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EFFECT OF ACORN FLOUR SUBSTITUTION ON ARABIC BREAD PROPERTIES

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Arabic bread (AB) is the most common type of bread that consumed in the Middle East countries. It is prepared from white wheat flour which considered to have a low nutritive value. Acorn kernel flour (AKF) is produced from oak acorn *Quercus aegilops* (Malloul) which is available in Jordan and it is rarely utilized in the human diet. Wheat flour (WF) was substituted with different concentrations of AKF (5, 10 and 15%) to formulate the acorn kernel bread (AKB). The physicochemical and sensory properties of the AKB produced were evaluated and compered with wheat bread (WB) as control. The results indicated that the substitution of WF by AKF will affect the rheological characteristics of the dough as it assessed by the farinograph. It has been found that the water absorption of the WF dough was 57.8% and it increased as AKF substitution increased. Additionally, both of arrival time and dough development time were decreased and dough stability was increased as AKF substitution was increased. The results indicated that the AKB has a high fiber content that gives a healthy nutritional advantage compared with WF bread without substituting with AKF. The AKB has lesser white and darker as increasing of the AKF substitution percentage compared with WB. The AKF addition did not affect the firmness of the bread one hour after baking, but the freshness reduced by increasing of AKF substitution after 24 hours when assessed by penetrometer. The overall quality in term of sensorial attributes showed that substitution by AKF up to 15% results in product like that of wheat bread. It can be concluded from the above results, that substitution of WF by AKF up to 15%, can permit economic benefits in terms of reducing the importation of wheat and help exploring certain untapped plant products of high nutritional value as acorn.
Keywords: Acorn, wheat flour, bread, physiochemical analysis, sensory characteristics
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INTRODUCTION

Cereals, particularly wheat, is the most important staple food around the world as it provides more nutrients than any other single food source (Shewry and Hey, 2015). Wheat is used to make a variety of food categories as well as different kinds of breads. Among the Flatbreads all over the world, the Arabic flatbread is the most common type of bread consumed in the Middle East. It is prepared mainly from wheat flour in most of the countries (Gocmen *et al.*, 2009; Al Omari and Abdul-Hussain, 2013; Garduno, 2015) including Jordan (Amr and Ajo, 2005). However, the improvement of bakery products especially bread by using composite flour (i.e. a complete or partial substitution of wheat flours with other ingredients such as cassava, yam, rice, green gram and potato flours) has been increasingly attracted much attention (Jisha *et al.*, 2008; Noorfahahzilah *et al.*, 2014; Chandra *et al.*, 2015). Promising of having composite flour has economic advantages, such as reducing the importation of wheat and wheat flour and encouraging the use of locally grown crops such as flour substitution for achieving nutritional and health benefits (Jisha *et al.*, 2008; Hasmadi *et al.*, 2014).

In Jordan, there are large tracts of forest lands planted with oak trees, *Quercus aegilops* (Malloul) and these trees produce 35000 tons of acorns annually (MOA, 2007). Oak acorn need to be tapped to overcome the shortages in cereals production, particularly wheat. Khraishy and Vasquez (2015) indicated that the production of wheat is negligible in Jordan. However, according to an estimate in the years 2015 and 2016, the Jordanians consumed approximately 8 million loaves of Arabic bread per day, an average of 90 kg per person per year (Martinez, 2014). Wheat flour -based bread represents the main staple food for most people (Scheuer *et al.*, 2015). It is essential to investigate the possibility of using supplement ingredients in food products, such as bread to take advantage of nutritionally valuable untapped plant products in the baked goods industry.

Rakic *et al.* (2007) reported that the acorn has contributed a part of the European diet for some time, which was furnishing up to 25% of the food consumed by the poorer classes of Italy and Spain. Polimac and Komlenic (2015) reported that the acorns could become one major food source and an attractive novel ingredient for the future. Oak acorns have been proved to improve the food quality and reduce the cost considerably

(Jacknis, 2004). Rakic´ *et al.* (2007) demonstrated the existence of antioxidant compounds from the oak acorn varieties. These are functional nutrients could be a resource for establishing a potential applicability functional food.

