast, allowed to rise, and finally baked in an oven [7]. Multigrain breads are reported to have lot of health benefits. Multigrain breads introduce more fibre in the diet than other types of breads. Multigrain breads also provide required quantity of thiamine, phosphorous, potassium, riboflavin, pantothenic acid, calcium, iron, zinc and copper [8]. The vitamin B in multigrain breads helps to convert in energy. There was a need to quantify the different levels of various grains for development of multigrain breads. Such information will increase the understanding of the functionality of multigrain bread in the diet to harness the potential benefits of various grains. Therefore the present investigation was planned to optimise the different levels of various grains for development of nutritionally enriched multigrain bread.

Materials and methods

The work was carried out in the Department of Food Technology, Islamic University of Science and Technology Awantipora during the year 2011-2012. Wheat, maize, oat, barley and rice flour were purchased from local market of Srinagar, J&K. The flours were separately stored in air tight plastic containers at refrigerated temperatures until used. Flax seeds, shortening, compressed yeast; salt and sugar were purchased from local market of Srinagar. The formulation for development of multigrain breads enriched with flax seeds were according to Table 1. Breads were prepared from blended flours (wheat, oat, barley, maize,

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Parameter	Treatments									
	T1	T2	T3	T4	T5	T6	T7	T8	T9	Control
Protein (%)	7.2 ^b	8.03 ^e	8.00 ^e	7.30 ^{bcd}	8.00 ^e	8.4 ^{gh}	8.07 ^{ef}	8.00 ^e	6.00 ^a	7.00 ^b
Fat (%)	3.60 ^e	4.60 ^f	3.00 ^d	3.60 ^e	2.60 ^c	3.00 ^d	2.30 ^b	3.00 ^d	2.00 ^a	2.60 ^c
Fibre (%)	15.00 ^e	13.00 ^d	16.00 ^f	13.00 ^d	13.00 ^d	11.00 ^c	14.00 ^e	10.00 ^a	11.00 ^c	10.30 ^{ab}
Ash (%)	0.50 ^a	1.00 ^b	1.50 ^c	2.50 ^a	1.50 ^c	2.00 ^d	1.50 ^c	1.00 ^{bc}	2.00 ^d	1.00 ^b
Carbohydrate(%)	35.64 ^c	47.07 ^f	42.98 ^e	60.00 ^f	36.60 ^{cd}	47.66 ^{fg}	29.33 ^a	32.98 ^b	50.36 ^h	54.10 ⁱ

Mean value in a row with same superscript do not differ significantly (p<0.05)

T: Treatment

Table 1: Proximate composition of bread samples.

rice) along with flax seeds. The ingredients were weighed accurately and the yeast was activated in warm water (55°C). All the ingredients were mixed in a vessel and yeast was added while taking into account the amount of water. The dough was then placed in an incubator at 37°C for fermentation. Dough was taken out after 2.5 hours and then knocked back to remove the excess gases. The dough was again placed in incubator for fermentation and removed after 30 min, moulded into pans and then allowed to ferment for another 35 min. The pans were then placed in baking oven (model SM 601 T) at 225°C for 30-35 min. The breads were taken out, cooled and then sliced. The breads were stored at room temperature and packaged in LDPE material.

Proximate analysis

Moisture content

Moisture (%) in the bread was determined by Gravimetric method [9]. 1gm sample was pre weighed (W₁) in a petriplates and placed in a hot air oven (model NSW 144) at 105°C for 24 hrs. The sample was removed from oven, cooled in desiccators and re weighed (W₂). Moisture percentage was calculated according to formula:

$$\text{Moisture (\%)} = \frac{(W_1 - W_2)}{W_1} \times 100$$

Total ash

Total ash content was determined as total inorganic matter by incineration of sample at 600°C [9]. Sample 1g was weighed into pre weighed porcelain crucible and incinerated overnight in a muffle furnace (model NSW-101) at 600°C. The crucible was removed from muffle furnace, cooled in desiccators and weighed. Ash content was calculated according to formula:

$$\text{Total Ash (\%)} = \frac{\text{Ash weight}}{\text{Sample weight}} \times 100$$

