CHAPTER IV

RESULTS AND DISCUSSION

4.1 Gluten Content

The percentage of wet gluten content of the control and other flours is presented in Table 3. The range of gluten content was from 11.58 to 18.88%. The highest wet gluten was present in sample C, while the lowest gluten content was present in the control sample D. The flour samples A, B, and C were all better than the control sample D, in term of gluten content. The average percentages of gluten for three samples (flour A, B, C) were 17.87%, 15.58%, 18.88%, respectively. All the flour samples were significantly different ($p < 0.05$) from each other. Flour samples in this study were high gluten flour, but sample C has the highest gluten content.

The results obtained in this study were comparable to the result obtained by Malomo et al. (2011). The results in their work varied between 14.00 and 18.30%. In this study, the highest wet gluten was present in sample C which was almost the same as the highest value obtained by Malomo et al. (2011). The lowest value was present in D, the control sample (11.58%), and this was lower than the value obtained by Malomo et (2011). The variation was ascribed to the genotype and difference in growing conditions of the wheat used to produce the flour (Wieser and Kieffer, 1999). Accordingly, the levels of the gluten contents were closely associated with protein levels of the breads (Malomo et al., 2011).

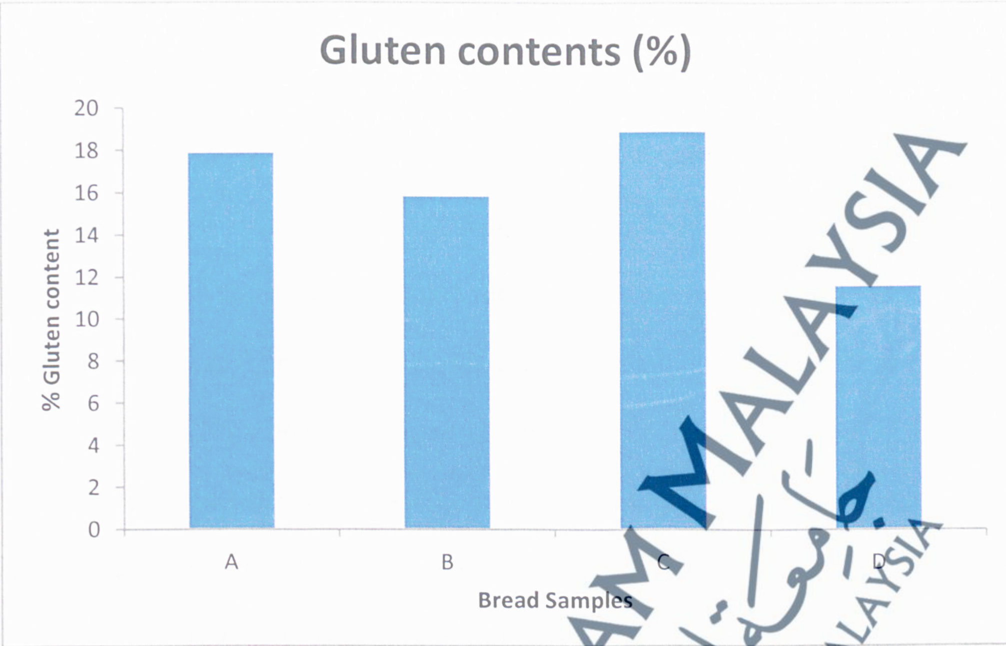


Figure 7: Percentage of gluten contents

According to Saleh and Brennan, (2012) and Dijana et al. (2009), it is assumed that storage and growing conditions during cultivation of the wheat has impact on the gluten quantity. Past research works have also proved this statement to be true. The difference of gluten content in flours is assumed to have a slight contribution to protein content in final product, bread. Good quality wheat flour has a very strong gluten yield which plays a significant role in the end product (Ames et al., 2003; Edward et al., 2003).

It was recognized that quantity and quality of gluten have a fundamental significance in bread making performance of wheat flour (He and Hosseney, 1991; Jan et al., 1995). Wadhawann and Bushuk (1989) reported that gluten is used for its capability to increase volume and improve bread crumb and texture.

4.2 Physical analysis of bread

4.2.1. Cell Structure

Carbon dioxide (CO_2) gas which is produced by the leavening agent spreads in dough. As a result, gas cell is formed and the density of the dough is reduced (Scanlon and Zghal, 2001). When the bread is put into the oven, the gas bubbles are trying to escape from the intense heat. The structure of the crumb is maintained by columns of cooked dough, not only by trapped gas. These columns formed because some of the gluten stands clumped together (Wing and Scott, 1999). The gluten network formed to trap gas during swelling of the dough. Furthermore pores are created for moisture migration (Rosell et al., 2009). Olinda et al. (2004) indicated that different concentration levels of gluten influence bread quality which included crumb's characteristics.

Figure 8: Cell structure and appearance of bread A

Comparing the structure of four breads (Figure 8-11), it can be seen that all of them contain various size of isolated cells. The largest cell around two centimeter was observed in bread B (Figure 9), located in upper side of crumb, closed to its crust. This happened when the CO_2 gas produced by natural leavening agent, trying to escape the crumb but failed during baking process. The highest amount of cells can be seen in bread D (Figure 11). Although all breads showed different final shapes, but their cell sizes are considered about the same, where each bread contain small and large cells arrangement, distributed in various unique ways.

Figure 9: Cell structure and appearance of bread B

Figure 10: Cell structure and appearance of bread C

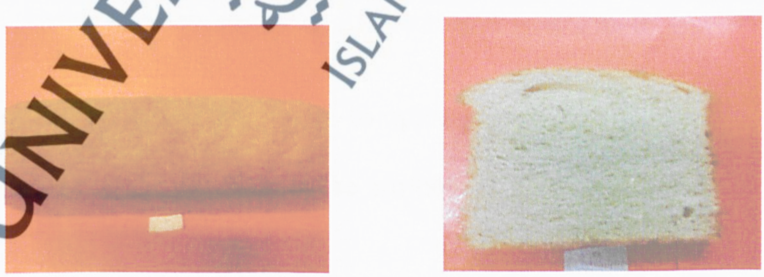


Figure 11: Cell structure and appearance of bread D

It is a mutual agreement that good quality bread should possess a high porosity and fine, regular gas cell structure in the crumb (Liu and Scanlon, 2003; Van Vliet, 1999; Lassoued et al., 2008). Grain characteristics are even more important in bread crumbs because grain attributes act a key role in bread acceptability (Collar et al., 2005). All the bread samples showed a more opened crumb structure but it was more pronounced in bread sample C (Figure 9).

