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Utilization of broken rice, corn and sweet lupin flour for preparation high nutritional value and quality gluten-free basbousa

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ABSTRACT

The aim of this study was to prepare high nutritional value of gluten-free basbousa from broken rice and corn flour with enriched sweet lupin. Six formulas were prepared by mixing broken rice, corn and sweet lupin flour to make basbousa. F1 (Control) was semolina flour 100% as a superior quality basbousa. The formulas F2 and F3 were prepared from corn and broken rice flour, F4, F5 and F6 formulas made from broken rice and corn flour replaced partially with 30% sweet lupin. All the flour of formulas were packed and stored for six months at room temperature before preparing gluten-free bassbousa product. Chemical analysis, shelf life, texture profile analysis (TPA), sensory evaluation and quality characteristics of produced gluten-free basbousa were estimated. Results showed that protein content, water absorption capacity and gumminess were increased in gluten -free basbousa with replacement corn or rice flour with sweet lupin flour, total carbohydrates content and oil absorption capacity were decreased. Meanwhile there is no-significant differences in chewiness compared to F1 (control) formula. All the flour of formulas which stored for six months at room temperature showed low peroxide value and the rancidity was not detected. Water activity was below 0.6 during the storage period which is considered less than the level growth of any microorganisms. Total count bacteria, yeast and mold were increased after six months in all the flour of formulas but it was safe limit**.** Sensory evaluation of all gluten -free basbousa product which prepared after storage period (zero, two, four and six) months for the flour of formulas at room temperature were acceptable in general appearance and odor, meanwhile F3, F4, F6 formulas had the best sensory quality compared of all formulas while decreased non-significantly compared with F1 (control). From the results it could be recommended that the gluten- free basbousa could be make from broken rice and corn flour with enriched sweet lupin flour and produce commercially at a large scale to be available for celiac disease.

Keywords: Lupin, gluten- free, basbousa, shelf life, sensory evaluation, Palatability

Introduction

Basbousa or semolina cake is a traditional Arabian dessert, very popular in certain countries. In Turkey it is called Revani which is moist semolina cake in lighter syrup. In Egypt it is called Basbousa, and often called Hareesa in Alexandria, Jordan, and Morocco. The basic ingredients of basbousa are semolina flour, sugar, butter, yoghurt and trace amount of baking powder. Sometimes people like to add coconut and dry nuts to increase its acceptability. These ingredients are mixed, then baked, and finally sugar syrup was poured on the surface of the baked basbousa (Ahmed *et al*., 2004).

Gluten-Free foods have attracted much research interest. Especially, with rising number patients of celiac disease. In addition to the rapid change in consumer lifestyle (Abdel-Haleem, 2016).

Integration between cereals and legumes offers products with a higher content of protein with a high biological value, where legumes are deficient in sulfurous amino acids and rich in lysine, cereals are deficient in lysine and relatively rich in sulfur containing amino acids. Therefore, cereals and legumes are considered complementary in the nutritional quality (Oliveira *et al*., 2015).

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Lupin contained higher level of crude protein, crude fat, crude fiber and lower level of total carbohydrates compared to broken rice flour that distinguished by the highest value of total carbohydrates. Lupin flour does not contain gluten thus it is sometimes used as functional ingredient in gluten-free foods with improved nutritional quality (Mohammed, 2017) and can be used easily in foods because it is pale in color and low in odor and flavor (Clark and Johnson, 2002).

Cereal grains provide about 50% of the daily calories ingested by people throughout the world. The most extensively cultivated grains are wheat, rice, corn. Rice and corn are most important due to they are main source of carbohydrate (Ali *et al*., 2016).

Rice is a cereal rich in starch that feeds more than half of the world's human population. It is the third largest cereal crop in the world after wheat and corn. Broken rice is a by- product that usually separated during rice milling. It is usually used in producing of various products **(**Saleha, and Meullenet, 2013**)**. Rice has been used in food manufacturing. It is a suitable ingredient to prepare gluten-free products, because its tender taste, white color, easily digestible carbohydrates (Abdel-Haleem, 2016).