Crude protein

Crude protein was determined by Kjeldhal's method [9]. 700g of defatted and dried sample was placed in Kjeldhal's digestion flask. 5 g K₂SO₄ + 0.5 g CuSO₄ and 25 ml concentrated sulphuric acid was added to sample. The sample was digested for 1h. 20 ml deionised water was added to sample after allowing it to cool and transferred to a 50 ml volumetric flask. The volume was made upto mark with the distilled water. 10 ml of aliquot was taken and transferred in a distillation assembly followed by addition of 10 ml of 40% NaOH. On distillation ammonia liberated was collected in a 250 ml conical flask containing 10 ml of 0.01N HCl to which methyl red indicator (2-3 drops) was priorly added. It was titrated with 0.01N HCl. A blank was prepared and treated in the same manner except that the tube was free of sample. Protein percentage was calculated according to formula:

$$\text{Crude protein (\%)} = \frac{(\text{Sample titre} - \text{Blank titre}) \times 14 \times 6.25 \times 100}{\text{Sample weight}}$$

Where, 14 is molecular weight of nitrogen and 6.25 is nitrogen factor.

Crude fat

Crude fat was determined by employing solvent extraction using a Soxhlet unit [9]. Sample 1g was weighed in an extraction thimble and covered with absorbent cotton. 50 ml solvent (petroleum ether) was added to a pre weighed cup. Both thimble and cup were attached to extraction unit. The sample was subjected to extraction with solvent for 30 mins followed by rinsing for 1.5hrs. The solvent was evaporated from cup to the condensing column. Extracted fat in the cup was placed in an oven at 110°C for 1h and after cooling, the crude fat was calculated according to formula:

$$\text{Crude fat (\%)} = \frac{\text{Extracted fat}}{\text{sample weight}} \times 100$$

Crude fibre

Crude fibre in a sample was determined by method described by AOAC [9]. Defatted sample 1g was placed in a glass crucible and attached to extraction unit in Kjeldhal's unit. 150 ml boiling 1.25 per cent sulphuric acid was added. The sample was digested for 30mins and then the acid was drained out and the sample was washed with boiling distilled water. After this, 1.25% sodium hydroxide solution (150 ml) was added. The sample was digested for 30mins, there after the alkali was drained out and the sample was washed with boiling distilled water. Finally the crucible was removed from extraction unit and oven dried at 110°C overnight. The sample was allowed to cool in a dessicator and weighed (W₁). The sample was then ashed in a muffle furnace at 500°C (model NSW-101) for 2 hrs, cooled in a dessicator and re weighed (W₂). Extracted fibre was expressed as percentage of original undefatted sample and calculated according to formula:

$$\text{Crude fibre (\%)} = \frac{\text{Digested sample (W}_1\text{)} - \text{Ashed sample (W}_2\text{)}}{\text{sample weight}} \times 100$$

Texture profile analysis

Texture analyzer (TA HD Plus, stable micro Systems, Godalming, Surrey, UK) was used to measure the hardness, springiness, cohesiveness and chewiness [10]. For firmness the sample was removed from its place of storage and was placed centrally over the supports just prior to testing. The texture profile analysis was done at pre-test speed of 1.0 mm/s, test speed of 1.7 mm/s using a 5 kg load cell.

Colour analysis

Colour analysis of multigrain breads was done by using Hunter Lab colorimeter (model SM-3001476 micro sensors New York). The instrument was calibrated with user supplied black plate calibration standard that was used for zero setting, white calibration plates were used for white calibration settings. The instrument was placed at three different exposures at different places were conducted. Readings were displayed as L*, a* and b* colour parameters according to CIELAB system of colour measurement. The value of a* ranged from -100 (redness) to +100 (greenness), the b* values ranged from -100 (blueness) to +100

(yellowness) while as L^* value indicating the measure of lightness, ranged from 0 (black) to 100 (white)

Specific volume

Loaf volume was measured after baking by rapeseed displacement method. Specific volume was calculated as loaf volume (cm^3)/loaf weight (g)

Organoleptic characteristics

A panel of 10 judges evaluated the organoleptic characteristics of prepared breads. They assessed crust colour, appearance, flavour, texture, taste and overall acceptability, using 9-point Hedonic rating scale (9-Like extremely, 8-Like very much, 7-Like moderately, 6-Like slightly, 5-Neither Like nor dislike, 4-Dislike slightly, 3-Dislike moderately, 2-Dislike very much, 1-Dislike extremely).

