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# Physical properties and sensory characteristics of, Hulless Barley Flour fortified cookies, using response surface methodology (RSM) technique

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**Abstract**
The produced cookies' physical characteristics, including diameter, thickness, spread ratio, and weight ranged from 42.69 to 46.23 millimeters, 10.8 to 12.12 millimeters, 3.52 to 4.28 millimeters, and 11.42 to 14.28 g respectively. The regression model for the aforementioned physical characteristics was non-significant. Color, appearance, texture, taste, and general acceptability of the cookies were given sensory scores ranging from 6.25 to 8.75, 5.5 to 8.5, 6.15 to 8.5, 6.75 to 8.25, and 5.95 to 8.4 correspondingly. The findings of the regression model for the aforementioned sensory attributes were found to be 5% significant. The information revealed that the sensory qualities of the cookies were positively linearly significant as a function of the amount of barley flour used into the cookies. Hunter colour values of developed barley fortified cookies i.e., L*, a* and b* values ranged from 34.58 to 55.65, 9.86 to 12.02 and 13.88 to 30.2 respectively.

**Keywords:** Cookies, hullless barley, physical, sensor

## Introduction
Cookies, a type of confectionery product dried to low moisture content and popular among people of all ages, are the largest category of snack foods in most parts of the world according to Lorenz K (1983), [10] Around $1,825.00 billion is estimated to be the size of the global cookie market in 2016. Like many other developing nations, Nigeria is experiencing an expansion in urbanization, which along with the rise in working mothers has substantially influenced the popularity and consumption of snack foods like cookies and biscuits. The cookies are readily available, ready to eat, and are eaten all around the world. According to Arshad *et al.* (2007) [4], cookies are a fantastic option to substitute blended flour, making nutritional improvement simple and appropriate. Consuming whole cereals that are gluten-free, high in fiber, and high in protein has become more popular among consumers in recent years. As a result, a number of research have examined the use of composite flours made from cereal, pseudo cereals, and root crops as a substitute for wheat flour in the production of cookies and other useful items. The challenge is to attain acceptable physical and sensory features of the formed goods in addition to the benefits of these composite flours developed by Arshad *et al.* (2007) and Mc Watters *et al.* (2003) [4, 11].

## Material and methods
Physical parameters such as weight, diameter, thickness and spread ratio were determined using AACC (2000) [1]. All parameters were determined in five replications.

**Diameter:** Measured by vernier caliper and expressed in mm or diameter of cookies was measured by laying six cookies edge to edge with the help of a scale rotating them 90° and again measuring the diameter of six cookies (mm) and then taking average value.

**Thickness:** Measured by screw gauge and expressed in mm or thickness was measured by stacking six cookies on top of each other and taking average thickness (mm).

**Spread ratio (D/T):** Spread ratio was calculated by dividing the average value of diameter by average value of thickness of cookies.

**Weight:** Weight of cookies was determined by using weighing balance and expressed in g. as average.

**Sensory evaluation of developed Cookies**

**Measurement of colour and appearance:** The colour scanning machine (Model: Colour Flex EZ) was used for measurement of colour of crust and crumb of cookies. The colour was measured by using CIELAB (1976/D65) scale at 10 observers at D65 illuminate. The instrument was calibrated before placing the sample by placing black tile and white tile provided with the instrument. Once the instrument was standardized, it was ready to measure the colour of crust and crumb of cookies. It can also be crosschecked by placing the white tile which was provided for the L*, a*, b*, C* and H*values. The cookie was placed in sample cup. The deviation of the colour of the sample to standard was also observed and recorded in the computer interface. It provides readings in terms of L*, a*, b*, C* and H* where, L* indicate darker, a* indicate green, b* indicate yellow, C* indicate brighter and H* indicate hue.

