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Research Article

The Effect of Wheat, Tef and Soybean Flours Blending Ratio and Baking Temperature on Nutritional Quality of Bread

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Abstract: This study was conducted to determine the effect of wheat, soybean and tef flour blending ratio and baking temperature on quality of wheat-based composites flour bread. The effect of two factors, blending ratio (wheat, soybean and tef) and baking temperature (190°C, 220°C and 250°C) were studied. The experiment was conducted using custom design. The corresponding proportion of wheat from 70 to 90%, soybean 5 to 15% and tef 5 to 15% were taken from similar study, and using wheat (100%) flour bread as a control. Supplementing soybean and tef to wheat increased moisture, ash, crude fat, crude fiber, crude protein, and decreased carbohydrate. Baking temperature significantly ($P<0.05$) affected protein, fiber, moisture, ash, fat and carbohydrate of the blended product. Optimum values (13.65 – 14.08%) of protein and (3.24 – 3.27%) ash were obtained at 220°C and 190°C, when the proportion ranged from 75 to 80% for wheat, 15% soybean and 5 to 15% tef. In general, proportion of wheat from 80 to 85%, soybean from 5 to 10% and tef from 5 to 10% were found optimum for both nutritional quality of the wheat-based blend bread.

Keywords: Bread, Baking Temperature, Blending Ratio, Proximate Composition

1. Introduction

Increasing urbanization as well as the advancement in baking technology and changing food habits, made bakery food products such as bread popular in urban and semi urban areas of most developing countries [1]. Flour of both hard and soft wheat classes have been the major ingredient of bakery products for many years because of its functional proteins. However, recognition of the beneficial nutritional attributes of some other grains due to the complementarities of their essential amino acids with those of wheat has led to world-wide attempts to fortify traditional wheat bakery products, such as bread with locally grown unexploited grains [2]. Several studies about the influence of the addition of cereal flours such as sorghum, maize and barley, as well as rich lysine legumes to wheat flours on the physicochemical properties of wheat bread dough and the quality of its final products have been reported in the last three decades [3].

Bread is one of the major products of baked foods and is consumed worldwide [4]. Bread products and the production techniques vary from country to country. Basic ingredients are wheat flour, water, yeast and salt [5, 6]. Other ingredients which may be added include flours of other cereals, fat, malt flour, soya flour, yeast foods, emulsifiers, milk and milk products, fruit and gluten [6]. With appropriate process optimization, breads with acceptable quality can be made with the addition of nontraditional ingredients [7].

Wheat is a good source of calories and other nutrients but its protein is of lower nutritional quality than milk, soy, pea and lupin proteins as its protein is deficient in the essential amino acids such as lysine and threonine [8]. It is known that legumes contribute significantly the protein, mineral and B-complex vitamin needs of people in developing countries. Hence, supplementation of wheat flour with inexpensive staples, of other cereals and pulses will help, in improving the nutritional quality of wheat products [9].

The principal use of tef grain for human food is the Ethiopian bread (injera). Injera is a major staple food, and provides approximately two thirds of the diet in Ethiopia [10]. Even-though, the reported high iron content of tef injera has been refuted by some workers, the lack of anemia in Ethiopia was implicated due to the available iron from injera [11].

Legumes are the most important plant food material for the outstanding reason that they are the cheap sources of concentrated protein for the vegetarian population. However, they are under-utilized in various countries because of antinutrient factors, such as enzyme (trypsin, chymotrypsin, α-amylase) inhibitors, phytic acid and flatulence causing factors [12]. Soybean (*Glycine max*) is a source of high quality cheap protein that is often used to improve protein quantity and quality of most cereals and starch based foods. Soybean is rich in iron, calcium and some B vitamins though low in sulphur containing amino acids: methionine and cystine [13]. Its use in the production of bread as composite flour has been reported [14].

The most important problems in most developing countries including Ethiopia are protein energy malnutrition and micronutrient deficiencies [10]. The high cost and inadequacy in production of protein-rich foods have resulted in protein energy malnutrition among children and vulnerable group of people in the developing world [15]. In this research, an attempt was made to address problems associated with protein energy malnutrition through developing nutritious foods based on cereal-legume composite bread.

2. Literature Review

2.1. Wheat Production in Ethiopia

Ethiopia is the second largest producer of wheat in sub-Saharan Africa, following South Africa [16]. Wheat is one of the major cereal crops in the Ethiopian highlands and it grows between 6 and 16°N, 35 and 42°E, and from 1500 to 2800 meters above sea level. Wheat is the 4th and 3rd most important cereal crop in terms of area of cultivation (1.6 million hectares, 12.9%) and grain production (3.9 million quintals, 15.6%) among the grains produced in Ethiopia [17]. In Ethiopia wheat is produced under rain fed conditions and about 60% of the wheat area is covered by bread wheat and 40% by durum wheat [16].

2.2. Wheat for Bread

Roughly 90 to 95% of the wheat produced in the world [18] is common wheat (*Triticum aestivum* L.), which is better known as hard wheat or soft bread wheat, depending on grain hardness. Wheat is utilized mainly as flour (whole grain or refined) for the production of a large variety of leavened and flat breads, and for the manufacture of a wide variety of other baking products.

2.3. Production, Consumption and Use of Tef in Ethiopia

Tef [*Eragrostis tef* (Zucc.) Trotter] is an indigenous cereal crop in Ethiopia with largest share of area (24.3%, 3.0 million hectares) under cereal cultivation and third (i.e. after maize and wheat) in terms of grain production (17.6%, 4.4 million quintals [17]. Tef grain has a proximate composition of about 9.4-13.3% protein, 73% carbohydrate, 1.98-3.5% crude fiber, 2.0-3.1% fat and 2.7-3.0% ash [19]. Tef grain flour is widely used in Ethiopia for making *injera* (staples for the majority of Ethiopians, a fermented, pancake-like, soft, sour, circular flatbread), sweet unleavened bread, local spirit, porridges and soups [20].