4.3.2 Crust Colour test

The colour of the bread crust was measured using hunter labscan XE. Color values were recorded as "L" (0, black; 100, white), "a" (-a, greenness, $^{+}$a, redness) and" b" (b^{-}, blueness, b^{+}, yellowness). The colour value average was calculated and presented in Table 3.

Table 3: Colour analysis of bread samples

Samples	L*	a*	b*	L	a	b	DE*
A	54.11^{c}	10.21^{ab}	24.84^{b}	47.01^{c}	7.91^{b}	15.77^{a}	60.27^{b}
B	56.44^{b}	9.96^{b}	24.70^{b}	49.34^{b}	8.31^{b}	15.84^{a}	60.99^{b}
C	61.24^{a}	11.81^{a}	27.22^{a}	54.30^{a}	9.73^{a}	15.81^{a}	66.80^{a}
D	54.78^{bc}	9.55^{b}	24.51^{b}	46.67^{c}	8.24^{b}	16.44^{a}	60.27^{b}

*Means in columns with different superscripts differ ($p < 0.05$)

Concerning the colour of the bread samples, significant differences were detected among most of the samples except the attribute "b" which denotes the yellowness of the bread samples.

From Table 4 and Figure 12, it was observed that sample C had the highest value of L (54.30). This could be attributed to its high gluten content (18.88%). Al-Saleh and

Brennan (2012) reported that in their study of bread wheat quality that bright colour in bread is likely related to its high protein (gluten) content. The results in this study agreed with their findings. As reported by Du and Sun, 2004, Papadakis et al., 2000 and Mendoza et al., 2006; colour is regarded as a fundamental physical property of the bread. They stated that it has been generally proven that the colour correlates well with other physical and sensory indictors of bread quality. It was revealed that the bread samples tend to be yellow in colour. The sample with the highest value of yellow was sample D. This was as a result of the baking technique or the constituents of the flour. The red colour ("a") in bread could be traced to the presence of visible brownish bran particles in the flour (Alessandro and Concha, 2009).

The positive correlation between "L" and protein content in their work was also observed in this study. The redness values "a" did not show significant difference among samples A, B and D; only the bread sample C was significantly different from other samples. This was due to the constituents of the flour sample used for the bread (Alessandro and Concha, 2009). There was no significant difference in "b" values of the samples. This was in contrary to findings of Al-Saleh and Brennan (2012), who observed significant difference in "b" values of the samples. The difference was due to the growing conditions genotype and pigments of the wheat (Al-Saleh and Brennan 2012). A negative correlation between yellowness and ash was observed in this study, also observed by Al-Saleh and Brennan (2012).

The "L" values obtained in this study were lower to the values obtained by Al-Saleh and Brennan (2012). The values in their study ranged between 89.93 and 92.97. The "L" values in this study ranged from 46.67 to 54.30. Sample C was lighter in colour as shown by higher "L" value than other bread formulations. The values observed in this research were due to the Maillard reaction, browning and caramelization which were affected by the distribution of water and the reaction between amino acids and reducing sugars (Siddiq et al., 2009). Sample A had the lowest value of "a" which means that its crust colour was greener when compared to other samples' crust colour. The same observation was found in "b" values. The values of "a" and "b" ranged from 7.91 to 9.73 and 15.77 to 16.44 respectively.

In contrast, "b" value showed no a significant difference among all crusts. The average percentages of bread samples A, B, C and D were 15.77, 15.84, 15.81 and 16.44, respectively. Bread D had the highest "b" value (16.44), which indicates its crust colour was more bend to yellowness.

Wing and Scott (1999) stated that there three major colours for bread, these are brown, tan and dark brown. All the bread samples were brown in colour, the brown crust colour of the bread samples were formed as a result of heat-driven chemical reaction catalysed by acid produced during dough fermentation (Wing and Scott, 1999).

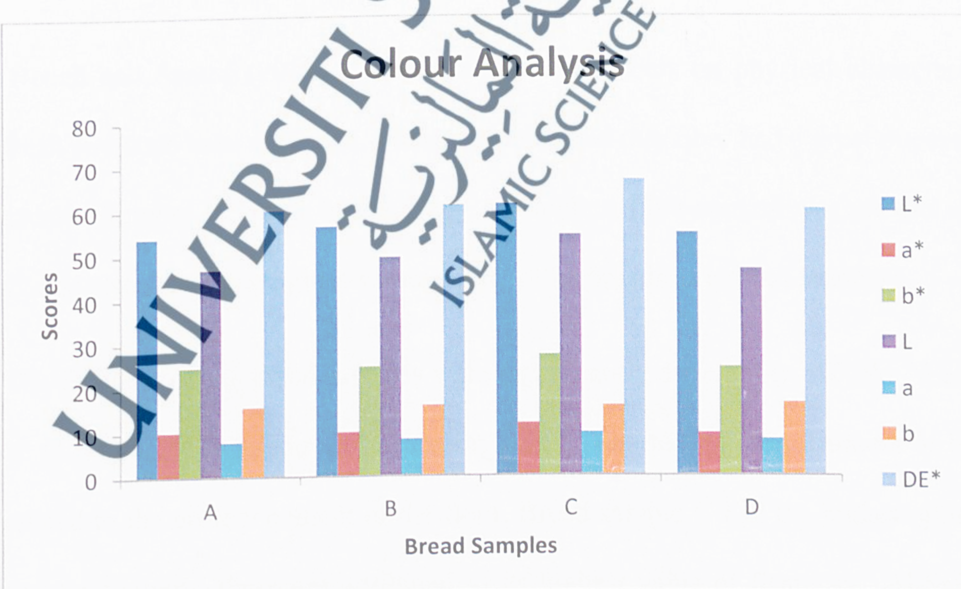


Figure 12: Colour analysis of the bread samples

4.3.3 Texture Analysis

Firmness is an important characteristic, and it is commonly used as index to determine bread quality, as change in firmness is frequently accompanied with loss of resilience during storage (Wang et al., 2007). The averages of energy force for all bread samples are presented in Table 4.

Table 4: Energy force (firmness) for control and other bread samples

	Samples			
Firmness (g)	A	B	C	D
	79.28^{c}	119.40^{ab}	142.79^{a}	88.44^{bc}

Means that do not share a letter are significantly different. (Tukey's HSD, P< 0.05).