**Textural analysis of cookies:** The cookies were analyzed for its penetration and cutting force using Texture analyzer (INSTRON). Penetration and cutting force max of the cookies were measured by triple beam 40 snap setup (Gaines, 1985). Load cell of 5 kg, 3 mm/s test speed and 5 mm travel distance were used. The sample was placed on two supporting beams a parted by 3 cm distance. The probe, TA-9 was programmed to travel a distance of 5 mm with a speed of 2 mm/sec with a normal cycle. Another beam connected to moving part was brought down to break down the cookies. Five samples from each type of cookies, fresh and stored were analyzed at 30 days interval (for 90 days). Mean value of three determinations was reported.

**Taste of developed Cookies:** A semi trained panel of 10 members was given samples of barley flour Cookies to evaluate the following sensory quality attributes *viz*., colour, taste, flavor, texture and overall acceptability score. A 9-point Hedonic scale (Appendix-I) was used as described in AACC (1967) [2]. The data were statistically analyzed by standard procedure as described by Meilgaard *et al.,* (2007).

**Result and discussion**

The use of barley flour and other ingredients in food products is currently of interest since consumers are more cognizant of nutrition. Hullless barley flour can improve the nutritional value of foods, especially baked items like cookies since it provides non-glutinous protein, carbs, and soluble fiber. The B-glucans molecule included in barley and wheat contributes to decreasing blood cholesterol levels because of its ability to bind two molecules of cholesterol. Cookies made with hull-free barley flour in this way can be successfully used to treat diabetics and those with cardiovascular diseases while postponing the onset of disease. Using hulless barley flour and refined wheat flour, experimental results on optimizing the amounts of baking materials for the production of cookies are justified in this chapter. The reported values of various parameters provided by various studies have been used to explain the results, and they are discussed as follows.

**Diameter**

According to Table 3, the diameter of the hulless barley biscuits reached its maximum in experiment 17 (46.23 mm) and its minimum in experiment 18 (42.69 mm). In these tests, the proportions of RWF: HBF, sugar, guar gum, and ammonium bicarbonate were 85:15, 35 g, 3.5 g, 3.5 g, and 75:25, 35 g, 3.5 g, 3.5 g, respectively. The table value of 2.38 is more than the model's F-ratio of 0.24 (Table 4.4). Model terms are considered significant when the P-value is less than 0.0500. The F-value for the lack of fit, 2.19, indicates that the lack of fit is not significant in comparison to the pure error. The model's $R^2$ score is 11.30 percent. As a result, the model is non-significant and could only account for 11.30 percent of the experiment's variability. The diameter of the cookies made with hulless barley flour increased significantly (p 0.05) for samples 18 and 17, going from 42.69 to 46.23 mm, respectively. This might be explained by how much fat was added to the flour mixtures when they were being made. Similar to this, Gernah *et al.* (2010) [7] observed a rising tendency for the diameter (38.90-40.20 mm) of cookies manufactured from wheat barley grain flour blends. The results, however, contradict the observation made by Abdul *et al.* (2015) [3] who claimed that cookies' width decreased as oat bran substitution levels increased.

**Thickness**

The thickness of the hulless barley biscuits was maximum (12.12 mm) in experiment 18 and minimum (10.8 mm) in experiment 17, according to a fast glance at table 3. In these tests, the proportions of RWF: HBF, sugar, guar gum, and ammonium bicarbonate were 75:25, 35 g, 3.5 g, 3.5 g, and 85:15, 35 g, 3.5 g, 3.5 g, respectively. The table value of 2.38 indicates that the model is significant, while the model F-ratio of 25.60 indicates otherwise. The model's $R^2$ score is 93.09 percent. As a result, the model is significant and could only account for 93.09 percent of the variability in the experiments. The regression model's coefficients, which are shown in table 4.3, showed that, at the 5% level of significance, the amount of barley flour had a positive linear significant effect on a particular cookie's thickness. Rests, all other model factors were not significant even at a 10% level. The diameter of the cookies changed depending on the ingredients and how they were combined, ranging from 11.2 to 12.3. The thickness of cookies is significantly positively affected linearly by the graded amounts of hulless barley flour. In a similar vein, Hooda and Jood (2005) [9], Sharma and Chauhan (2002) [13], and Hooda and Jood (2005) [9] all found that the thickness of cookies changed while they baked.