Acorns has nutritional constituents compared with cereals, as being rich source of carbohydrates as well as protein (essential amino acids), fats, dietary fiber and vitamins, specialty A and C and antioxidant compounds (Rosenberg, 2008) furthermore, Ciesla (2002) reported that acorn is rich in magnesium, calcium and phosphorus. The aim of this research was to study the possibility of replacing wheat flour (WF) with acorn kernel flour (AKF) in the production of Arabic flatbread (AB) and compare physiochemical characteristics of AKB with wheat flour bread.

MATERIALS AND METHODS

Materials**:** Straight grade (Muwahad) wheat flour (WF) was obtained from Al Namish International Mills (Irbid, Jordan) with an extraction rate ranging 77% to 80% according to JSMO (Jordan Standards and Metrology Organization), No. 293 (2005). One-kilogram sample was taken from the 50-kg bag of the flour, mixed thoroughly and used for characterization of flour.

Acorns from *Q. aegilops* were collected from northern region, Jordan. 20 kg of acorns fruits randomly harvested at the maturity stage. Samples were washed after exclusion of all damaged ones, followed by blanching at 60°C in water to prevent darkening of the color of acorn kernel flour (AKF), caused by oxidation. Then, deshelled and chopped into small pieces, dehydrated at 60°C until complete drying and ground in an Europemill (EM-25/251, Denmark) to pass through a 60 mesh sieve (British standard screen) to obtain the AKF. The AKF samples were kept in tight polyethylene bags sealed and stored in a refrigerator (4°C) until further use. Compressed yeast (Yeast Industries Company Limited**,** ASTRICO, Jordan) and salts were purchased from the local market.

Rheological properties**:** Wheat flour and AKF composite samples (5, 10, and 15%), mixed thoroughly and used for rheological characterization as following:

Farinograph test was performed according to the (AACC, 2000). The apparatus using 300 g Brabender Farinograph Dusiburg, Mod.810104, supplied with model 820501(S 300 N) mixer. The sample was introduced to the mixing double – jacketed bowl of the farinograph, in which water with a controlled temperature of about 30°C was circulated. The optimum water absorption is the amount of water required to center the farinograph curve on the 500-Brabender Unit (BU) line. Parameters obtained from the farinogram were calculated according to the guidelines prescribed Farinograph Handbook (D'Appolonia, 1984).

Chemical analysis of flours and breads**:** Proximate chemical analysis (moisture, ash, protein, lipid, fiber, carbohydrate) of WF, AKF composite samples and all treated bread produced was carried out according to approved methods (AACC, 2000) in triplicates.

Breadmaking process**:** For the formulation of bread, AKF was incorporated in Arabic flatbreads following modes of three substitutions (5, 10 and 15%). Bread without the inclusion of AKF to their ingredients, was considered as a control. The code used to identify the bread sample were as follows: WB bread prepared from wheat flour was considered as control; and bread production from composite flours by replacing WF by AKF at levels of 5, 10 and 15% respectively, were coded as AKB 5, AKB 10, AKB 15 respectively. All other ingredients, used in preparation of the bread were obtained from local markets.

A lean formula used in the preparation of bread ingredients were flour, salt (1.5%), compressed yeast (2.0%), sugar (2%). The dry ingredients were mixed together, and water added to obtain the optimal dough. The dough was mixed for 5 min and then left to ferment for first proofing for 30 min, then sheeted manually for 2 to 3 min into 1 cm thick loaves. The loaves were left for a second proofing stage for 15 min at 27-30ºC and then baked at 415°C for 1 to 2 min, followed by cooling for 10-15 min. then the samples were packed in polyethylene bags and stored for further evaluation, according to Ajo (2013).