From the Table 4, the trend of the firmness ranged between 79.28 to 142.79g. Statistical analysis showed that there were significant differences among all the samples in term of firmness.

Rosell and Santos (2010) studied on impact of fibers on physical characteristic of fresh and stale bake off bread. Their study showed that fiber had a great impact on the crumb firmness of bread. In this study, the highest fibre content was present in bread C, and also it had the highest value among other breads in term of firmness.

The firmness of the bread samples were significantly different ($p < 0.05$). Weegels et al. (1996) and Johansson and Svensson (1998) reported that the firmness of bread is related to the protein content of the flour. Bread sample C had the highest gluten and protein contents; these are attributed to its highest value of firmness. Al-Saleh and Brennan (2012); obtained the values of firmness that were higher than the levels obtained in this work. The values in their work ranged from 498.04 to 965.90g. The values obtained in this study were not as high as those obtained by Al-Saleh and Brennan (2012), possibly because of different sample of flours and baking methods. There was a relationship between protein contents and firmness. These results are in general agreement with several studies emphasized the close association between bread-making quality of the wheat flour and the flour protein content (Sapirstein et al., 2007; Huebner et al., 1999; Borghi et al., 1995; Randall and Moss, 1990).

Alessandro and Concha (2009) stated that textural attributes are vital characteristics that consumers appreciate in bread. Crumb freshness is related to its specific structure and, mainly with the mechanical properties of the cell walls that form the air cells in bread (Ponte and Ovadia, 1996; Liu and Scanlon, 2003; Liu and Scanlon, 2004). The bread samples had good firmness as a result of their not too high firmness values as shown in Table 4 and Figure 13.

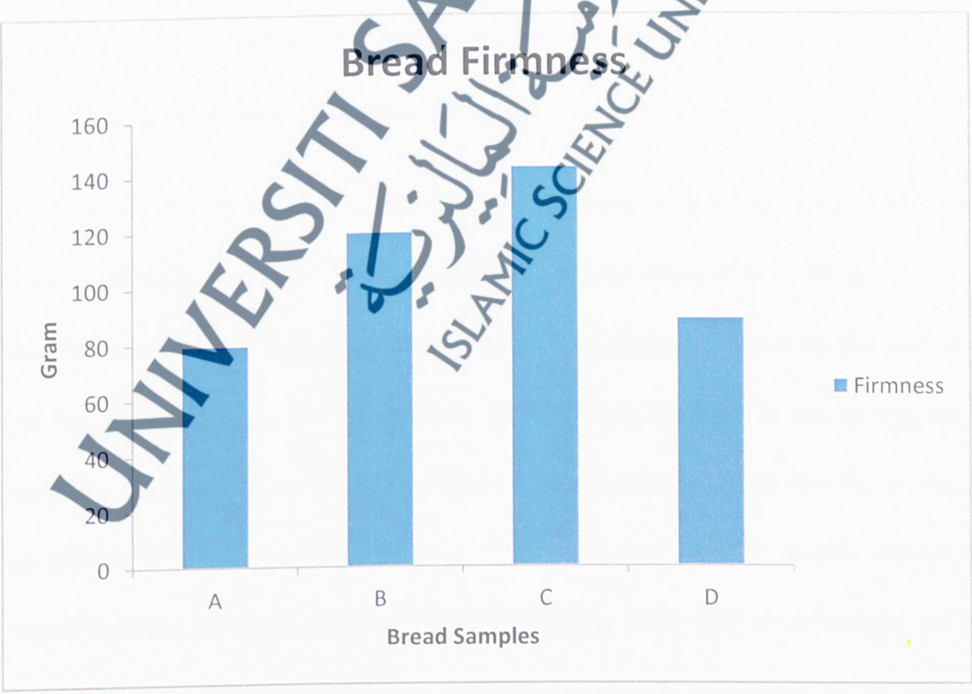


Figure 13: Firmness of the bread samples

4.3.4 Bread height and weight

From Table 5 and Figure 14, the weight of breads ranged between 806.00g to 819.70g. While for height, it ranged from 9.83cm to 13.43cm. When ANOVA was carried out to test the significance difference between bread samples, all samples showed no significant difference except bread A for the weight. Loaf weight reduction during baking is an undesirable quality attribute as consumers are often attracted to bread with high weight and volume believing that it has more substance for the same price (Ndife et al., 2011).

As regards to height, there was no significant difference between bread B and bread D. The highest height was recorded by bread C that contains the highest amount of protein. Bread volume increases with the percentage of protein, as reported by Finney (1984). From the Table 6 and Figure 15, the highest value of weight to height ratio was obtained from sample D, showing that it was the highest density in cell structure (Figure 10), compared to other bread samples. Sample C had the lowest weight/height ratio, 60.16g/cm among all bread samples.

Ndife et al. (2013) in their study formulated bread with wheat flour and soya bean flour blends and recorded bread weight that ranged from 550 to 800g. All the bread samples in this work had more weight than the weights obtained by the authors. This can be traced to high gluten contents of the flour samples in producing the bread samples. Malomo et al. (2011) produced bread with a composite flour containing breadfruit, breadnut and wheat flour. They obtained loaf of breads whose weight varied between 550 and 600g. All samples in this study had more weight, all greater than 800g. This is in accordance with the result of Akobundu et al. (1988) that highlighted the effect of protein forming structure contribution to loaf weight.

Table 5: The values of weight, high with weight and height ratio of bread

Samples	Parameters		
	Weight (g)	Height (cm)	Weight/Height (g/cm)
A	819.70[a]	11.63[b]	70.50[b]
B	811.17[b]	9.97[c]	81.56[a]
C	810.77[b]	13.43[a]	60.16[c]
D	806.00[b]	9.83[c]	82.50[a]

Means that do not share a letter are significantly different. (Tukey's HSD, $p < 0.05$).

Borla et al. (2004) reported in their research that there was a direct association between protein content and loaf weight: bread weight increases with percentage of protein in the flour sample used for the baking. This was also reported by Finney (1984). Uheln et al. (2004) reported that protein content and protein quality have vital influence on the baking potential of wheat flour. This was a reason for the higher loaf weights recorded by bread samples in this research.