**Spread Ratio (D/T)**

In experiment 17, the hulless barley flour cookies' spread ratio was at its highest (4.28), while in experiment 18, it was at its lowest (3.52) (Table 1). In these studies, the ratios of RWF: HBF, sugar, guar gum, and ammonium bicarbonate were 85:15, 35 g, 3.5 g, 3.5 g, and 75:25, 35 g, 3.5 g, 3.5 g, respectively. The table value, 2.38, is higher than the model F-value of 0.79, indicating that the model is not significant. The model's $R^2$ score is 29.42 percent. The results show that the model is non-significant and could only account for 29.42% of the variability in the experiments. The spread ratio of the cookies ranged between 3.52 and 4.28; cookie experiment 17 had the highest spread ratio value, while the experiment 18 had the least. A similar finding was observed by Giwa and Abiodun (2010) [8].

**Weight**

According to Table 1, the weight of the cookies made with hulless barley flour was highest in experiment 18 (14.25 g)

and lowest in experiment 17 (11.42 g), corresponding to ingredient ratios of 75:25, 35 g, 3.5 g, 3.5 g, and 85:15, 35 g, 3.5 g, 3.5 g of RWF: HBF, sugar, guar gum, and ammonium bicarbonate, respectively. The Model (ANOVA Table 3) shows that the F-ratio is more than the table value, or 2.38, with a value of 30.66. Additionally, the model's $R^2$ score is 94.16 percent. The results showed that the model is substantial and that it can account for 94.16 percent of the variability in the experiments. The regression model's coefficients, which are shown in Table 2, showed that, at the 5% level of significance, barley flour levels had a positive linear significant effect on cookie weight. Even at a 10% threshold of significance, the remaining model terms were all non-significant. The cookies ranged in weight from 11.42 to 14.28 g, with sample 18 being the heaviest and bulkiest while sample 17 was the lightest. The weight of the cookies decreased significantly by 5% after the addition of hulless barley flour. The results were at odds with some researchers' observations, who noted a considerable decrease in the weight of cookies made from soya beans and wheat flour (Ayo *et al.*, 2007) [5].

**Table 1:** Physical properties of hulless barley flour cookies

| Experiment | Diameter (mm) | Thickness (mm) | Spread Ratio (D/T) | Weight (g) |
|---|---|---|---|---|
| 1 | 46.02 | 11.51 | 3.99 | 11.83 |
| 2 | 45.18 | 12.1 | 3.95 | 13.87 |
| 3 | 45.7 | 11.56 | 3.98 | 11.83 |
| 4 | 45.82 | 11.98 | 4.10 | 13.87 |
| 5 | 45.28 | 11.5 | 3.93 | 12.24 |
| 6 | 45.59 | 12.12 | 4.01 | 13.46 |
| 7 | 45.62 | 11.45 | 3.98 | 12.24 |
| 8 | 45.45 | 12.18 | 3.95 | 13.46 |
| 9 | 45.39 | 11.55 | 3.93 | 12.24 |
| 10 | 44.93 | 12.1 | 3.98 | 13.46 |
| 11 | 45.3 | 11.6 | 3.91 | 11.83 |
| 12 | 45.75 | 12.2 | 3.95 | 13.46 |
| 13 | 45.9 | 11.56 | 3.94 | 11.83 |
| 14 | 45.92 | 12.15 | 4.00 | 13.46 |
| 15 | 46.22 | 11.57 | 4.03 | 11.83 |
| 16 | 44.85 | 12.2 | 3.83 | 13.46 |
| 17 | 46.23 | 11.2 | 4.28 | 11.42 |
| 18 | 42.69 | 12.3 | 3.52 | 14.28 |
| 19 | 43.72 | 11.8 | 3.62 | 12.65 |
| 20 | 43.36 | 11.92 | 3.61 | 12.65 |
| 21 | 42.19 | 11.89 | 3.56 | 13.06 |
| 22 | 44.26 | 11.9 | 3.67 | 12.65 |
| 23 | 44.15 | 11.82 | 3.76 | 13.06 |
| 24 | 42.68 | 11.97 | 3.71 | 13.06 |
| 25 | 44.01 | 11.82 | 3.68 | 13.06 |
| 26 | 45.12 | 11.96 | 3.74 | 12.65 |
| 27 | 43.06 | 11.95 | 3.61 | 12.65 |
| 28 | 42.63 | 11.95 | 3.61 | 13.06 |
| 29 | 44.24 | 11.89 | 3.67 | 12.65 |
| 30 | 42.28 | 12.1 | 3.60 | 13.06 |