Table 1. *Proximate composition of wheat, tef and soybean flour.*

Types of nutrients	Wheat	Tef	Soybean
Moisture content	10.00	11.0	14.62
Protein	10.10	9.38-13.33	25.64
Fat	1.67	2.00-3.09	18.46
Carbohydrate	76.28	72.5-74.7	34.86
Fibers	1.00	1.98-3.5	5.03
Ash	0.95	2.7-3.0	4.62
Iron	3.1	5.7	11.10
Zinc	2.9	4.6	6.84
Phytic acid	800	393	160

Source: NRC [21]; EHNRI, [22].

Tef grain commands premium price among other cereals cultivated in Ethiopia. There is a growing interest on tef grain utilizations because of nutritional merits (whole grain), the protein is essentially free of gluten the type found in wheat (alternative food for consumers allergenic to wheat glutens) [23]. The grain proteins are also presumed easily digestible because prolamins are very small [21, 19].

2.4. Soybean Production and Utilization in African Countries

In Ethiopia, a soybean grower's manual was even published in Amharic, but trials were discontinued because yields were low. Trials began again in the late 1960s, and with the introduction of new high-yielding cultivars in the 1970s, new interest was generated. Throughout the 1970s Ethiopia produced 6,000 tons of soybeans a year, making it one of the top four African soybean producing countries. In 1981 about 2,000 hectares of land were under production by the state farms development authority. This had produced only 10% of the soybeans required by the Ethiopian nutrition institute (ENI). Soybean covers about 30,517.4 hectares of land and a production of about 610,249.4 quintals were obtained [17] in Ethiopia.

Flour blends are mixtures of cereal, root, or oilseed flours. The most commonly studied flour blends are made by partially replacing wheat flour with non-wheat flour. This practice arose from a need to increase the nutritional quality of wheat products, such as bread, that are consumed in developing countries. Soybean flour has been identified as a suitable complement to wheat flour for blends used in cereal-based products [24] for protein quality [25]. This type of flour can compensate for the lysine deficiency of wheat flour. Wheat flour contains more sulfur-containing amino acids and is able to supplement the low amount present in soybean flour. Blending 10% soy flour with wheat flour not only provides high protein content but it also improves amino acid balance. The addition of soy products in wheat flour requires very little change in technology and no changes at all in process equipment. However, the incorporation of high levels of soy products has negative effects in gluten network formation, extensibility properties and gas retention of dough, and final bread quality [26].

2.5. Composite Flours and Its Uses

Bread consumption has increased continuously in many developing countries due to changing eating habits, a steadily growing population and because a large proportion of the overall increased incomes can now be spent on foods [27]. However, the wheat flour needed for making bread had to be imported, since the climatic conditions and soil did not permit wheat to be grown locally [27]. Thus, research interest in composite flours has been on the rise in the recent past, driven by the desire to find non-wheat bread-making alternatives in order to reduce non-wheat-producing countries' dependence on imported wheat [28]. Much effort has been made to promote the use of composite flours, in which a portion of wheat flour is replaced by locally grown crops, in bread, thereby decreasing the cost associated with imported wheat [29], which in turn decreases the demand for imported wheat while producing protein-enriched bread [30].

Shittu *et al.* also agreed with that as the composite flours used were either binary or ternary mixtures of flours from some other crops with or without wheat flour [31]. The use of composite flours had a few advantages for developing countries such as the saving of hard currency; promotion of high-yielding, native plant species; a better supply of protein for human nutrition; and better overall use of domestic agriculture production [32]. Composite flour is considered advantageous in developing countries as it reduces the importation of wheat flour and encourages the use of locally grown crops as flour [33]. Local raw materials substitution for wheat flour is increasing due to the growing market for confectioneries [34]. Thus, several developing countries have encouraged the initiation of programmes to evaluate the feasibility of alternative locally available flours as a substitute for wheat flour [35].

According to Sudha et al., bakery products are varied by the addition of value-added ingredients [36]. Thus, the increasing number of applications of composite flour in numerous bakery and pastry products has spurred a growing number of studies on the effects of different types of materials used to produce flour on their physicochemical and functional properties. [28] reported that the experience gained in the use of composite flours has clearly demonstrated that, for reasons of both product technology and consumer acceptance, wheat is an essential component in many composite flours. They also reported that the percentage of wheat flour required to achieve a certain effect in composite flours depends heavily on the quality and quantity of wheat gluten and the nature of the product involved. Therefore, when bakery and pastry products are produced using composite flour, their quality should be as similar as possible to those of products made from wheat flour.

In addition, breads made from both barley and defatted soy flours, up to 15% level, are also considered as most acceptable, organoleptically and nutritionally as they contain appreciable amounts of protein, total lysine, dietary fiber, β-glucan and minerals [37]. Most non-wheat flours are devoid of gluten and its addition impairs the bread-making quality of wheat flour.

Generally, increasing the substitution amount of wheat flour with other flours progressively reduces the quality of bread. This has been attributed to reduced flour strength and gas retention capacity due to a reduction in gluten content, thereby reducing bread volume and the sensory appeal of most baked composite bread [38].

2.6. Baking Time and Temperature

In bread making, baking is a key step in which the raw dough piece is transformed into a light, porous, readily digestible and flavorful product, under the influence of heat. With the requisite quality attributes, the bread production presumes a carefully controlled baking process. [31] determined that varying temperature–time combination during baking leads to significant differences in the quality of composite cassava-wheat bread produced. The results clearly reflect complex polymeric changes caused by the changing temperature–time combination in baking. The influence of baking temperature was specifically more significant on loaf volume and crumb moisture while baking time had more significant influence on loaf weight, dried crumb hardness and density. During baking, 17-23% of vitamin B_1 may be destroyed. Another 15% may be lost during as little as sixty seconds of toasting [39]. During baking, proteins are denatured, which implies that they lose their three-dimensional structure, and become easier to digest, and less activating energy is required for enzyme hydrolysis [39].