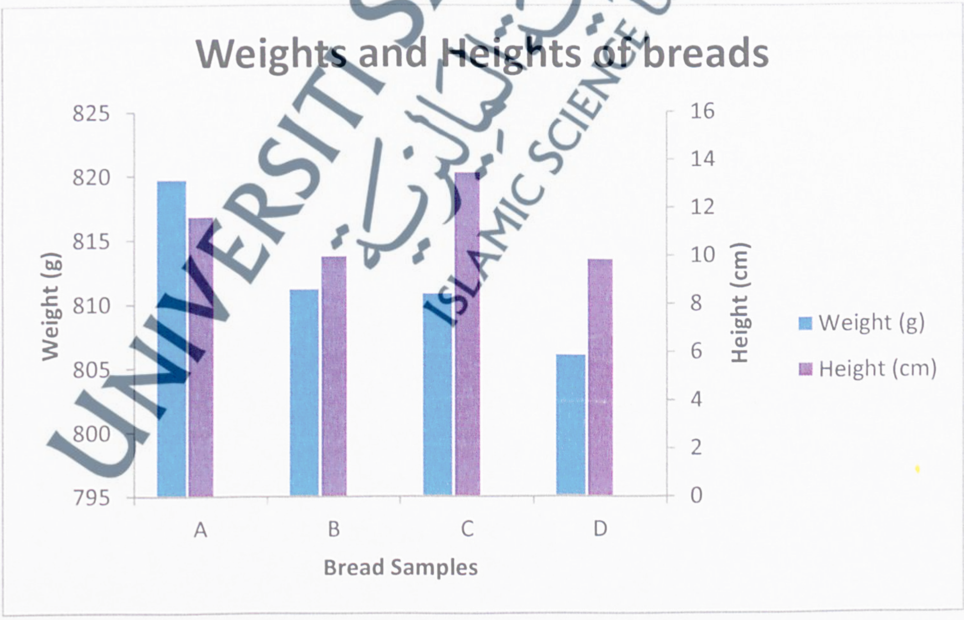
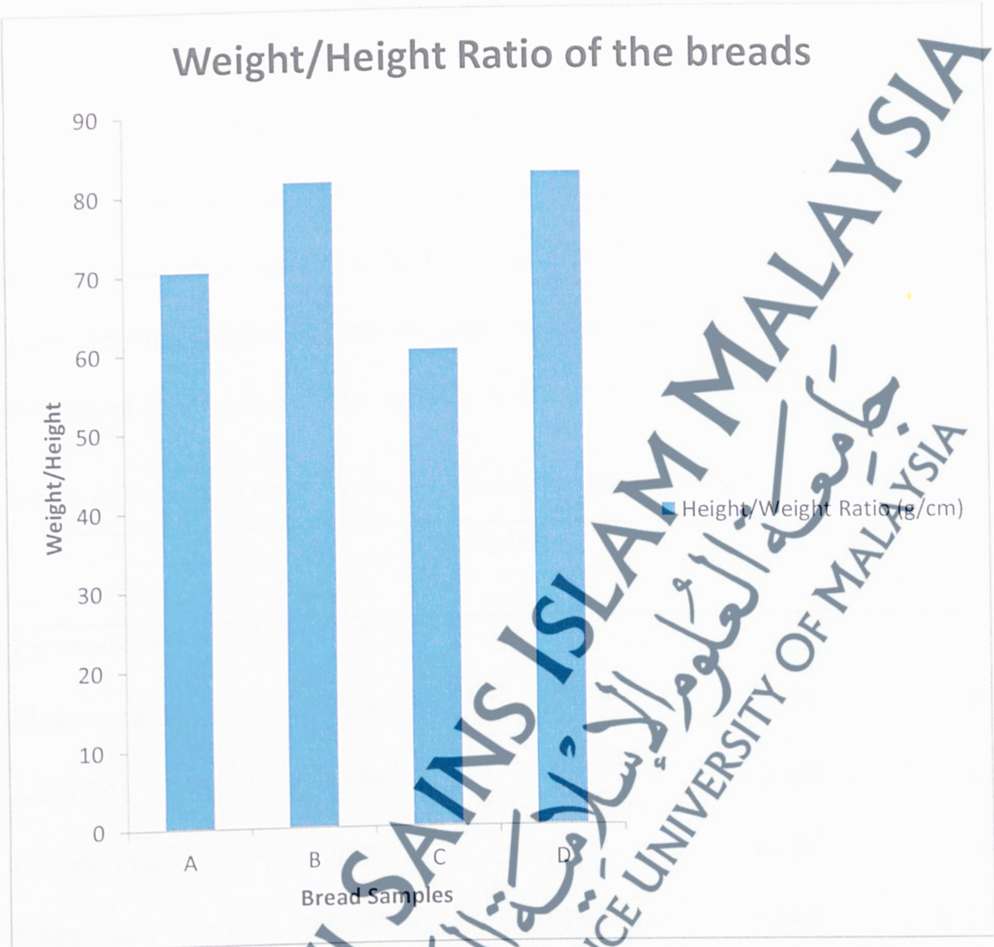


Figure 14: Weight and height of bread samples

Figure 15: Weight to Height ratios of the bread samples



4.4 Proximate Analysis of Bread Samples

4.4.1 Moisture content

Table 6 and Figure 16 shows average percentage of moisture content for the control and other breads. The average percentage of the moisture content for the bread samples A, B and C are 40.947%, 40.493%, 27.997%, respectively. Statistical analysis gave significant different between bread sample C and other samples. There was no significant difference between samples A, B and D.

Table 6: Proximate analysis result for bread samples

	Samples			
Parameters	A	B	C	D
Moisture (%)	40.95^{a}	40.49^{a}	27.99^{b}	37.46^{a}
Ash (%)	0.98^{a}	1.02^{a}	0.99^{a}	0.67^{b}
Protein (%)	10.23^{b}	9.41^{c}	10.54^{a}	8.37^{d}
Fibre (%)	0.082^{b}	0.145^{b}	1.066^{a}	1.027^{a}
CHO (%)	43.41^{c}	46.94^{bc}	56.66^{a}	51.27^{b}
Energy (Kcal)	252.49^{b}	243.36^{b}	292.59^{a}	249.39^{b}

Means that do not share a letter are significantly different ($p < 0.05$).

Sample C was significantly different ($P < 0.05$) from other bread samples and was the lowest in moisture content. This study was compatible with study obtained from (Ali, 2009) which showed that moisture content relates negatively to gluten content. The moisture contents obtained in this study could be compared to the work of Joel et al. (2013), their result ranged from 26.40 to 38.74%. The moisture results of the samples were within the regulatory specifications of moisture 40% maximum (Son, 2004).