**Table 2:** Regression coefficient of two factor interaction model and significant terms for physical properties of developed hulless barley cookies

| Coefficient | Diameter (mm) | Thickness (mm) | Spread Ratio (D/T) | Weight (g) |
|---|---|---|---|---|
| **Intercept** | 6.68 | 3.44 | 1.94 | 3.58 |
| **Linear** | | | | |
| β1 A | -0.0281 | 0.0420* | -0.0148 | **0.1070*** |
| β2 B | -0.0007 | 0.0024 | -0.0008 | -0.0025 |
| β3 C | 0.0154 | 0.0009 | -0.0088 | -0.0069 |
| β4 D | 0.0106 | 0.0050 | 0.0098 | -0.0071 |
| **Interactive** | | | | |
| β 1.2 AB | 3.587E-06 | 0.0003 | 0.0057 | 0.0037 |
| β 1.3 AC | -0.0022 | 0.0037 | 0.0084 | -0.0106 |
| β 1.4 AD | -0.0036 | 0.0000 | -0.0100 | -0.0032 |
| β2.3 BC | -0.0074 | -0.0001 | 0.0008 | 0.0037 |
| β2.4 BD | -0.0025 | 0.0024 | -0.0100 | -0.0037 |
| β 3.4 CD | 0.0106 | -0.0006 | 0.0056 | -0.0041 |

**Significant at 1%; *Significant at 5%; A- Hulless Barley flour; B -Sugar; C-Guar gum; D-Ammonium bicarbonate

**Table 3:** ANOVA of two factor interaction model for Physical properties of developed hulless barley cookies

| Source | Diameter (mm) | Thickness (mm) | Spread Ratio (D/T) | Weight (g) |
|---|---|---|---|---|
| Model SS | 0.0304 | 0.0435 | 0.0258 | 0.2800 |
| Model MS | 0.0030 | 0.0043 | 0.0026 | 0.0280 |
| Model DF | 10 | 10 | 10 | 10 |
| Error SS | 0.0335 | 0.0009 | 0.009 | 0.0049 |
| Error MS | 0.0067 | 0.0002 | 0.0018 | 0.0010 |
| Error DF | 5 | 5 | 5 | 5 |
| F ratio | 0.2421 | 25.60 | 0.7922 | 30.66 |
| F table | 2.38 | 2.38 | 2.38 | 2.38 |
| R Square | 0.1130 | 0.9309 | 0.2942 | 0.9416 |
| Std dev. | 0.1121 | 0.0130 | 0.0571 | 0.0302 |
| Mean | 6.68 | 3.44 | 2.51 | 3.58 |
| C.V. | 1.68 | 0.3783 | 2.28 | 0.8446 |

MS: Mean square; SS: Sum of squares; DF: Degree of freedom; STD Dev: Standard deviation

**Sensory Characteristics of developed cookies**

The results of the sensory assessment of cookies developed from refined wheat flour and hulless barley flour blends are presented in Table 4. Sensory evaluation of developed cookies was conducted on a nine-point hedonic rating scale ranging from "Extremely like" on point 9 to "Extremely dislike" on point. Colour & Appearance, Taste, Texture, and Overall Acceptability were the sensory evaluation characteristics evaluated. Each sample was judged independently by the panel members.