Soybean even though it has high quality proteins, oils and other valuable nutrients (carbohydrates, minerals, vitamins and phytonutrients such as isoflavones), its utilization as staples in Ethiopia is very limited. Tef grain is often used as whole grains and is rich in starches, dietary fibers, minerals, ash and phytonutrients such as phenolics. Even through tef *injera* is a staple for majority of Ethiopian due its high price it becomes unaffordable for majority of Ethiopians. Majority of the Ethiopian urban dwellers are accustomed to white bread. Yet production of brown bread in Ethiopia is not as such accustomed and this leads with the shift from whole grain tef products (unaffordability) to white bread potentially can pose health challenges because of limited whole grain consumption for such consumers. Baking conditions also has an influence on the product quality and sensory acceptance of the products. In view of this, supplementation of bread with soybean and tef flours for bread processing can be nutritionally sound to address nutrition related public health crisis. The product can be also affordable and can increase the soybean value chain. Thus, in this research the effect of wheat, tef and soybean flour blending ratio and bread baking temperature on the nutritional quality of bread are reported.

3. Materials and Methods

3.1. Experimental Site

These experiments were done at Wolkite University

College of Engineering and Technology in Food Process Engineering Laboratory.

3.2. Raw Materials Collection and Preparation

The materials for the investigation, bread wheat (*Digalo* variety) and tef (*Quncho* variety) were collected from Debre Zeit Agricultural Research Center and the soybean (*Afgat* variety) from Awassa Agricultural Research Center. All the samples were cleaned manually to remove foreign matters, immature and damaged seeds.

Cleaned wheat and tef grain was milled into flour using cottage commercial grain mill. Following milling, the flour was sifted to pass through 710 µm test sieve [40], sealed in plastic bags, and stored at dry and dark room temperature until the experiment was conducted. The soybean was cleaned/sorted for physical impurities. The soybean was blanched in boiling water bath (95°C) for 20 minutes to arrest the lipoxygenase enzyme [41, 13] and dried at 100-120°C for 3-4 hours in an oven [41]. Then the soybeans were roasted until light brown to inactivate/reduce the antinutritional factor and to remove seed coats (decorticate) using a commercial mill. The decorticated beans were manually winnowed to separate the hulls and milled to flour using a commercial mill. The flour was sifted to pass through 710 µm test sieve, sealed in plastic bags and stored at dry and dark room temperature until analysis.

3.3. Experimental Design

In this study the effect of blending ratio and baking temperature on the nutritional quality of bread was studied using custom design to determine appropriate formulation. The blending ratio of wheat were ranged from 70 to 90% whereas tef and soybean from 5 to 15%. The constraints proportions are decided based on previous study [42, 43, 29] were the percentage of wheat, and tef and soybean ranged from 80 to 100% and 0 to 20%, respectively. Bread of 100% wheat flour was used as a control in this study. The formulations had 12 runs and it was done in three replications.

***Table 2.** Experimental design.*

Run	Wheat	Soybean	Tef	Temperature	Response
1	0.80	0.15	0.05	T1	-
2	0.80	0.10	0.10	T1	-
3	0.70	0.15	0.15	T1	-
4	0.80	0.05	0.15	T1	-
5	0.75	0.15	0.10	T2	-
6	0.75	0.10	0.15	T2	-
7	0.85	0.05	0.10	T2	-
8	0.85	0.10	0.05	T2	-
9	0.70	0.15	0.15	T3	-
10	0.80	0.15	0.05	T3	-
11	0.80	0.05	0.15	T3	-
12	0.90	0.05	0.05	T3	-

Where: - T1=baking temperature at 190°C.
T2=baking temperature at 220°C.
T3=baking temperature at 250°C.

Mixture model has no constant term β_0 (intercept) and squared terms $\beta_{11}X_1^2$. In building the model, a regression equation is established to describe the relationship between the response y and the variables X. Second order model was generated for the three mixture components as follows.

$$Y=\beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_{12}X_1X_2 + \beta_{13}X_1X_3 + \beta_{23}X_2X_3 \quad (1)$$

Where Y is predicted response; β_1, β_2 and β_3 are linear coefficients; β_{12}, β_{13} and β_{23} are the cross product (interaction) coefficients; X_1, X_2 and X_3 are independent variables.

3.4. Proximate Composition Analysis of Blended Flours

The moisture, crude fiber, crude protein and ash crude fat content was determined by the method as described in the [44] and [45], respectively. Percent of total utilizable carbohydrate determined by subtracting the sum of other constituents from 100.

3.5. Statistical Analysis

At least a triplicate data was analyzed and modeled using the statistical software JMP™ 8, 2008 (by SAS Institute Inc., Cary, NC, USA). Mixture response surface methodology was applied to the experimental data using JMP version 8. A polynomial equation was fitted to the data to obtain a regression equation. Data obtained were analyzed through Analysis of Variance (ANOVA), using the General Linear Models Procedure (GLM) [46] and the least significant difference (LSD) were calculated on SAS package.

4. Results and Discussions

4.1. Proximate Composition of Wheat, Tef and Soybean Flour

The proximate compositions of wheat, tef and soybean (decorticated) used in this experiment are shown in Table 3. The moisture contents were 9.57, 10.47 and 4.16% for wheat, tef and soybean, respectively. The protein content of wheat flour was 11.52% and this value was in the range (9.68 to 13.45%) reported by [47]. The ash content of wheat grain used in this study was 1.57% which is in close agreement with those of [48] which ranged from 1.32 to 1.85%. Crude fat and fiber contents of wheat were 2.65% each. These values were lower than the 3.6 and 4.5%, respectively, reported by [49].