High moisture content has been associated with short shelf life of breads as they assist microbial multiplication that lead to spoilage (Ezeama, 2007). All ingredients were kept constant in amount, so the differences in moisture content were due to the use of different flour. According to Marie and Dana (2002), the moisture of flour is depended significantly on the temperature course during the storage period.

Ndife et al. (2011) produced functional breads with whole wheat and soya bean flour. The moisture contents in their study ranged from 28.50 to 39.50%. The results of this study were in the same range with their findings. Al-Saleh and Brennan (2012) obtained moisture contents that ranged between 11.10 and 14.50%. Their results were different to those obtained in this research; this was due to the different flour samples used and the baking conditions; oven temperature, mixing procedures and environment factors. Malomo et al. (2011) in their study of composite flour breads from breadfruit, breadnut and wheat obtained moisture contents that ranged from 35.51 to 39.06%. The levels of moisture obtained in this work were comparable to their result. Sample C in this study was better in moisture content to the bread produced by Malomo et al. (2011).

4.4.2 Ash content

The bread samples were analyzed for the ash content by using the dry ashing method, and results is shown in Table 6 and Figure 16. It can be seen that ash content of bread samples ranged between 0.67%- 1.02%. The lowest ash content is presented in bread D which served as control. There was no significant difference among the ash content of the breads A, B and C ($p < 0.05$). The average ash percentages of breads A, B and C were 0.98%, 1.02% and 0.99%, respectively. The ash content of bread B was within the range obtained by Ndife et al. (2013). The results in their work varied between 1% and 2.23%.

The finding obtained in this study was different from result obtained by Malomo et al. (2011). The results in their work varied between 1.24% and 2.69%.They used composite flours in their study. Generally, the ash content of bread samples increases as the level of supplementation increases implying that composite flours positively impacted inorganic nutrients in composite flour bread (Malomo et al., 2011). This might be the cause of higher ash contents in their bread when compared to the bread samples of this study.

Ndife et al. (2013) reported that the ash contents of whole wheat bread samples they analyzed contained 1.00 to 2.23%. All the ash contents were similar to the results of Ndife et al. (2013) except sample D, the control sample,. Sample B actually fell into the range (1.02%). Al-Saleh and Brennan (2012) obtained ash levels between 0.630 and 0.973%. The ash contents in this work were in the same range except sample B, which is slightly higher.

Ndife et al. (2011) in their study of composite flour bread of whole wheat and soya, reported ash levels that ranged from 1.80 to 2.65%. The higher ash in their samples might have been impacted by the soybean. According to Ndife et al. (2011), soybean has higher ash content (2.50%) than whole wheat flour (1.50%).

4.4.3 Protein content

Protein contents of bread samples in this study which is shown in Table 6 and Figure 16 ranged from 8.37 to 10.54%. The protein contents were significantly different ($p < 0.05$) across all the samples. Bread C had the highest protein content; this could be traced to gluten content in flour sample. Gluten content in flour is directly proportional to protein content in final product, bread. The protein contents of the bread samples (A, B and C) in this research were comparable to the protein results of Al-Saleh and Brennan (2012). The protein results of these authors were between 9.52 and 13.69%., Sample D did not within the range. This was attributed to its lower gluten content. Malomo et al. (2011) obtained protein values that varied between 10.66 and 11.96%. The results in this study were similar to their values.

Protein contents of the bread samples in this work compared very well with the results of Ndife et al. (2011). They obtained protein contents which ranged from 8.13 to 12.50%. The samples in their study that had higher protein contents than those in this work might be able to achieve this because of the combination of soybean with the whole wheat flour used in their breads. Mashayekh (2008) reported that increase in protein level of bread was as a result of the addition of soybean flour. Singh et al. (2000) and Awadelkareem et al. (2008) also reported an analogous increase of protein content in sorghum-soy composite flours.

The yields of gluten content were strongly associated with the protein contents of the bread samples (Malmo et al., 2011). Bread C has the highest protein content. This is in line, because flour C has the highest gluten content among the other flour samples. Ames et al. (2003) and Edward et al. (2003) mentioned that, increased protein is accompanied by increased gluten strength. The results obtained in this work were better to the work of Joel et al. (2013). The protein contents in their work ranged between 5.25 to 9.00%. However, the average protein content for bread B and bread D did not meet the standard specification of 10% minimum requirement (SON, 2004).

4.4.4 Fiber content

The average crude fiber content varied between 0.082 and 1.066% as presented in Table 6 and Figure 16. As shown in the table, bread sample C and D had the highest fiber content 1.065%, 1.027 respectively, while the lowest fiber content (0.082%) was obtained in bread sample A. The results in this work were lower than the values obtained by Alessandro and Concha (2009). The values obtained for their white pan bread samples ranged between 2.00 and 7.50%. Ndife et al. (2011) formulated bread samples with whole wheat and soybean flour blends. They obtained fiber contents that ranged from 3.30 to 5.60%. The crude fiber in their bread samples were higher than those obtained in this study because the hull of the soybean might have contributed to the fiber contents in their bread samples. Mannay and Shadaksharaswamy (2005) and Islam et al. (2007) reported that soybeans represent variable fraction of dietary fiber including the lignin, cellulose and hemicelluloses components. The crude fiber contents of the bread samples were within the recommended range of not more than 6g/100g dietary fibre and other non-absorbable carbohydrates per 100g dry matter (Shubhangini, 2002).

The increased fiber content of bread have many of health benefits, as it will help in the digestion of the bread in the colon, reduce constipation often associated with bread produced from wheat flour (Jideani and Onwubali,2009; Elleuch et al., 2011), and dietary fibre plays an important role in prevention of disease such as; cardiovascular disease, diverticulosis, irritable colon, cancer and diabetes (Slavin, 2005; Elleuch et al., 2011).

4.4.5 Carbohydrate content and Energy value

The carbohydrate content was determined by difference, which was calculated by the following formula: 100 – (protein + fat + moisture + ash+ fiber). [5]

Energy values of the bread samples were calculated by multiplying protein by factor of 4, fat by factor of 9 and carbohydrate content by factor of 4 (Malomo et al., 2011). Table 6 and Figure 16 show the average carbohydrate for control and other breads. The carbohydrate contents of the bread samples ranged from 43.41 to 56.66% with the lowest value in bread sample A. The average of carbohydrate contents for bread samples A, B, C and D were 43.41%, 46.94%, 56.66% and 51.27% respectively. Statistical analysis (ANOVA) showed that all the bread samples were significantly different from each other. Higher value of carbohydrate was observed in bread sample C (56.66%). This observation in sample C was attributed to its being the sample with the lowest moisture content.