Statistical analysis

The data was statistically analysed on a computer using design factorial in Completely Randomized Design (CRD) as suggested by Snedecor and Cochran [11].

Results and discussion

The different ingredients used in preparation of bread were flour (300 g), yeast (27 g), sugar (10 g), salt (5 g), shortening (12 g) and flax seeds (3 g). Figure 1 shows the flow chart for bread making process. It was found that flax seeds contain a high amount of fat content (37.5%), carbohydrate (29%). Dietary fibre (26%), protein (21.5%) and less percentage of moisture content (7%) and ash content (3.5%). Our results were in alignment with Halligudi [4]. The proximate composition of different flours used in the development of multigrain breads is shown in Table 2. The carbohydrate content of different flours varied from 62% (oats) to 76% (rice). However the carbohydrate content of wheat and barley were significantly same but vary from rest of the flours used in the preparation of bread samples. It is also revealed from the data in Table 2 that the protein content varied from 6.77 in rice to 11.65% in barley. The fat content varied from 0.51 in wheat to 4.58 percent in maize, although the percentage of fat is significantly same in oats and maize but differ from rest of the flours. The fibre content was found highest in barley (6.75%) and lowest in rice (0.62%) while ash content varied from 0.66% (wheat) to 2.2% (barley). Similar results were reported by Dingra [12]. The formation of various multigrain composite flours is displayed in Table 3. Nine (T1-T9) different combinations were prepared using different ranges of flours. Wheat flour percentage ranged from 50% to 60%, oat 10% to 25%, barley 5% to 20% while maize and rice 5% to 10%. The proximate composition of various multigrain breads (T1-T9) is depicted in Table 4. It is evident from the Table 1 that the protein content varied from 6.00% (T9) to 8.40% (T6) in various multigrain bread samples. Similar results were reported by Sanful and Darko [13]. The data in the Table 1 showed that minimum value of fat content (2%) was observed in T9 while as maximum value was observed in T2 (4.6%). The significant difference was observed in various multigrain bread samples. Same results were observed by Malomo, et al. [14]. The highest amount of fibre was found in in T3 (16%) while the least amount in T8 (10%). The fibre content of T6 and T9 were significantly same but differ from rest of the bread samples. The difference in the fibre content could be due to the presence of high amount of oat and barley present in different multigrain bread samples. These results are comparable to Olaoye [15]. The ash content ranged from 2.5% in T4 to 0.5% in T1 which implies that T4 possessed high amount of mineral content. The results could be due to the difference in supplementation

in different multigrain bread samples. Table 1 portrays that the carbohydrate value of different multigrain bread samples ranged from 29.33 to 60%. The highest value was observed in T4 and least value in T7, T1 and T6 were significantly same but differs from rest of the samples. These results were consistent with Malomo, et al. [14]. The sensory scores of multigrain breads are shown in Table 5. The value of colour ranged from 7.0 to 7.5. As the amount of oat is increased, the colour of the crust changed from creamy white to dull brown. These results are alluding to Gupta, et al. [16]. The data in Table 5 depicted that the crumb appearance scores for different samples are significantly similar. These results are parallel to the findings of Gupta, et al. [16]. The texture of the bread is related to external hardness or softness of bread. The texture is the quality of bread that can be decided by touch, the degree to which it is rough or smooth, hard or soft. The panellists preferred sample T1, T4, T6, T8 equally as compared to control sample. However the mean indicated that there is non-significant difference between the colours of the samples. These results are similar to the one reported by Sanful and Darko [13]. The flavour of the bread refers to its palatability. Table 6 reflects the score for flavour ranged from 6.8 (lowest) to 7.2 (highest). It is evident from data that the difference in