***Table 3.** Proximate composition of wheat, tef and soybean flour (%).*

Parameters	Wheat	Tef	Soybean (decorticated)
Moisture content	9.57±0.06	10.47±0.06	4.16±0.05
Protein	11.52±0.56	11.24±0.19	41.22±0.54
Fat	2.65±0.08	2.93±0.03	20.49±0.13
Ash	1.57±0.06	2.05±0.05	4.32±0.05
Fiber	2.65±0.12	2.31±0.09	4.33±0.11
Carbohydrate*	72.03±0.64	70.99±0.11	25.47±0.54

Values are mean ± standard deviation, *=determined by difference.

The proximate compositions of tef found in this work were in agreement with those reported by [19]. Compared to many cereals, tef has higher protein content (10.2%) than maize (8.3%), sorghum (7.1%), barley (9.0%) and millet (7.2%) [50]. The fat content (2.93%) of tef appeared to be lower than in maize (4.6%) but higher than in wheat (2.65%), barley and millet and almost equal to that of sorghum (2.8%). Whereas the ash content is lower than that of millet and higher than those of wheat, sorghum and maize [50]. The total carbohydrate content of the tef grain was 70.99%, which was in close agreement with the 72% report of the [21]. The crude protein, crude fat and carbohydrate content of decorticated soybean were 41.22, 20.49 and 25.47%, respectively. These results were in close agreement with the findings of [51] of 40.54, 18.79 and 24.84%, respectively, for decorticated soybeans. The ash and fiber content also were 4.32 and 4.33%, respectively, and are in close agreement with those of [52] who reported 4.62 and 5%, respectively.

4.2. Proximate Compositions of the Blended Products

4.2.1. Moisture Content

The moisture content of the composite breads ranged from 2.69-3.85% (Table 4). The highest moisture content (3.85%) was obtained from the bread of 80% wheat, 5% soybean and 15% tef baked at 190°C. The lowest moisture content (2.69%) was obtained from the bread of 80% wheat, 5% soybean and 15% tef baked at 250°C. This may be due to the fact that high baking temperature reduces the moisture content of the bread. However, the blend bread moisture content was significantly ($P<0.05$) different from the control sample.

The combined effects of wheat, soybean and tef on moisture content of the blend bread were significantly different ($P<0.0003$). The linear terms of wheat and tef were not significantly ($P>0.05$) different, whereas the linear term of soybean was significantly ($P<0.05$) decreased the moisture content of the product. This is probably due to high amount of solid matter soybean flour. All the interaction terms except W*S had insignificant ($P>0.05$) effect on moisture content. The moisture content of the blend bread was also significantly ($P<0.05$) influenced by the linear terms of baking temperature, in that when temperature increased the moisture content of the bread was significantly reduced.

Table 4. *Proximate composition of breads produced from composite flours at different baking temperatures.*

Run	w	s	t	T (°C)	Moisture (%)	Ash (%)	Crude fat (%)	Crude fiber (%)	Crude protein (%)	CHO (%)
1	0.80	0.15	0.05	190	3.12±0.02[d]	3.27±0.01[a]	5.12±0.06[a]	2.36±0.03[f]	14.08±0.21[a]	72.04±0.14[j]
2	0.80	0.10	0.10	190	3.62±0.08[b]	3.16±0.01[c]	3.51±0.09[e]	2.89±0.07[c]	12.86±0.13[de]	73.95±0.11[g]
3	0.70	0.15	0.15	190	3.76±0.09[a]	3.29±0.03[a]	4.65±0.10[c]	2.69±0.13[d]	13.54±0.10[b]	72.04±0.09[j]
4	0.80	0.05	0.15	190	3.85±0.06[a]	3.05±0.03[d]	2.31±0.06[h]	2.49±0.05[e]	12.30±0.33[fg]	77.15±0.29[d]
5	0.75	0.15	0.10	220	3.08±0.09[d]	3.24±0.09[ab]	4.18±0.17[d]	2.10±0.08[gh]	13.65±0.18[b]	73.74±0.42[g]
6	0.75	0.10	0.15	220	3.47±0.06[c]	3.06±0.02[d]	3.61±0.05[e]	1.99±0.06[hi]	13.17±0.40[cd]	74.70±0.32[f]
7	0.85	0.05	0.10	220	3.04±0.08[de]	2.95±0.01[e]	3.17±0.09[f]	1.96±0.12[i]	12.61±0.09[ef]	76.26±0.19[e]
8	0.85	0.10	0.05	220	3.55±0.02[bc]	3.02±0.03[d]	4.08±0.06[d]	1.93±0.04[i]	13.37±0.16[bc]	74.03±0.16[g]
9	0.70	0.15	0.15	250	3.82±0.09[a]	3.14±0.02[c]	4.87±0.06[b]	3.19±0.07[b]	12.36±0.29[fg]	72.60±0.22[i]
10	0.80	0.15	0.05	250	3.84±0.06[a]	3.18±0.01[bc]	4.10±0.09[d]	3.56±0.03[a]	12.17±0.14[g]	73.15±0.13[h]
11	0.80	0.05	0.15	250	2.69±0.05[g]	3.02±0.03[d]	2.72±0.05[g]	2.69±0.07[d]	11.35±0.16[h]	76.36±0.14[e]
12	0.90	0.05	0.05	250	3.55±0.06[bc]	2.94±0.03[e]	2.36±0.08[h]	2.70±0.06[d]	11.32±0.13[h]	77.10±0.07[d]
Cont. 1	1	0	0	190	3.09±0.05[d]	2.79±0.06[f]	1.81±0.09[j]	2.16±0.02[g]	11.03±0.18[hi]	79.40±0.27[a]
Cont. 2	1	0	0	220	2.96±0.02[e]	2.83±0.06[f]	2.41±0.08[h]	1.74±0.02[j]	10.93±0.29[i]	78.65±0.18[b]
Cont. 3	1	0	0	250	2.79±0.00[f]	2.85±0.07[f]	1.99±0.07[i]	2.56±0.04[e]	10.92±0.15[i]	78.17±0.23[c]
Mean					3.35±0.03	3.05±0.05	3.39±0.06	2.46±0.04	12.37±.13	75.29±0.16
Range					2.69-3.85	2.79-3.29	1.81-5.12	1.74-3.56	10.92-14.04	72.04-79.40