Malomo et al. (2011) in their study of bread samples formulated with composite flours made of breadfruit, breadnut and wheat obtained carbohydrate contents that ranged from 42.22 to 46.93. The bread samples in this study were better to theirs, higher carbohydrate contents obtained in this study was due to the different flours used in the bread making. Alessandro and Concha (2009) obtained values of carbohydrate content that varied between 38.90 and 48.00%. Bread samples C and D had higher carbohydrates content than their samples. The difference was due to the difference in the flour samples, baking procedures/conditions and methods of analysis.

The carbohydrate contents of wheat bread produced by Ndife et al. (2013) ranged from 45.74 to 59.40%. The carbohydrate contents in this study were lower than that of

Ndife et al. (2013), however, the carbohydrate contents in the bread makes it a quick source of energy for metabolism that aids fat metabolism (Malomo et al., 2011).

Table 6 and Figure 17 show the average carbohydrate for control and other breads. The energy values of the bread samples varied between 243.36 and 292.59Kcal. The highest energy value was observed in bread sample C because it had the highest protein and carbohydrate contents. There were no significant differences among the samples, except sample C. Alessandro and Concha (2009) reported that the energy values of whole white bread samples ranged from 232.00 to 260.00Kcal.

Ndife et al. (2013) obtained energy values that varied between 249 and 258Kcal. The energy levels of bread samples A and B in this research were similar to their findings. Research by Ndife et al. (2011) obtained energy values that varied from 241.00 to 285.60Kcal. The bread samples were produced from composite flours; whole wheat and soybean combined. The results of this study were compatible with their finding except sample C which had the highest energy value, despite the composite flour used in their study.

Malomo et al. (2011) formulated bread samples with composite flours from breadnut, breadfruit and wheat. The bread samples in their study yielded energy values that ranged between 261.40 and 274.17Kcal. The result in this research did not fall within their finding. Furthermore, discoveries in this study suggest that bread could serve as energy source for the metabolic processes in the human body (Bennet and Nozzolillo, 1987). The energy values of the bread samples were within regulatory specifications of and energy (1000 KJ/100 g) minimum (SON, 2004). The bread samples contained energy values in the range of 243.36 to 292.59 Kcal, and hence conformed to the (FAO/WHO, 1994) recommended minimum energy content of 1674 kJ/ 100 g.

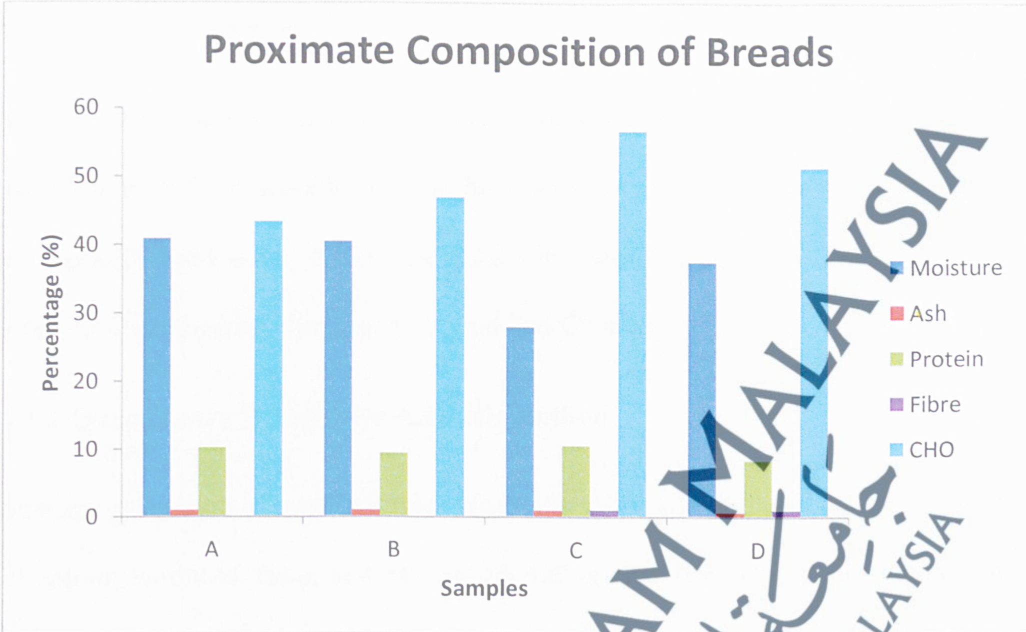


Figure 16: Proximate analysis of bread samples

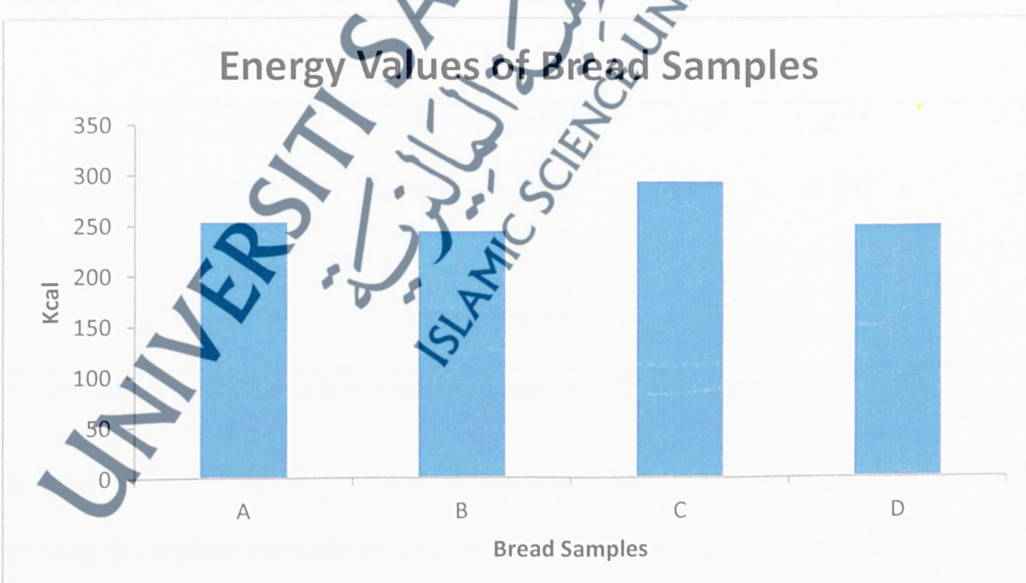


Figure 17: Energy values of bread samples

4.5 Sensory Analysis Results

Sensory evaluation is a quantitative technique in which numerical data are obtained to establish lawful and specific relationships between product characteristics and human perception (Wang *et al.*, 2007). The results for sensory properties of the bread provide interesting preliminary findings (Abboud and Charles, 2012).