Evaluation of Bread Quality**:**

Specific volume of bread**:** Loaves of bread were weighed in gram (g) and then their loaf volume (ml) was determined by the sesame seed displacement method (Amr, 1988). Specific volume was calculated by dividing the bread volume by bread weight (ml/g), results were recorded 1 hr. after baking in triplicate.

Softness measurement of bread crumb**:** The bread staling rate was determined by measuring the compressibility with a penetrometer (PNR-10 Penetrometer; Petrotest Instruments Gmbh & Co. KG, Dahlewitz, Germany) (Maleki *et al.*, 1980). Softness of AKB levels was measured one hour after baking (fresh) and after 24 h of storage in sealed polyethylene bags at room temperature (20°C). For crumb softness, two slices of 23 mm were taken from the center of the bread and each sample was compressed in five spots to a weigh of 54.6 g for 5 s. The compression spots were marked by holes on the four corners and center of a 6 × 6 cm cardboard template placed on the cut surface of each sample, as recommended by Al Omari *et al.* (2016). Data for five points from each bread treatments were averaged to give the compressibility, measured with a penetrometer unit (1 penetration unit = 0.1 mm) as suggested by Maleki *et al.* (1980).

Color measurement**:** The color of the breads was assessed using a Color Tech-PCM (Cole-Parmer International, USA) and recorded the color of a sample by the three dimensions, L*, a* and b*. The L* value gives a measure of the lightness of the product color from zero (0) = black to 100 = white through visual recording. The redness 0 to +100 / greenness 0 to −100 and the yellowness 0 to +100/blueness 0 to – 100 are denoted by a* and b* values respectively (Al-Saleh and Brennan, 2012; Al Omari *et al.*, 2016). Color was measured at 3 points of each bread treatments and the average was determined.

***Sensory evaluation of bread*:** Sensory evaluation for bread was achieved under white light at room temperature in separate sensory stands at the Food Technology Lab in Al-Huosn University College. Bread samples were evaluated within 2hr of baking by 16 panelists, comprising of students, laboratory technicians and teaching staff aged 20–50 years, who were familiar with Arabic flatbread characteristics. Prior to sensory evaluation, the panelists were educated about the descriptors. For evaluation, samples with (3-digit codes) were presented in randomly. They were asked to rate the bread using a score sheet where the scores of 5 for (cracks, crust color, blister, crumb color and crumb texture and evenness of layer) and scores of 10 for (flavor & aroma, and rolling & folding, ease of chewing, and quality of separation) were excellent and 1 was poor according to Amr and Ajo (2005) with modification.

The characteristics evaluated on the first day-included cracks on the crust, crust color, blister, as well as crumb color and crumb texture, evenness of layer, flavor & aroma, and rolling & folding, ease of chewing, and quality of separation. On the second day, loaves from the same treatments were evaluated for ease of chewing, and ease of rolling and folding. The overall quality of the bread evaluates out of 100 scores. Water was provided to the panelists for mouth washing and neutralizing between the testing of each sample.

***Statistical analysis*:** The data was analyzed using the Statistical Analysis System (SAS, 2002). A one-way analysis of variance (ANOVA) test was performed to test the differences between treatments followed by mean of separation using Least Significant Difference (LSD) test. Findings with a P-value ≤ 0.05 were considered statistically significant.

RESULTS AND DISCUSSION

***Chemical composition of flours*:** The chemical composition of WF and AKF was presented in the Table 1. The moisture content AKF (14.21%) was significantly higher (P≤0.05) than the moisture content of wheat flour (12.76%). All these types of the flour are within the Wheat Flour Standard, No.293 (JSMO, 2005) concerning moisture. The AKF had significant (P≤0.05) high content in the ash (1.93%), fiber (2.63%) and lipid (5.20%), then the WF 0.63%, 1.31% and 1.09%, respectively. This agrees with the results reported by Saleh *et al.* (2016) that the acorn contains more than 55% of starch, 2.75–8.44% proteins and 0.7–7.4% fat; however, the WF had high contents of proteins (9.54 %) and carbohydrates (74.67%).