Values are in Mean ± SD. Means within a column with the same letter are not significantly different ($P>0.05$) (a>b>c….. i>j). T=baking temperature, CHO=carbohydrate, W, S and t are fractions of wheat, soybean and tef, respectively [53] reported that moisture content of the product was reduced when baking temperature increased. This could be attributed to high level of evaporation because of increased heat involved. The following model was developed to predict the moisture content.

$$MC=1.16W-87.78S+53.73t+110.43\,(W*S)-68.86\,(W*t)+76.23\,(S*t)+0.009T \quad (R^2=0.57) \tag{2}$$

Where MC=moisture content (%) predicted, W=Wheat (%), t=Tef (%), S=Soybean (%), T=Baking temperature (°C)

The predicted values of moisture content (Figure 1a) were correlated with the experimental data as demonstrated by regression coefficient ($R^2=0.57$). The majority of the points were randomly distributed nearby the diagonal line.

The residual versus predicted plot is presented in Figure 1 (b). The points were randomly distributed about the zero value horizontal line on the vertical axis. This indicates that the model was adequate in describing the data.

4.2.2. Ash Content

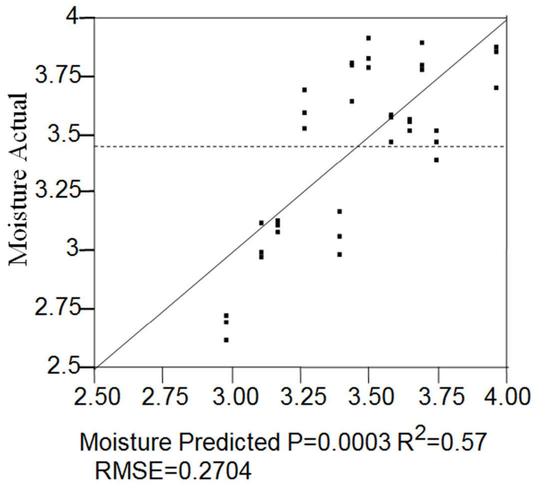
The ash contents of the blended bread were in the range of 2.94-3.29% (Table 4). The highest three values, 3.24, 3.27 and 3.29% with no significant difference among them were obtained from the blends having 15% soybean. On the other hand, the least two values, 2.94 and 2.95% with no statistical difference between them were obtained in breads with only 5% soybean blend in common. The association of the high ash in breads having the 15% soybean and the low ash to those with 5% soybean blends can be directly related to the high content (4.32%) of ash in the soybean seeds (Table 3). The ash content of the control samples was 2.79, 2.83 and 2.85% for 190, 220 and 250°C baking temperature, which were significantly ($P<0.05$) the least as compared to the blended products.

The ANOVA analysis of the data showed that combining wheat, soybean and tef had a significant (P<0.0001) effect on the ash content of the bread. The linear terms of wheat, soybean and baking temperature were significant (P<0.05) on ash content whereas those of tef and the interaction term of W*t were not (P<0.05). The interaction terms of W*S and S*t were both significant (P<0.05). The following model was developed to predict the ash content.

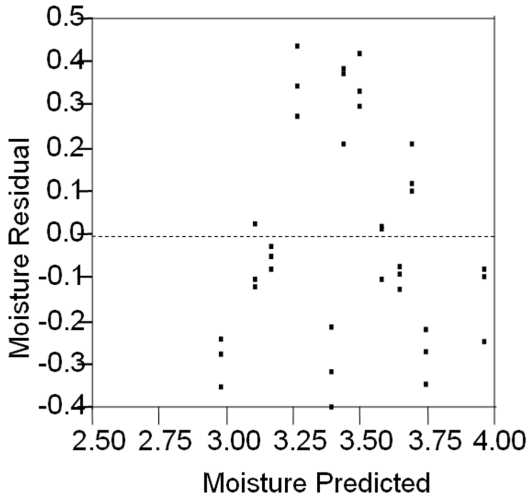
$$A=3.23W+19.99S+2.47t-17.22\,(W*S)+2.15\,(W*t)-21.62\,(S*t)-0.002T\ (R^2=0.89) \quad (3)$$

Where A is predicted ash (%), W=Wheat (%), S=Soybean (%), t=Tef (%), and T=baking temperature (°C)

The plots of analyzed versus predicted values of ash contents (Figure 2a) were randomly distributed along the diagonal line with the regression coefficient of R^2=0.89. Measure of goodness of fit is how well the points lie along the 45 degree diagonal line.



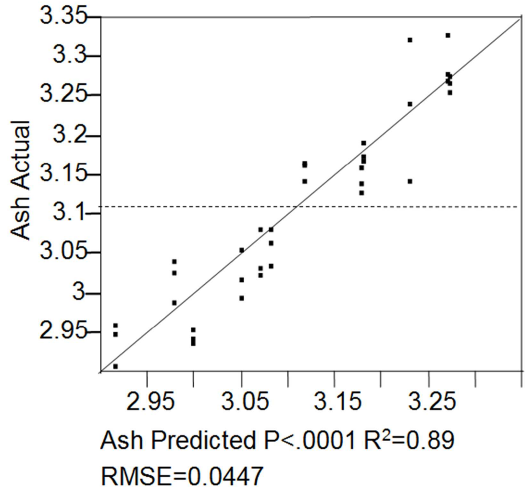
(a)