For all 5 sensory qualities, cookies having the highest percentage of barley (i.e., 45%) received the lowest marks. All five of the sensory attributes exhibited a declining trend as the amount of hulless barley flour in the cookies increased. The color rating for cookies made with hulless barley flour ranged from 5.5 to 8.75. At the 5% level of significance, the amounts of hulless barley flour had a positive linear significant color of cookies. Hullless barley flour cookies received sensory scores ranging from 6.25 to 8.5 for color, appearance, texture, taste, and overall acceptability, respectively. The regression model's findings for the aforementioned sensory qualities were considered significant. The findings suggest that levels of barley flour had a positive linear significant effect on colour, appearance, texture, Taste and overall acceptability sensory score of barley flour cookies. The effect of sugar and improver levels was also observed significant in linear term for colour score of barley flour cookies.

The results are in accordance with the findings of Tsuji, Kimoto, and Natori (2001) who observed that darker colour of cookies may be due to the non-enzymatic reaction (Maillard reaction) between reducing sugar molecules and lysine protein. Also, Sudha, Baskaran, and Leela-Vathi (2006) [14] stated that darker colours are generally associated with enriched high fibre biscuits.

**Colour and Appearance**

Table 4's color and appearance scores dramatically enhanced from 6.25 to 8.75 and 5.5 to 8.5, respectively, as the proportion of refined wheat flour made from hulless barley was reduced. In general, cookies made with 85 percent refined wheat flour and 15 percent malted barley flour scored the highest (8.75 and 8.5), while those made with 25 percent wheat flour and 75 percent malted barley flour scored the lowest (6.25 and 5.5). In these studies, the proportions of the ingredients were 85:15, 35 g, 3.5g, 3.5 g of composite flour (RWF: HBF), sugar, guar gum, and ammonium bicarbonate, and 75:25, 35 g, 3.5g, 3.5 g, respectively.

According to Anova Table 6, the F-ratio (3.11 and 4.67) is greater than the Table value of 2.76. The R2 value of the model is 33.21 and 42.78%, indicating that it was significant and could account for the variability in these experiments that was 33.21 and 42.78%.

At a 5% level of significance, Table 5 shows that amounts of hulless barley flour had a positive linear significant effect on the color and look of cookies. Even at a 10% level of confidence, the rest of the model's terms were found to be non-significant.

**Texture score**

Texture score as represented by table 4 showed significantly increased score from (6.75) in experiment 18 to (8.25) in experiment 17 with decrease in hulless barley flour ratio in subsequent refined wheat flour. These experiments represented the combination of ingredients as 75:25, 35 g, 3.5 g, 3.5 g and 85:15, 35 g, 3.5 g, 3.5 g of RWF: HBF, sugar, guar gum, and ammonium bicarbonate respectively.

The Anova Table 6 indicates that the F-ratio (7.74) is higher as compared to Table value of 2.76. The model's $R^2$ score is 55.32 percent, indicating that it was significant and that it could account for 55.32 percent of the experimental variability. At a 5% level of significance, Table 4.6 shows that the amount of hulless barley flour had a positive linear significant effect on the texture of cookies. Even at a 10% level of confidence, the model's remaining terms were all found to be non-significant.

**Taste score**

The taste rating shown in table 4 dramatically increased from (6.15) in experiment 18 to (8.5) in experiment 17, while the amount of hulless barley flour in the finished cookies decreased. In these studies, the proportions of RWF: HBF, sugar, guar gum, and ammonium bicarbonate were 75:25, 35 g, 3.5 g, 3.5 g, and 85:15, 35 g, 3.5 g, 3.5 g, respectively.

The F-ratio (4.08) was greater than the Table value of 2.76, according to ANOVA Table 6's results. The model's R2 score is 39.48 percent. The results show that the model was significant and could account for 39.48 percent of the experiment's variability. According to Table 4.6, at a 5% level of significance, the amount of hulless barley flour had a positive linear significant effect on the flavor of cookies. Even at a 10% level of confidence, the model's remaining terms were all found to be non-significant.

**Overall Acceptability**

The overall Acceptability score of the created cookies is

shown in Table 4, which considerably improved from 5.95 in experiment 18 to 8.4 in experiment 17. In these tests, the proportions of RWF: HBF, sugar, guar gum, and ammonium bicarbonate were 75:25, 35 g, 3.5g, 3.5 g, and 85:15, 35 g, 3.5 g, 3.5 g, respectively.