***Rheological characteristics*:** Table 2 shows the effect of substitution of the WF by acorn kernel flour (AKF) on rheological characteristics of the dough as evaluated by a farinograph. The water absorption of the dough was found to 57.8% of the wheat flour, while it increased gradually with increasing the substitution of AKF up to 62% of the AKF15. This may be due to the higher fiber content of AKF compared to WF. Holloway and Grieg (1984) reported that the fiber is characterized by its high water holding capacity and similarly Hegazy *et al.* (2014) reported that water absorption increase with chestnut flour substitution level increased in the blend owing to high fiber content of the chestnut flour. However, it was not compatible with that obtained by Majzoobi *et al.* (2013).

The other farinogram parameters of the WF and AKF15 were: the arrival time was (2 and 1.5 min), Dough development time (3 and 2.5) and stability (12 and 14), respectively. These results were indicating that the increasing of AKF substitution will decrease the arrival time and dough development time while the dough stability will increase. Sarker *et al.* (2008) reported that generally for a given variety of wheat, as protein content increases, arrival time also increases. The results for

Table 1. Proximate composition (%) of wheat and acorn kernel flour[*] [†].

	Moisture (%)	Ash (%)	Fiber (%)	Protein (%)	Lipid (%)	Carbohydrate (%)[§]
WF	12.76±0.04b	0.63±0.11b	1.31±0.03b	9.54±0.12a	1.09±0.13b	74.67±1.12a
AKF	14.21±0.42a	1.93±0.17a	2.63±0.35a	6.91±0.65b	5.20±0.34a	69.12±1.21b

WF=Wheat Flour, AKF= Acorn Kernel Flour; [*] Values are means of replicates ± SD of three triplicate; [†] Means with different letters in the same column are significantly differed at P≤0.05 according to LSD; [§]Percent calculated by difference.

Table 2. The farinograph analysis data of the dough of wheat flour and its substitution with acorn kernel flour.

	WF	AKF5	AKF10	AKF15
Absorption (%)	57.8	59	60	62
Arrival Time (min)	2	2	1.5	1.5
Dough development time (Peak Time) (min)	3	2.5	2	2
Stability time (min)	12	12.5	13	14

WF= wheat flour as control; AKF5= acorn kernel flour 5%; AKF10= acorn kernel flour 10%; AKF15= acorn kernel flour 15%.

arrival time could be attributed to the dilution of protein by acorn kernel flour carbohydrate and hence the dough development time has reduced for AKF dough blends. Therefore, this may be an advantage for improving the time for bread production, which is confirmed with the results obtained with Gonzaga *et al.* (2015).

The stability time increased with increase of the AKF substitution level, which means that the longer stability times the more strengthen of the flour and more tolerance to mixing; the results harmonize with those reported by Gonzaga *et al.* (2015) that the substitution of wheat flour by acorn flour increase stability time and agreed with Majzoobi *et al.* (2013). But these results were inconsistent with Yaping *et al.* (2013), who investigates different rheological properties of mixture of *Q. Mongolia* flour and wheat flour, where the stability time decreased with increase acorn flour. Differences may be attributed to differences in the variety of the oak acorn.

***Chemical composition of Mediterranean Flatbread*:** The proximate chemical composition of Arabic flatbread produced by substitution of wheat flour by acorn kernel flour at different proportions were illustrated in Table 3. The results showed that the moisture of the bread reduced significantly ($P \leq 0.05$) with the increase of AKF % substitution. Indeed, the moisture of the WB was 29.44%, while the moisture % of the AKB5 was 29.25%, AKB10 was 28.55% and the AKB15 was 27.48%, which supported the findings of Gonzaga *et al.* (2015) who pointed out that the moisture content was low in the bread with acorn flour.