4.5.1 Quantitative Descriptive Analysis method

Sensory evaluation of bread samples was undertaken and the most acceptable in terms of colour, hardness, taste, dryness, aroma and appearance. The results of the sensory analysis of the bread samples are presented in Table 7 and Figure 18. Detailed discussions of selected sensory attributes are outlined below:

Table 7: Sensory evaluation result for bread samples

SAMPLES	Crust Colour	Hardness	Taste	Dryness	Aroma	Appearance
A	4.50^{c}	4.02^{b}	4.85^{c}	4.70^{a}	$6.20^{a b}$	4.32^{c}
B	6.73^{a}	4.80^{ab}	6.63^{a}	4.85^{a}	6.75^{a}	7.32^{a}
C	5.97^{b}	5.25^{a}	5.93^{b}	5.25^{a}	5.80^{b}	5.55^{b}
D	6.78^{a}	5.20^{a}	6.68^{a}	5.02^{a}	6.75^{a}	7.60^{a}

Means that do not share a letter are significantly different ($p< 0.05$).

For crust colour attribute, the mean scores ranged between 4.50 and 6.78. The bread D showed the highest intensity of crust colour. The brownish bread appearance could be directly related to the increase in fiber content (Hu et al., 2007). In addition, browning of the breads could also occur due to caramelization. Moreover the crust colour formation is mainly due to Maillard reaction which happens during bread baking.

Siddiq et al. (2009) reported that the change in crust colour may be attributed to the Maillard reaction between proteins and reducing sugars. They also reported that during baking the amount of water on the dough surface quickly decreased providing favorable conditions for Maillard reactions resulting in darker brown color. Statistical analysis through ANOVA gave significant difference when comparing control bread (D) with bread A and bread C, while there was no significant difference between bread B and control bread, sample D.

Al-Saleh and Brennan (2012) in their studies obtained crust colour scores ranged from 2.58 to 5.77. The scores in this work were better than their findings. Borla et al. (2004) obtained better results when compared to this study. They obtained sensory scores for colour varied between 4.80 and 9.30. Al-Saleh and Brennan (2012) obtained a negative correlation between bread colour and protein content. In this study bread A and bread C had the highest protein content and received the lowest scores in crust colour.

The results for sensory scores of hardness in this study ranged from 4.02 to 5.25. Malomo et al. (2011) obtained scores ranged from 1.84 to 2.50. The samples of bread in this work had better texture when compared to the bread samples of Malomo et al. (2011). Results of Al-Saleh and Brennan (2012) ranged from 3.75 to 6.84. The results of this work were not too different from their findings. The little difference observed due to different flour used in making bread. Ndife et al. (2011) formulated bread samples with composite flour (whole wheat and soybean flours combined). The texture (hardness) scores of their bread samples varied between 4.40 and 5.40. Their findings and the results obtained in this research were similar. Borla et al. (2004) obtained hardness scores of 1.80 to 8.50.

In their research, the breads were produced from wheat flour that contain no commercial gluten and that enhanced the hardness (texture) of their samples. High-gluten flours were used in this study and that was a reason for the little disparity in the levels of hardness. According to Gomez et al. (2003); Bakke and Vickers (2007); Akhtar et al. (2008) and Serrem et al. (2011), the baking conditions that include temperature and time variable; the state of the bread components such as starch, fibres, gluten, weather damaged or undamaged and the amounts of absorbed water during the dough mixing, all contribute to the final texture of breads. Bread C obtained the highest score, and that means it was the hardest crumb as compared to other bread samples. This result was corresponding to result of texture profile analysis that has been discussed earlier, which also reported that Bread C had the hardest crumb. ANOVA gave significant difference when comparing control bread (D) with bread A and bread B, while no significant difference between bread C and control bread.

The scores obtained for taste of the bread samples ranged from 4.85 to 6.68. There was no significant difference between samples B and D. Samples A and C were significantly different from each other and other samples. The results obtained in this work were better to the results obtained by Borla et al. (2004). The scores obtained for taste in the sensory analysis of their bread samples varied between 1.00 and 5.40. The gluten content in the flour samples used in this research for the bread production could be the factor that enhances the bread taste in this work. The result of this work was also better to the results of Al-Saleh and Brennan (2012). The scores in their study varied between 2.62 and 3.78. Ndife et al. (2011) obtained taste scores that ranged from 2.00 to 5.00. The result obtained in this study was better than their finding.

Ndife et al. (2013) did a comparative evaluation of the nutritional and sensory quality of major commercial whole wheat breads and observed that the scores obtained for the taste of the samples studied varied between 5.54 and 6.45. The result in this study was better except sample A (4.85). Malomo et al. (2011) obtained taste scores that were lower (2.06 and 3.89) to the levels obtained in this research. The poor results were due to the breadnut and breadfruit flour mixed with wheat flour in the flour used for the breads used in their study. Bread sample D had the highest score among other samples. Vickers (2007) reported that soft texture and sweet taste of white bread is much more appreciated than the hard texture and low sugar of whole- grain bread.

There were no significant differences among the dryness of the bread samples. The scores ranged from 4.70 to 5.25. Sample C had the highest score for dryness. This might be ascribed to its being produced from flour with the highest gluten content. Al-Saleh and Brennan (2012) observed a positive correlation between water absorption of flour sample and its protein content. Flour sample with high gluten content has good water absorption which enhances dryness of breads (Al-Saleh and Brennan, 2012). However, according to ANOVA, there were no significant differences among all samples. The dryness of bread is related to moisture content. It can be seen that bread C was the driest bread due to panelist perceptions and it had the lowest moisture content when analyzed by using moisture analyzer.