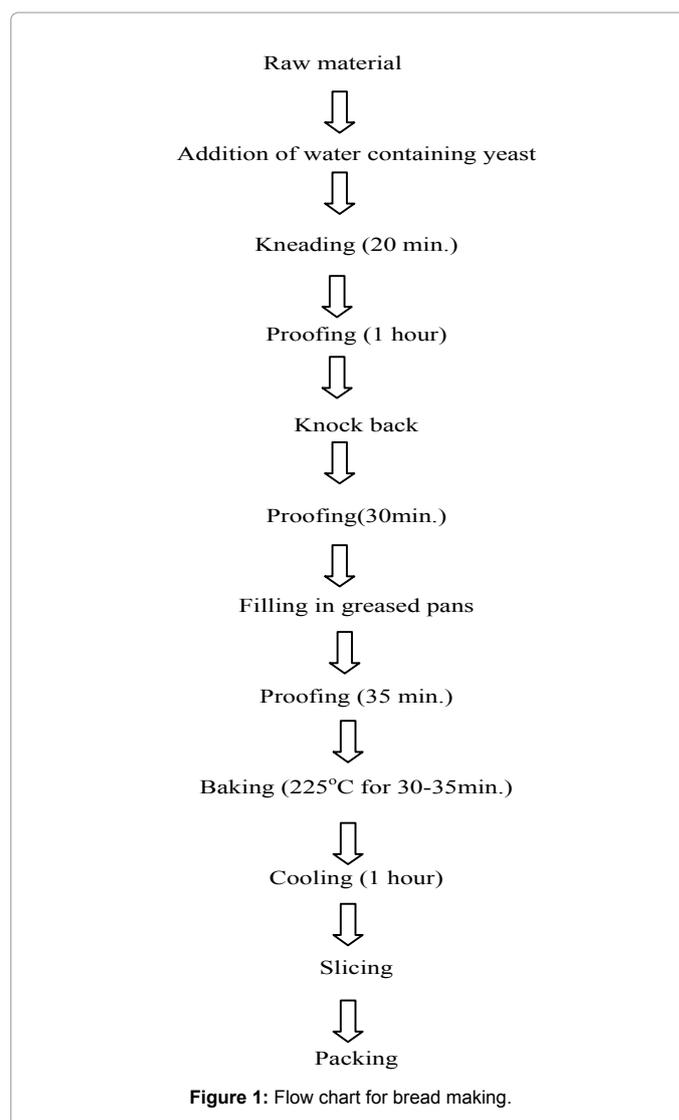


Figure 1: Flow chart for bread making.

Flours	Ash (%)	Protein (%)	Fibre (%)	Fat (%)	Carbohydrate (%)
Wheat	0.66 ^a	9.55 ^b	1.29 ^a	0.51 ^a	73.94 ^c
Barley	2.20 ^e	11.65 ^e	6.75 ^e	2.31 ^c	75.00 ^{cd}
Oat	1.70 ^c	9.60 ^b	5.13 ^d	4.50 ^d	62.00 ^a
Maize	2.00 ^d	9.78 ^{bcd}	1.38 ^{abc}	4.58 ^{de}	70.32 ^b
Rice	0.76 ^b	6.77 ^a	0.62 ^a	0.94 ^b	76.91 ^e

Mean value in a column with same superscript do not differ significantly ($p < 0.05$)

Table 2: Proximate composition of flours.

Ingredients	Combination								
	T1	T2	T3	T4	T5	T6	T7	T8	T9
Wheat (%)	50	50	50	60	60	60	70	70	70
Oat (%)	25	20	10	10	20	15	15	10	10
Barley (%)	15	20	20	20	10	15	5	10	10
Maize (%)	5	5	10	5	5	5	5	5	5
Rice (%)	5	5	10	5	5	5	5	5	5

1% flax seeds were incorporated in each preparation

T: Treatment

Table 3: Formation of multigrain composite flours.