The application of acorn kernel flour resulted in decreasing the protein content (10.6 -10.8%) significantly ($P \leq 0.05$) when comparing with the control (11.21%) but with small value, this result could be due to the low content of proteins in AKF compared to WF. However, these findings contradicted with the reports of Korus *et al.* (2015), who found that application of acorn flour results in protein content increase in in the gluten-free bread, compared to corn starch.

The increase of fat content in AKB numerically was observed with the increase of AKF but not significantly compared to WB. On the other hand, we recorded a gradual increase in fiber (1.59 to 2.42%) and ash content (1.79 to 2.05%) in AKB with the increase of AKF % substitution comparing to WB as a control. This could be due to higher fiber and ash content of AFK than the WF. However, the carbohydrate contents were insignificantly different ($P > 0.05$) between the different breads produced in the present study.

The results propose to produce high fiber AB with healthier nutritional value when substitution of WF by AKF in production of AB. Molavi *et al.* (2015) concluded that substitution of wheat flour with acorn flour of cake production leads to an increase in its nutritional value.

***Physical characteristics of the Arabic Flatbread*:** The physical characteristics results of Arabic flatbread produced at 1hr and after 24hr are presented in Table 4. The data indicated that in most cases of substitution of AKF significantly influenced the color and other physical parameters of the bread produced.

Table 3. Proximate chemical composition of Arabic flatbread produced*‡.

Treatments†	Moisture (%)	Protein (%)	Fat (%)	Fiber (%)	Ash (%)	Carbohydrate (%)§
WB	29.44±0.19a	11.21±0.05a	1.97±0.79a	1.37±0.05d	1.40±0.13b	54.61±1.01a
AKB5	29.25±0.26a	10.73±0.08b	2.40±0.30a	1.59±0.06c	1.79±0.55ab	54.24±0.37a
AKB10	28.55±0.22b	10.60±0.30b	2.23±0.13a	1.81±0.04b	1.91±0.11ab	54.90±0.27a
AKB15	27.48±0.39c	10.80±0.17b	2.35±0.08a	2.42±0.11a	2.05 ±0.16a	54.90±0.16a

*Data presented as Means ± SD of three triplicate; †WB= bread from wheat flour as control; AKB5= bread from acorn kernel flour 5%; AKB10= bread from acorn kernel flour 10%; AKB15= bread from acorn kernel flour 15%; § Percent calculated by difference; ‡Different letters in the same column with the same day was significant (p≤ 0.05) different according to (LSD).

Table 4. Physical characteristics of Arabic flatbread produced*§.

Treatments†		*L**	*a**	*b**	Chroma value	Crumb softness (PU) ‡	Staling rate % PU‡	Specific volume
WB	After 1hr	67.49±0.48a	13.10±0.94ab	10.14±1.55a	16.33±0.12a	7.23±0.72a	100	2.19±0.05a
	After 24hr	69.78±0.11a	9.46±1.84a	9.46±0.72a	15.26±0.06ab	6.68±0.48a	92a	
AKB5	After 1hr	67.49±0.48a	12.33±0.43b	7.53±2.49a	14.50±0.10d	7.68±0.29a	100	1.99±0.02a
	After 24hr	57.87±0.14b	6.16±1.32b	6.16±0.48b	14.77±0.18c	5.74±0.73b	75b	
AKB10	After 1hr	56.13±1.00b	13.88±0.82a	7.31±0.86a	15.67±0.04b	7.22±0.16a	100	2.19±0.23a
	After 24hr	57.99±0.30b	3.54±0.50c	3.54±0.16c	15.51±0.08a	5.30±0.31b	73c	
AKB15	After 1hr	56.13±1.00b	12.75±0.39ab	9.39±1.78a	15.27±0.16c	6.97±0.44a	100	2.16±0.02a
	After 24hr	57.76±0.73b	6.62±0.51b	6.62±0.38b	15.03±0.31bc	4.73±0.38c	67.8d	