The sensory scores for aroma, shown in Table 8, varied between 5.80 and 6.75. Sample C was significantly different from other samples and had the lowest aroma scores. The results obtained for aroma in this study were not similar to the findings of Al-Saleh and Brennan (2012). The aroma scores in their study ranged from 3.84 to 6.30. The aroma of breads in this work was better than theirs. The result in this study was better to the findings of Borla et al. (2004). They obtained values that varied between 1.10 and 6.50. Malomo et al. (2011) produced bread samples from composite flours. The aroma of their bread samples ranged from 1.22 to 3.74. The scores of aroma attribute of the bread samples were higher than that of Malomo and co-authors. The composite flours used for their breads might have impacted on the aroma of the breads. According to Hansen and Schieberle (2005), the unique aroma of bread is mainly influenced because of the generation of sufficient amount of volatile compounds, influenced by yeast during fermentation.

The overall appearance of the bread samples ranged from 4.32 to 7.60. Bread samples A and C were significantly difference from each other and also among other samples (B and D). Malomo et al. (2011) reported appearance scores that ranged from 1.24 to 2.94 for their bread samples. The appearance of the bread samples in this research was better. The appearance scores of the high-gluten flour breads in this study were also ranked higher than those of Ndife et al. (2011); they obtained scores between 4.20 and 4.90. High gluten content in bread samples of this research might have enhanced their appearance. However, the results of the appearance scores of the breads in this work were similar to the findings of Ndife et al. (2013). They obtained appearance scores that varied between 4.62 and 7.85. The appearance of the bread samples could be described as good when compared to the study of Ndife et al. (2013).

The appearance of the bread samples in this work could also be compared positively with the bread samples studied by Borla et al. (2004). The sensory scores for appearance of their bread samples were from 5.80 to 7.90. The scores of appearance in this work were not different from their findings/results. Al-Saleh and Brennan (2012) obtained scores that ranged from 2.62 to 7.19. These results were lower to the appearance of the bread samples in this study. The high-gluten of the flour samples used in this study might have contributed to the better appearance of the bread samples.

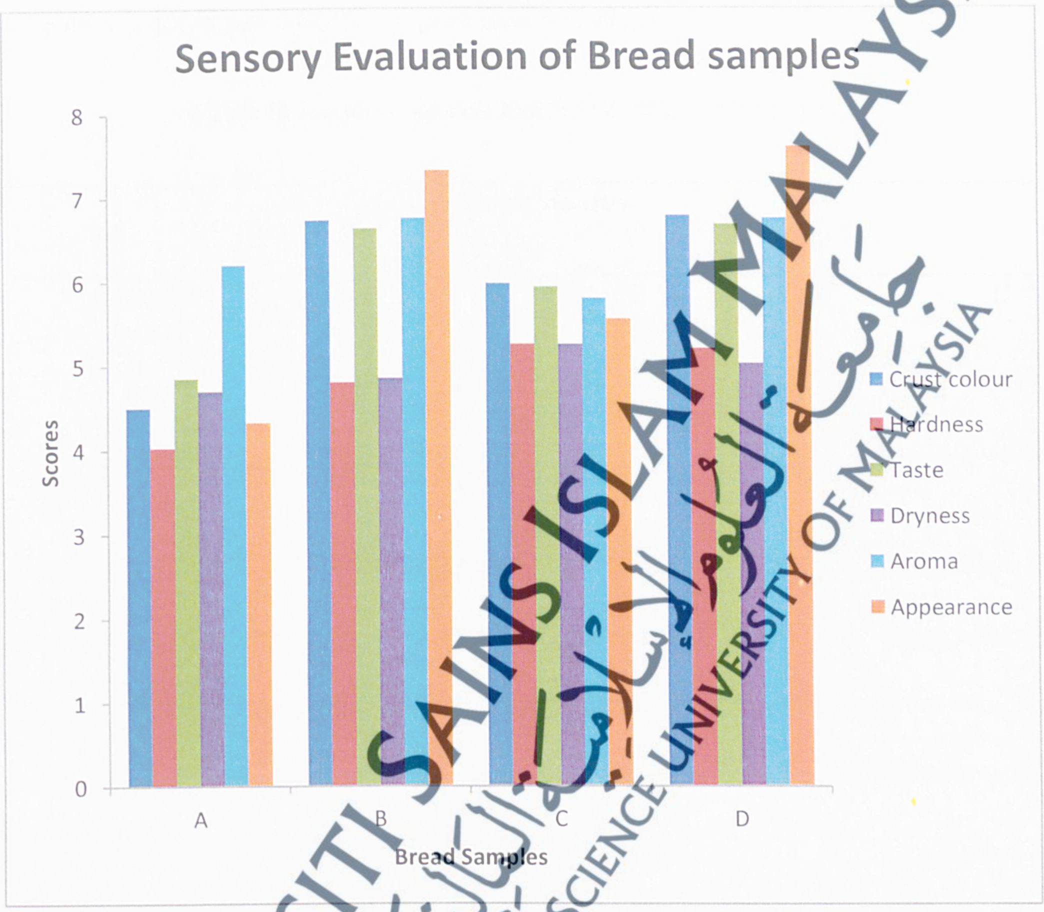


Figure 18: Sensory evaluation results of the bread samples

4.5.2 Hedonic/ Liking test

A 7 point Hedonic scale rating was used in evaluating the sensory attributes of bread samples, where 1= dislike extremely and 7= like extremely. The results of hedonic test/ overall acceptability of bread samples are presented in Table 9.

Table 8: Hedonic scores/ overall acceptability of bread samples

	Hedonic Scores			
Samples	A	B	C	D
	4.38[c]	5.93[a]	5.07[b]	6.23[a]

Means that do not share a letter are significantly different ($p < 0.05$).

Referring to Table 8 and Figure 19, bread D had the highest value of 6.23. Bread A, B and C obtained scored 4.38, 5.93 and 5.07, respectively. There was no significant difference between samples B and D but they (B and D) were different from samples A and C. The panelists prefer sample D because it having the highest scores for appearance, aroma, taste and crust colour.

Malomo et al. (2011) evaluated the formulation of bread with composite flours, and they obtained scores that ranged from 3.32 to 3.89. This showed that the consumer acceptance of bread samples were better to their bread. Ndife et al. (2011) formulated breads with wheat and soybean flours, and they obtained overall acceptability scores that ranged from 3.80 to 4.40. The results of this work in term of overall acceptability were better to the results of Ndife et al. (2011). This could be as a result of pure wheat flours used in this study. Ndife et al. (2013) in their study of different commercial breads obtained 6.04 to 7.15 as their overall acceptability scores. Their result was higher than the scores obtained in this research.

Figure 19: Overall acceptability of the bread samples