Combination	L'	a'	B'	Hue
T1	58.09 ^c	2.29 ⁱ	29.75 ^h	85.59 ^{bc}
T2	56.92 ^{ab}	2.33 ⁱ	29.67 ^h	85.50 ^a
T3	60.05 ^{gh}	1.38 ^d	27.44 ^a	87.12 ^{gh}
T4	61.26 ⁱ	2.13 ^h	27.65 ^b	85.59 ^{bc}
T5	59.43 ^d	1.76 ^{fg}	28.95 ^g	86.51 ^d
T6	59.17 ^d	2.33 ^{ij}	29.94 ^{ijk}	85.54 ^b
T7	58.91 ^c	0.90 ^c	27.87 ^b	88.15 ⁱ
T8	59.50 ^d	0.68 ^{ab}	28.18 ^{cdef}	88.61 ^{ij}
T9	59.73 ^{de}	1.59 ^e	27.74 ^b	86.71 ^e
Control	71.29 ^j	1.68 ^f	29.19 ^g	86.70 ^e

Mean value in a column with same superscript do not differ significantly ($p < 0.05$)

Table 4: Colour analysis of multigrain breads.

Parameter	Treatments									
	T1	T2	T3	T4	T5	T6	T7	T8	T9	Control
Crust colour	7.0 ^a	7.0 ^a	7.0 ^a	7.5 ^d	7.0 ^a	7.4 ^c	7.0 ^a	7.0 ^a	7.1 ^b	8.0 ^e
Crumb appearance	7.1 ^a	7.1 ^a	7.0 ^a	7.2 ^{abc}	7.0 ^a	7.0 ^a	7.0 ^a	7.1 ^a	7.1 ^a	8.0 ^d
Texture	7.2 ^c	7.0 ^a	7.1 ^b	7.2 ^c	7.1 ^b	7.2 ^c	7.1 ^b	7.2 ^c	7.0 ^a	7.6 ^d
Flavour	6.8 ^{ab}	6.7 ^a	7.1 ^c	6.8 ^{ab}	7.2 ^{cd}	6.8 ^{ab}	6.7 ^a	6.8 ^{ab}	8.0 ^e	0.11
Overall acceptability	7.0 ^a	7.1 ^a	7.4 ^d	7.1 ^a	7.2 ^{bc}	7.1 ^a	7.1 ^a	7.1 ^a	8.0 ^e	0.12

Mean value in a row with same superscript do not differ significantly ($p < 0.05$)

Table 5: Sensory mean scores of multigrain breads.

Type of bread	Hardness	Springiness	Chewiness	Cohesiveness	Moisture of crumb (%)
T1	10.87 ^b	0.96 ^a	0.76 ^a	0.43 ^a	38.00 ^g
T2	11.43 ^b	1.20 ^a	0.80 ^a	0.47 ^a	27.30 ^c
T3	12.44 ^c	1.50 ^b	0.86 ^a	0.48 ^a	29.00 ^{de}
T4	14.97 ^d	1.96 ^c	0.90 ^a	0.50 ^a	24.60 ^a
T5	15.30 ^d	2.50 ^d	0.96 ^{abcd}	0.56 ^{bc}	38.30 ^{gh}
T6	16.43 ^e	2.90 ^e	1.50 ^e	0.60 ^d	28.30 ^c
T7	17.40 ^f	3.30 ^f	1.96 ^f	0.66 ^e	45.30 ^j
T8	17.90 ^f	3.50 ^g	2.00 ^{fg}	0.70 ^f	45.30 ^j
T9	18.50 ^f	3.96 ^h	2.60 ^h	0.77 ^{ghi}	35.60 ^f
Control	7.87 ^a	4.00 ⁱ	3.00 ⁱ	1.50 ^j	25.00 ^{ab}

Mean value in a column with same superscript do not differ significantly ($p < 0$)

Table 6: Moisture content and TPA (texture profile analysis) of bread samples.