*Data presented as Means ± SD of three triplicate; †WB= bread from wheat flour as control; AKB5= bread from acorn kernel flour 5%; AKB10= bread from acorn kernel flour 10%; AKB15= bread from acorn kernel flour 15%; §Different letters in the same column with the same day was significant (p ≤ 0.05) different according to (LSD).

$$\ddagger\ PU = Penetration\ Unit: \%\ PU = \frac{(PU)\ second\ day}{(PU)\ first\ day} \times 100\%$$

The color of bread significantly affects acceptability by consumers. The highest value of the *L** parameter which corresponded to lightness was obtained for WB as control. The level of AKF substitution reduced significantly ($p \leq 0.05$) this value. The AKB were less white and became darker with increased AKF substitution percentage. These results agreed with that obtained by Gonzaga *et al.* (2015). In the case of *a** parameter, which was a positive value and - insignificant difference between WB and all bread produced from different proportion of AKF substitution for the first day of evaluation, but there was a dramatic drop in values during storage in the second day of evaluation, especially regarding bread with AKF. The *b** parameter was positive, in the evaluation of the first and second day, which corresponds to the yellow color, but those values were dropped during storage after 24 hr., especially regarding bread with AKF, these results coincide with the data obtained by Gonzaga *et al.* (2015) and Korus *et al.* (2015).

In case of chroma value, were value near 0 is an indicative of subdued colors, while high chroma values represent vibrant colors (Ho *et al.*,2013), The color of the WB presented significantly ($p < 0.05$) greater chroma values than the AKB, probably due to the higher b* values.

The crumb Bread texture (softness) is a good quality indicator as it is considered as a key factor for bread acceptability. This serves as an indicator about changes in crumb texture during bread storage, owing to moisture loss, starch retrogradation and other interactions (Angioloni and Collar, 2009; Korczyk-Szabó and Lacko-Bartosova, 2015).

The data depicted in Table 4, indicate that all bread produced were insignificantly different ($P>0.05$) compared to the control at the first day of evaluation by penetrometer instrument, which indicated that the AKF did not affect the firmness of the bread. These results were agreed with the report of Korus *et al.* (2015) on the gluten free bread. Indeed, they found that replacements of the starch with acorn flour up to 20% had beneficial effect on hardness. Whereas, at the second day of evaluation, observed that the softening was reduced with the increase the of AKF substitution. Bread with AKF 15% had the lowest penetration value compared to all breads produced, which indicates that it had the higher firmness. This was illustrated by calculating the staling rate (% PU), where it has found that the rate of change of staling was elevated with increased substitution by AKF. Similar results were obtained by Gonzaga *et al.* (2015) indicating that addition of acorn flour increased significantly the hardness of bread with aging.

Arabic flatbread specific volume results (shown in Table 4) indicated that there were no significant differences ($P>0.05$) between bread samples. These results are in contradiction with the reports Molavi *et al.* (2015) and Korus *et al.* (2015), who investigated respectively the cake and gluten free bread. The Flatbread was considered having low specific volume such as Kmaj breads divided into groups based on their crumb content and specific volume as follows (Amr, 1988): The non-crumb forming group single layer include the Mashrouh (1.82 cc/g), Tannour (1.79 cc/g), and Lizzaqi (1.81cc/g). The low crumb group comprised of Thick Kmaj (1.64 cc/g) Thin Kmaj, (1.80cc/g), Baladi (1.75cc/g), Mankoush (2.21cc/g) and Taboun (2.10cc/g). The Arabic flatbreads produced by substitution of WF by AKF were within the specific volume of all types of the flatbreads.

***Sensory evaluation of bread*:** The sensory analysis of Arabic flatbread produced from different treatments were focused on characteristics related to cracks, crust color, blister, crumb color, crumb texture and evenness of layer, each of which was

Table 5. Sensory evaluation of the Arabic flatbread produced[*§].