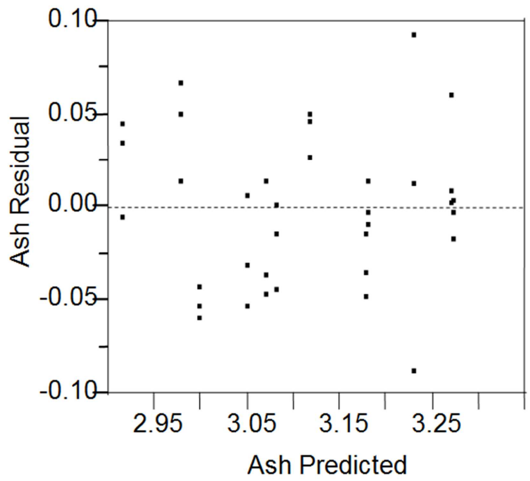
(b)

Figure 1. *Analyzed value versus predicted (a) and residual versus predicted (b) plot of moisture content.*

The residual by predicted plot is presented in Figure 2b. The points were randomly distributed about the zero value horizontal line which indicated that the model was adequate in describing the data.



(a)



(b)

Figure 2. *Analyzed value versus predicted (a) and residual versus predicted (b) plot of ash content.*

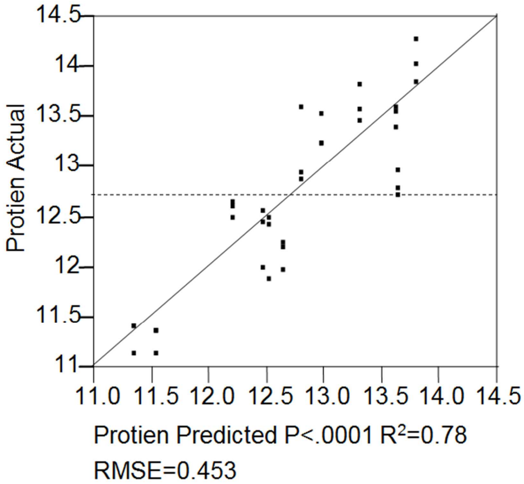
The optimum value (3.14 – 3.16%) of ash for the composite bread was obtained when the proportion of wheat lies between 70 – 80%, soybean 10 – 15% and tef 5 – 15%. Increasing the proportion of soybean in the blending ratio (5 – 15%) had increased the ash content from 2.94 to 3.29 of the blend bread. Maximum proportion of soybean and tef (15%) in the mixture had increased the level of ash content. Ash content indicates rough estimation of mineral content of the product [42] and this is reflected in the current work with soya and tef with higher contents of iron (10.69 – 11.85 mg $100g^{-1}$) and zinc (6.04 – 3.62 mg $100g^{-1}$) resulting in 2.94 – 3.29% ash.

4.2.3. Crude Protein Content

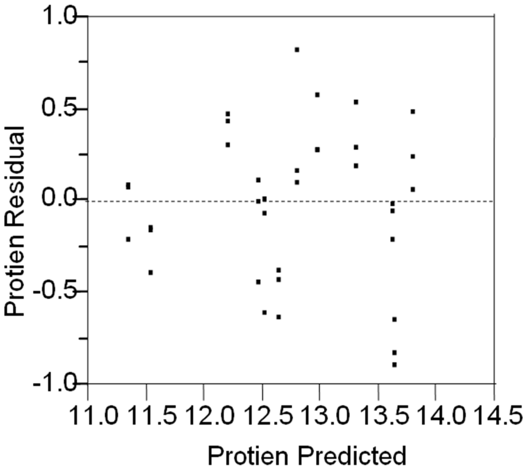
The protein content of the blend bread was significantly (P<0.0001) influenced by blending. The protein content of the blended bread ranged from 11.32-14.08% (Table 4). Bread of

80% wheat, 15% soybean and 5% tef flour had statistically the highest (14.08%) amount of crude protein. The lowest protein content (11.32%) in the blend was found to be when 90% wheat, 5% soybean and 5% tef flour were blended. Increasing the soybean in the blend had increased the protein content of the blend bread product. This is similar to the findings of [54], who reported that increasing the proportion of soybean flour from 0 to 20%, resulted in an increase of protein content from 9 to 14%.

All the blend breads contained significantly ($P<0.05$) higher amount of protein than the control bread sample because of high protein contents in the soybean. Baking temperature had significantly ($P<0.05$) increased the protein content of the blend bread. This is probably due to the degradation of soluble components and antinutritional factors which in turn raised the proportion of other components.



(a)



(b)

Figure 3. *Analyzed value versus predicted (a) and residual versus predicted (b) plot of protein content.*

4.2.4. Crude Fat Content

The combined effects of wheat, soybean and tef blended products on the crude protein content was significant ($P<0.0001$). The linear terms of wheat and baking temperature had significant effect ($P<0.0001$) on crude protein content of bread processed by blending. All the interaction terms and linear terms of soybean and tef showed no significant ($P>0.05$) effect on crude protein content of the blend bread. Increasing baking temperature from 190 and 220°C significantly ($P<0.05$) increased the protein content, but decreased afterwards increasing the temperature at 250°C. The increment of protein content during baking temperature is probably due to the degradation of soluble components and antinutritional factors [55]. The following model was developed to predict the crude protein content of the blend.

$$P=14.51W-72.39S-41.64t+122.23\ (W*S)+67.71\ (W*t)+191.45\ (S*t)-0.019T\ (R^2=0.78) \quad (4)$$

Where P is predicted crude protein (%), W=Wheat (%), S=Soybean (%), t=Tef (%), and T=baking temperature (°C)

The predicted values of protein were closely correlated with the experimental data as demonstrated by regression coefficient (R^2) values of 0.78 as shown in Figure 3a. The majority of the points were distributed nearby the diagonal line which indicated the goodness of fit of the model.

The plot of the residual versus predicted values of protein (Figure 3b) were randomly distributed about the zero value horizontal line on the vertical axis indicating that the model was adequate in describing the data.