According to Anova Table 6, the F-ratio (7.59) was greater than the table value of 2.76. The R2 score for the model was 54.85%. The results showed that the model was significant and that it could account for 54.85% of the experimental variability. According to Table 4.6, barley flour levels showed a positive linear significant effect on cookie flavor at the 5% level of significance. Even at a 10% level of confidence, the remaining model terms were found to be non-significant.

**Table 4:** Sensory characteristics of developed cookies using hedonic rating scale

| Exp. No. | Colour | Appearance | Texture | Taste | Overall Acceptability |
|---|---|---|---|---|---|
| 1 | 7.75 | 8.25 | 8.25 | 8 | 8 |
| 2 | 7.25 | 7.45 | 7.25 | 7.5 | 7.45 |
| 3 | 7.6 | 8 | 7.75 | 7.75 | 7.7 |
| 4 | 7.75 | 7.75 | 7 | 7.5 | 7.45 |
| 5 | 7.75 | 8.25 | 7.75 | 7.75 | 7.85 |
| 6 | 7 | 7.25 | 7.75 | 6.75 | 7.15 |
| 7 | 7.75 | 7.25 | 7.75 | 7.75 | 7.65 |
| 8 | 7.25 | 7.75 | 7 | 7.75 | 7.4 |
| 9 | 7.75 | 8.25 | 7.75 | 7.25 | 7.65 |
| 10 | 7.75 | 7.75 | 7.25 | 7 | 7.4 |
| 11 | 8 | 7.25 | 7.75 | 7.75 | 7.7 |
| 12 | 8 | 7.25 | 7.75 | 7 | 7.4 |
| 13 | 8 | 7.75 | 7.75 | 7.75 | 7.7 |
| 14 | 7.75 | 7.5 | 7.25 | 7.5 | 7.45 |
| 15 | 7.25 | 8 | 7.25 | 8 | 7.65 |
| 16 | 7 | 7 | 7 | 7.75 | 7.2 |
| 17 | 8.75 | 8.5 | 8.5 | 8.25 | 8.4 |
| 18 | 6.25 | 5.5 | 6.15 | 6.75 | 5.95 |
| 19 | 7.5 | 7.75 | 7 | 8 | 7.5 |
| 20 | 7.95 | 8.25 | 7.5 | 8 | 8.25 |
| 21 | 7.25 | 7.75 | 7.75 | 7 | 7.4 |
| 22 | 7.75 | 7 | 7.25 | 7 | 7.25 |
| 23 | 8 | 7.75 | 7.25 | 7.5 | 7.65 |
| 24 | 8 | 7.75 | 7.5 | 7.75 | 7.65 |
| 25 | 7 | 8 | 7 | 7.75 | 7.45 |
| 26 | 7 | 8 | 7.25 | 7.75 | 7.5 |
| 27 | 7.75 | 7.5 | 7.25 | 8 | 7.7 |
| 28 | 7 | 7.25 | 7.25 | 7.5 | 7.3 |
| 29 | 8 | 7.25 | 7 | 7.25 | 7.25 |
| 30 | 7.75 | 7.5 | 7.5 | 7.4 | 7.55 |

**Table 5:** Regression coefficient of two factor interaction model and significant terms for sensory characteristics of developed hulless barley cookies

| Coefficient | Colour | Appearance | Texture | Taste | Overall Acceptability |
|---|---|---|---|---|---|
| Intercept | 2.75 | 2.76 | 2.72 | 2.75 | 2.74 |
| **Linear** | | | | | |
| β1 A | -0.0542* | -0.0722* | -0.0649* | -0.0477* | -0.0610* |
| β2 B | 0.0037 | -0.0092 | -0.0056 | 0.0134 | 0.0074 |
| β3 C | -0.0084 | 0.0206 | -0.0170 | 0.0095 | -0.0077 |
| β4 D | 0.0105 | -0.0091 | -0.0017 | -0.0019 | -0.0037 |