flavour scores could be due to the incorporation of maize flour in the multigrain bread samples Gupta, et al. [16]. Higher the amount of oat and barley added in the samples more is the undesirable flavour. The data in the Table 5 outlined that the majority of panellists accept the bread made out of 100 per cent wheat flour (control sample) which has score of as 8.0 on 9 point Hedonic scale. It is evident from the data that that the mean sensory scores increased upto 15% level of substitution and beyond that the trend reversed. The preference of the panellists for sensory attributes of whole wheat bread flour may be due to the familiarisation of consumers to the normal whole wheat flour. The colour analysis of all multigrain breads is shown in Table 4. There is no significant difference between the L^* values of different multigrain bread samples. However the a^* values showed little difference among different bread samples with increase or decrease in the amount of oat and barley flour in the samples. Similarly b^* values also varied among the different multigrain bread samples by varying the proportion of different flours [12]. Table 6 displayed that the hardness increased in the multigrain bread samples with the increase in the fibre content while as the control sample showed least hardness. The Table 6 points out that the springiness (elasticity) of the bread samples decreased with the increase in the fibre content, less the amount of composite flours, more desirable is the chewiness. Cohesiveness also varied by varying the composition in different multigrain bread samples. The moisture content of crumb increased by addition of fibre as shown in Table 6 which could be due to the incorporation of high amount of substitution levels in the multigrain bread samples. Similar results were reported by Goesaert, et al. [17]. Figures 2-4 depicts that bread volume, dough expansion and specific volume increased by increasing the amount of whole wheat flour and decreasing the fibre content in each sample. The increase in bread volume, dough expansion and specific volume is because of the high gluten network present in wheat flour that helps to trap carbon dioxide and hence increases the volume. These results are in alignment to the findings of Ndife, et al. [18] and Aissa, et al. [19].

Conclusion

In conclusion, breads prepared from multigrain mix with flaxseed substitutions were found to be nutritionally superior to ordinary bread. Multigrain bread would serve as functional food because of its high fibre content. It can also be concluded that use of multigrain mix up to the level of 30% can be considered for the production of bread with perceptible taste of multi-grains. However, further research work should be focused on the phytochemical analysis. There is also the need

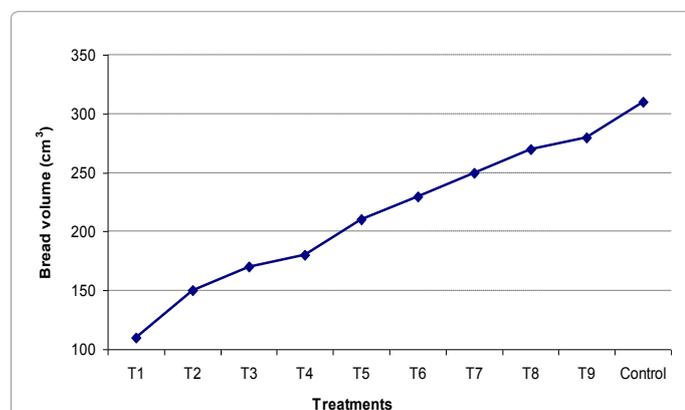


Figure 2: Graphical representation of bread volume (cm³) analysis of multi grain breads.

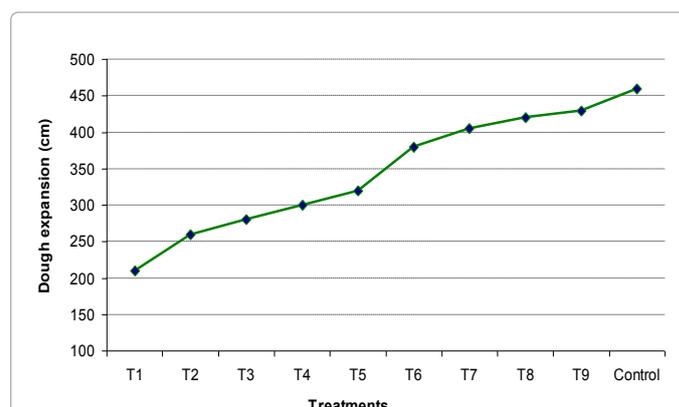


Figure 3: Graphical representation of dough expansion (cm) analysis of multi grain breads.