The crude fat content of the blended bread was in the range of 2.31-5.12% (Table 4). The highest three values, 4.65, 4.87 and 5.12% with significant difference among them were obtained from the blends having 15% soybean. On the other hand, the least two values, 2.31 and 2.36%, with no statistical difference between them were obtained in breads with only 5% soybean blend in common. The association of the high fat in breads having the 15% soybean and the low fat to those with 5% soybean blends can be directly related to the high content (20.49%) of fat in the soybean seeds (Table 3). The crude fat content of the control samples was 1.81, 2.41 and 1.99% for 190, 220 and 250°C baking temperature, which were significantly ($P<0.05$) the lowest as compared to the blended products.

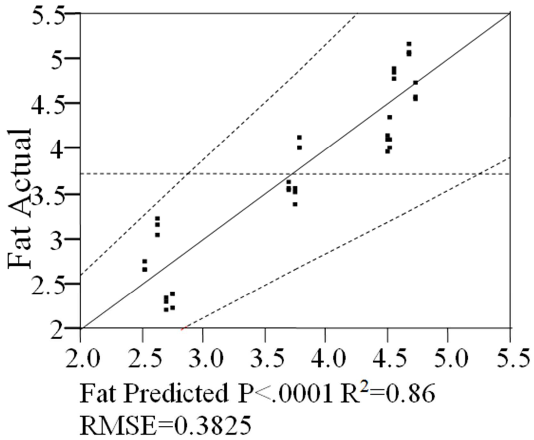
The combined effect of the blended product on the crude fat content was significant ($p<0.0001$). The linear term of wheat was significant ($P<0.05$) on fat content, whereas those of the soybean, tef, baking temperature and all the interactions were not significant ($P>0.05$) on the crude fat content. The crude fat content of wheat is lower than the raw tef and soybean flour. This was significantly ($P<0.05$) increase in the bread when it was blended with tef and soybean flour. The following model was developed to predict crude fat contents.

$$F=2.88W-4.48S+29.51t+29.34\ (W*S)-37.84\ (W*t)+19.43\ (S*t)+0.003T\ (R^2=0.86) \quad (5)$$

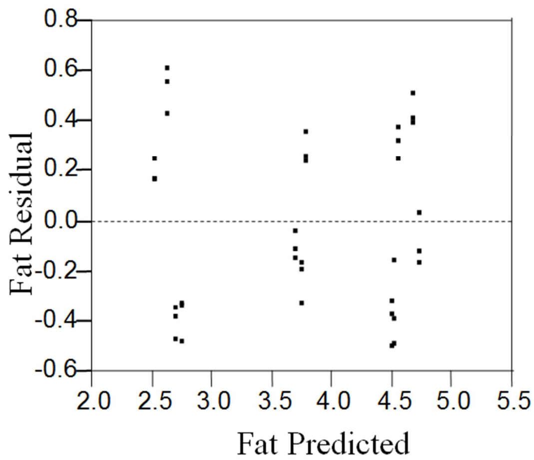
Where F is predicted fat (%), W=Wheat (%), S=Soybean (%), t=Tef (%), and T=baking temperature (°C)

The analyzed value versus predicted plot (Figure 4a) was randomly distributed nearby the diagonal line which indicates the goodness of fit of the model.

The residual versus predicted plot (Figure 4b) were randomly distributed over the zero valued horizontal line which indicates that the model was adequate in describing the data.



(a)



(b)

Figure 4. *Analyzed value versus predicted (a) and residual versus predicted (b) plot of fat content.*

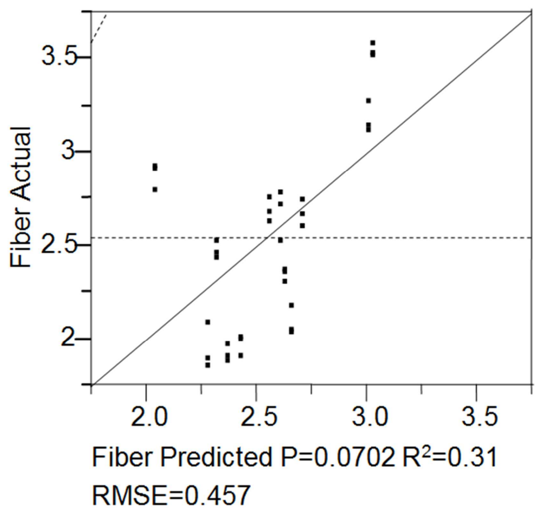
4.2.5. Crude Fibre Content

The crude fiber content of the bread processed by blending was significantly (P<0.05) affected by the blend soybean (Table 4) with values ranging from 1.93-3.56%. The highest two values, 3.19 and 3.56% with significant difference among them were obtained from the blends having 15% soybean. On the other hand, the least two values, 1.93 and 1.96%, with no statistical difference between them were obtained in breads with only 5 and 10% soybean blend in common. The association of the high fiber in breads having the 15% soybean and the low fiber to those with 5 and 10% soybean blends can be directly related to the high content (4.33%) of fiber in the soybean seeds (Table 3). The crude fiber content of the control samples was 2.16, 1.74 and 2.56% for 190, 220 and 250°C baking temperature, which were significantly (P<0.05) the lowest as compared to the blended products. Supplementation of wheat with soybean significantly increased the fiber content of the blend bread.