**Significant at 1%; *Significant at 5%; A- Hulless Barley flour; B -Sugar; C-Guar gum; D-Ammonium bicarbonate

**Table 6:** ANOVA of two factor interaction model for sensory characteristics of hulless barley cookies

| Source | Colour | Appearance | Texture | Taste | Overall Acceptability |
|---|---|---|---|---|---|
| Model SS | 0.0752 | 0.1392 | 0.1087 | 0.0611 | 0.0924 |
| Model MS | 0.0188 | 0.0348 | 0.0272 | 0.0153 | 0.0893 |
| Model DF | 4 | 4 | 4 | 4 | 4 |
| Error SS | 0.0364 | 0.0191 | 0.0061 | 0.0124 | 0.0046 |
| Error MS | 0.0073 | 0.0038 | 0.0012 | 0.0025 | 0.0009 |
| Error DF | 5 | 5 | 5 | 5 | 5 |
| F ratio | 3.11 | 4.67 | 7.74 | 4.08 | 7.59 |
| F table | 2.76 | 2.76 | 2.76 | 2.76 | 2.76 |
| R Square | 0.3321 | 0.4278 | 0.5532 | 0.3948 | 0.5485 |
| Std dev. | 0.0778 | 0.0863 | 0.0593 | 0.0612 | 0.0551 |
| Mean | 2.75 | 2.76 | 2.72 | 2.75 | 2.74 |
| C.V. % | 2.83 | 3.13 | 2.18 | 2.23 | 2.01 |

MS: Mean square; SS: Sum of squares; DF: Degree of freedom; Std dev.: Standard deviation

**References**


1. AACC. Official Methods of Analysis of AACC International, American Association of Cereal Chemists, Washington, District of Columbia; c2000.
2. AACC. Approved Method of American Association of Cereal Chemists. Cereal Laboratory Methods, St. Paul, Minnesota; c1967.
3. Abdul WK, Javid A, Tariq M, Muhammad A, Mohammad P, Said H. Effect of oat bran on the quality of enriched high fiber biscuits. World Journal of Dairy and Food Sciences. 2015;10:68-73.
4. Arshad MU, Anjum FM, Zahoor T. Nutritional assessment of cookies supplemented with defatted wheat germ. Food Chemistry. 2007;102:123-128.
5. Ayo JA, Ayo VA, Nkama I, Adeworie R. Physio-chemical, *in vitro* digestibility and organoleptic evaluation of acha-wheat biscuit supplemented with soybean flour. Nigerian Food Journal. 2007;25:15-17.
6. Gaines P, Donelson J. Evaluating cookie spread potential of whole wheat flours from soft wheat cultivars. J. of Cereal Chem. 1985;62:134-136.
7. Gernah DI, Senger IA, Audu JO. Physicochemical and sensory evaluation of cookies produced from wheat and brewers spent grain composite flour. Nigerian Food Journal. 2010;28:440-447.
8. Giwa EO, Abiodun IV. Quality characteristics of biscuits produced from composite flours of wheat and quality protein maize. African Journal Food Science. 2010;1:116-119.
9. Hooda S, Jood S. Organoleptic and nutritional evaluation of wheat biscuits supplements with untreated and treated fenugreek flour. Food Chem. 2005;90:427-435.
10. Lorenz K. Protein fortification of Biscuits. Cereal Foods World. 1983;28:449-452.
11. McWatters KH, Ouedraogo JB, Resurreccion AVA, Hung YC, Phillips RD. Physical and sensory characteristics of sugar cookies containing mixtures of wheat, fonio (*Digitaria exilis*) and cowpea (*Vigna Unguiculata*) flours. International Journal of Food Science and Technology. 2003;38:403-410.
12. Okaka JC. Handling, storage and processing of plant foods. Academy publishers Enugu, Nigeria; c2009. p. 132.
13. Sharma HR, Chauhan GS. Effects of Stabilized Rice Bran: Fenugreek Blend on the Quality of Breads and Cookies. Journal of Food Technology. 2002;39:225-233.
14. Sudha ML, Vetrimani R, Leelavathi KL. Influence of fibre from different cereals on the rheological characteristics of wheat flour dough and on biscuit quality. Baking and Confectionery Technology Department, CFTRI, Mysore; c2006.