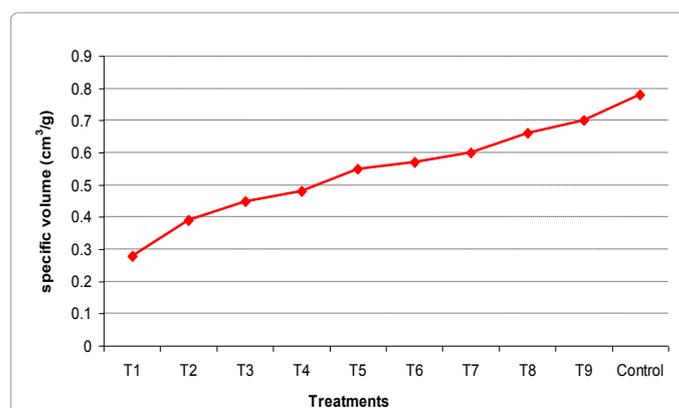


Figure 4: Graphical representation of specific volume (cm³/g) analysis of multi grain breads.

to adjust the mixing ingredients and baking techniques in order to improve the multigrain bread qualities.

References

- Nigham V, Nambiar VS, Tuteja S, Desai R, Chakravorty B, et al. (2013) Effect of wheat ARF treatment on the baking quality of whole wheat flours of the selected varieties of wheat. *Journal of Applied Pharmaceutical Science* 3: 139-145
- Indrani D, Soumya C, Rajiv J, Venkateswarao G (2010) Multigrain bread-its dough rheology, microstructure, quality and nutritional characteristics *Journal of Texture Studies* 41: 312-309.
- Mandge HM, Sharma S, Dar BN (2014) Instant multigrain porridge: effect of cooking treatment on physicochemical and functional properties. *Journal of Food Science and Technology* 51: 97-103.
- Halligudi N (2012) Pharmacological properties of flax seeds. *Hygeia: Journal of Drugs and Medicines* 4: 70-77.
- Donaldson M (2004) A review of the evidence for an anti cancer diet. *Nutritional Journal*.
- Cayot N (2007) Sensory quality of traditional foods. *Food Chemistry* 101: 154-162.
- Dewetnick K, Van Bockstaele F, Kühne B, VandeWalle D, Courtens TM, et al. (2008) Nutritional value of bread: influence of processing, food interaction and consumer perception. *Journal of Cereal Science* 48: 243-247.
- Angioloni A, Collar AC (2009) Multigrain breads as reinvented healthy and convenient value added goods. *International Association for Cereal Sciences and Technology*.
- AOAC (2000) Official methods of analysis. Association of Official Analytical

- Chemists International. Maryland, USA.
10. AACC (2004) Approved Methods of the AACC. Methods 10-05, 74-09. American Association of Cereal Chemists, St. Paul, MN.
 11. Snedecor GW and Cochran WG (1967) Statistical Methods. The Iowa State University Press, USA.
 12. Dhingra S, Jood S (2004) Effect of Flour Blending on Functional, Baking and Organoleptic Characteristics of Bread. *International Journal of Food Science and Technology* 39: 213-222.
 13. Sanful, RE, Darko S (2010) Production of Cocoyam, Cassava and Wheat Flour Composite Rock Cake. *Pakistan Journal of Nutrition* 9: 810-814.
 14. Malolma SA, Eleyinmi AF, Fashankin JB (2011) Chemical composition, rheological properties and bread making potential of composite flours from bread fruit, bread nut and wheat. *African Journal of Food Sciences* 5: 400-410.
 15. Olaoye OA, Onilude AA, Idowu OA (2006) Quality characteristics of bread produced from composite flours of wheat, plantain and soybeans. *African Journal Biotechnology* 11: 1102-1106.
 16. Gupta M, Bawa AS, Semwal AD (2011) Effect of Barley Flour Blending On Functional, Baking and Organoleptic Characteristics of High-Fiber Rusks. *Journal of Food Processing and Preservation* 35: 46-63.
 17. Goesaert H, Leman P, Bijttebier A, Delcour JA (2009) Antifirming effects of starch degrading enzymes in bread crumb. *Journal of Agricultural and Food Chemistry* 57: 2346-2355.
 18. Ndife J, Abdulraheem LO, Zakari UM (2011). Evaluation of the nutritional and sensory quality of functional breads produced from whole wheat and soy bean flour blends. *African Journal of Food Sciences* 5: 466-472.
 19. Aissa MFB, Monteau JY, Perronnet A, Roelens G, Bail AL, et al. (2010) Volume Change of Bread and Bread Crumb During Cooling, Chilling and Freezing and the Impact of Baking. *Journal of Cereal Science* 51: 115-119.