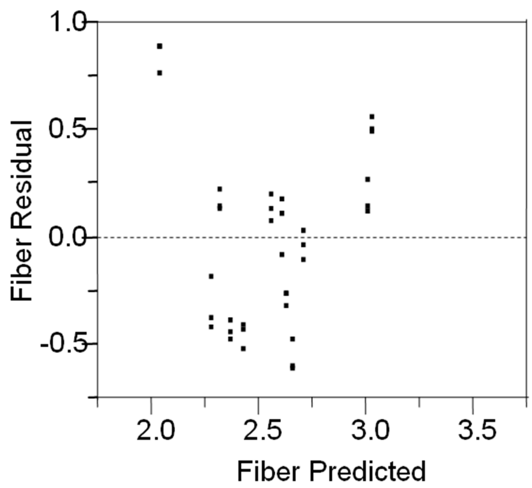
The combined effect of wheat, soybean and tef was significant (P<0.0702) on crude fiber content of the blend bread. All the linear and interaction terms were insignificant (P>0.05) on the crude fiber content of the blend bread. The following model was developed to predict crude fiber content of the blend bread.

$$CF=1.73W+81.33S+55.87t-92.52\,(W*S)-64.63\,(W*t)-174.83\,(S*t)+0.006T\ (R^2=0.31) \tag{6}$$

Where CF is predicted crude fiber (%), W=Wheat (%), S=Soybean (%), t=Tef (%), and T=baking temperature (°C)



(a)



(b)

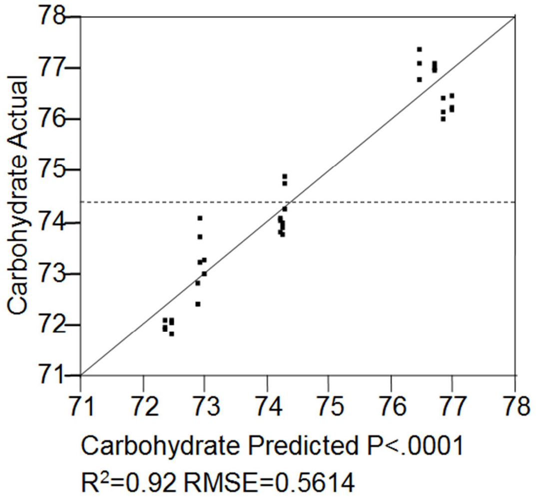
Figure 5. *Analyzed value versus predicted (a) and residual versus predicted (b) plot of crude fiber content.*

The plots of analyzed versus predicted values of fiber contents were presented in Figure 5a. The coefficient R^2 was 0.31. This implies that only 31% of the variations could be accounted by the fitted model and 69% of the total variation cannot be explained by the model.

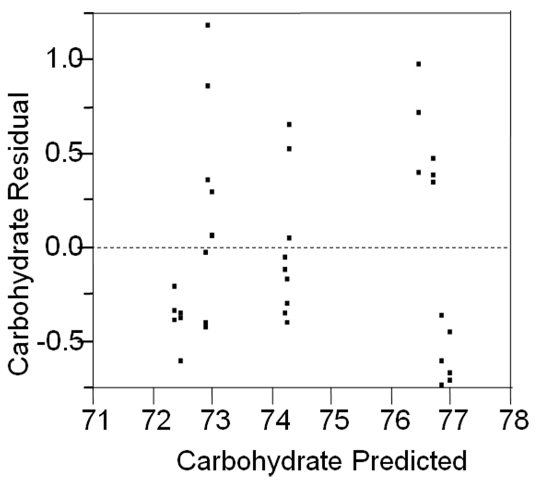
The residual by predicted plot is presented in Figure 5b. The points were randomly distributed about the zero value horizontal line which indicates that the model was adequate in describing the data.

4.2.6. Total Utilizable Carbohydrate

Blending has a significant ($P<0.05$) effect on the carbohydrate content of the bread processed (Table 4). The carbohydrate content of the bread ranged from 72.04 to 77.15%. The variations in carbohydrate content among the bread samples may result from the difference in the level of the same in the component materials. The lowest values (72.04%) of carbohydrate were obtained when 80% wheat, 15% soybean and 5% tef were blended and when 70% wheat and 15% each of soya and tef were combined. The highest value of carbohydrate content different from the control was obtained when 80% wheat, 5% soybean and 15% tef, and when 90% wheat, 5% soybean and 5% tef were blended. The control bread samples were of highest carbohydrate content relative to the blend breads. This may be directly related to the high carbohydrate content of the wheat as compared to tef and soybean.



(a)



(b)

Figure 6. *Analyzed value versus predicted (a) and residual versus predicted (b) plot of carbohydrate content.*

The combination of wheat, soybean and tef had a significant ($P<0.0001$) effect on the carbohydrate content of the blended bread. The linear terms of wheat, soybean and baking temperature had a significant ($P<0.05$) effect on the carbohydrate content of the blend bread. However, the linear term tef and all the interaction terms had no significant ($P>0.05$) effect on the carbohydrate content of the blend bread, which means most of the carbohydrate content was not obtained from tef. The following model was developed to predict the carbohydrate content.

$$CHO=76.49W+163.32S+0.05t-152.26\,(W*S)+101.48\,(W*t)-90.65\,(S*t)+0.008T\ (R^2=0.92) \quad (7)$$

Where: - CHO=predicted carbohydrate (%), W=Wheat (%), S=Soybean (%), t=Tef (%), and T=baking temperature (°C)

The predicted values of carbohydrate contents (Figure 6a) were correlated with the experimental data as demonstrated by regression coefficient ($R^2=0.92$). The residual versus predicted plot is presented in Figure (6b). The points were randomly distributed about the zero value horizontal line on the vertical axis. This indicates that the model was adequate in describing the data.

5. Conclusions

The supplementation of soybean and on cereals can improve the nutritional value of the food product. Supplementing soybean and tef to wheat increased moisture, ash, crude fat, crude fiber, crude protein of the blend bread product and decreased carbohydrate. The sensory evaluation showed that among the blended bread products improvements in sensory characteristics were obtained when the proportion of soybean and tef in the blend was in the range of 5 to 10%.

It was thus concluded that, proportion of wheat from 80 to 85%, soybean from 5 to 10% and tef from 5 to 10% were optimum levels for nutritional quality of the wheat based blend bread. An optimum mixing level is important in determining nutritional quality of products.

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