Attributes (Score)	Treatment			
	WB	**AKB5**	**AKB10**	**WKB15**
Cracks (5)	3.68±1.44a	3.56±1.11a	3.93±0.97a	3.71±1.11a
Crust Color (5)	4.56±0.79a	3.00±1.01b	2.81±0.95b	2.50±0.79b
Blister (5)	4.31±0.92a	4.25±0.83a	3.56±1.11b	3.75±1.25b
Crumb color (5)	4.68±0.58a	2.81±0.88b	2.62±0.93b	2.37±0.92b
Crumb texture (5)	3.68±1.16a	3.06±1.03a	3.31±1.16a	3.31±0.98a
Evenness of layer (5)	3.50±1.17a	3.12±1.17a	3.56±0.93a	2.93±1.34a
Flavor & aroma (10)	6.68±2.78a	6.37±2.93a	7.56±1.66a	6.68±2.44a
Rolling & folding (10)	7.25±2.30a	7.12±2.72a	7.06±2.33a	7.06±2.68a
Ease of chewing (10)	7.75±2.08a	6.62±2.82a	6.93±2.54a	7.68±2.17a
Quality of separation (10)	8.06±2.13a	7.56±2.32a	8.18±2.10a	8.68±1.40a
Ease of chewing/2nd day (10)	7.00±2.12a	6.25±2.22a	6.31±1.81a	6.93±2.30a
Rolling & folding/2nd day (10)	7.43±2.03a	6.50±1.96a	6.12±2.01a	7.25±2.30a
Quality of separation/2nd day (10)	8.93±1.33a	8.06±1.60a	7.50±2.78a	7.62±2.87a
Overall quality (100)	77.56±11.97a	68.31±11.96a	69.06±10.83a	70.09±16.45a

[*]Data presented as Means ± SD of three triplicate; [†]WB= bread prepared from wheat flour as control; AKB5= bread prepared from acorn kernel flour 5%; AKB10= bread prepared from acorn kernel flour 10%; AKB15= bread prepared from acorn kernel flour 15%; [§]Different letters in the same column significant ($p \leq 0.05$) different according to (LSD).

translated into score of 5 points and evaluated 1h after baking. The flavor and aroma, rolling and folding, easiness of chewing and separation quality, were translated into score of 10 points, and they were carried out after 24 hrs of baking. All attributes scores were brought together to final overall quality attributes to a maximum of 100. Data of sensory evaluation were presented in Table 5. The results showed that all sensory attributes scores were not significantly different ($P>0.05$) between bread samples, except for crust color, blister, and crumb color which showed reduced scores significantly ($p\leq0.05$) for AKB compared with WB. It could be accepted as logical due to dark color of AKF that affects these attributes. The crust color is the important mark in term of acceptance of the bread and therefore in the case of increasing the proportion of substitution of AKF could be a critical factor for deciding the overall acceptance. Similar findings were obtained by Gonzaga *et al.* (2015), who found that the addition of acorn flour influenced significantly the crust and crumb color.

The panelist's scores showed that the AKB had no significant difference in overall quality compared to wheat breads. These results are encouraging that the addition of AKF to wheat bread may improve the nutritional value, as well as health and economic avails. Molavi *et al.* (2015) concluded through his study that lower levels of substitution of acorn flour (less than 10%) in cakes had acceptable texture and sensory properties as compared to the control.

***Conclusion*:** The results of this study advocate that it is possible to produce bread with addition of acorn kernel flour to an extent of 15% concentration to achieve best nutritional and health benefits. The substitution has observed to affect the quality attributes of the bread, mainly, the color and bread softness. Overall, quality and sensory evaluation indicated that substitution of wheat flour by acorn kernel flour up to 15% may yield a product with qualities similar to that of wheat bread. Furthermore, the application of AKF as a replacement for WF could result in achieving economic benefits in terms of reducing the importation of wheat and to explore plant products of nutritionally superior quality, such as acorn. Findings of the present study recommend attempting the possibility of large-scale application of acorn kernel flour for manufacture of food products with high nutritional value such as bagel, biscuits, pasta, etc.

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