Durum wheat is very hard and can be processed into coarse particles called semolina. The coarsely particles obtained from the grinding of hard wheat is the principal material used in the manufacture of macaroni (Al Shehry, 2015).Semolina uses to make pasta, couscous and also used to produce various types of traditional cakes (Kezih *et al*., 2014).

Corn is the cereal which considered the highest production worldwide and is used for human consumption (Gwirtz, and Garcia-Casal, 2014). It is a third most important crop after wheat and rice. Corn is a source of a large number of industrial products besides its uses as human food and animal feed. Most of the products obtained after milling are used for industrial sectors (Sharma *et al*., 2012). Corn like rice does not contain gluten therefore, corn flour dough does not demonstrate rheological properties comparable to those of wheat flour dough (Quaglia, 1991).

The main issue for patients of celiac disease is the daily challenge to find healthy and tasty foods that do not contain gluten, thus it is very important to develop gluten-free foodstuffs with ingredients of high nutritional quality .These foods must be appealing in flavor, color, and texture. Therefore, the objective of the present study is to prepare gluten-free basbousa made from rice, corn and sweet lupin with high nutritional value and high acceptable quality characteristics.

Materials and Methods

Materials

Semolina flour, sweet lupin, sugar, ghee, baking powder and vanilla were purchased from local market, Giza, Egypt. Broken rice was obtained from Sakha Station Agricultural Research Center, Kafr El-Shiekh, Egypt. Corn kernels were obtained from Field Crops Research Institute, Agricultural Research Center. Total plate count agar media was obtained from Canada Pronodisa, Spain. Yeast and mould agar media were obtained from Difco TM Co. USA.

Methods

Preparation of lupin coarse particles

Sweet lupin was cleaned and washed with tap water, then soaked for 24 h at room temperature (25±5 ºC) by running tap water then boiling for 15 min. then washed with tap water and dehulled manually and finally dried in oven laboratory at (50±5 ºC) for 18h.

Preparing of gluten-free basbousa formulas

Sweet lupin, broken rice and corn were milled using a laboratory mill and sieved to obtain coarse particles like semolina particles size around 25 mesh and then kept in polyethylene bags at refrigerator (4± 1ºC) till using. Different basbousa formulas were prepared according to Abd-ELmoteleb, (1995) as presented in Table (1) with some modification. Where 30% of sweet lupin was added to the rice and corn, meanwhile control formula was prepared from semolina without addition of lupin, corn and rice. All the flour of formulas were mixed with sugar and vanilla, then had packed and kept in polyethylene bags and were stored for six months at room temperature (25±5 ºC).

Table 1: Formulas of the gluten-free basbousa (g).

Ingredients / Treatment	Semolina	Corn	Rice	Lupin	Sugar	Ghee	Baking powder	Yoghurt	Water	Vanilla
F1	100	-	-	-	10	37	2	50	-	1
F2	-	100	-	-	10	37	2	-	50	1
F3	-	-	100	-	10	37	2	-	50	1
F4	-	-	70	30	10	37	2	-	50	1
F5	-	70	-	30	10	37	2	-	50	1
F6	-	35	35	30	10	37	2	-	50	1

F1= 100% wheat semolina (control), F2=100% coarse corn flour, F3= 100% coarse rice flour, F4= 30% lupin + 70% coarse rice flour, F5= 30% lupin + 70% coarse corn flour, F6= 30% coarse lupin flour +35% coarse rice flour +35% coarse corn flour

Analytical methods

Crude protein, crude fat, ash, crude fibers were analyzed in the flour of formulas and basbousa product according to the procedures described in (AOAC, 2005)**.** Total Carbohydrates were calculated by difference.

Water absorption capacity (WAC) and Oil absorption capacity (OAC)

Water absorption capacity (WAC) and Oil absorption capacity (OAC) for the flour of formulas were determined according to AACC, (2000).

Water activity (a_w)

The water activity (a_w) for the flour of the formulas was measured using Rotronic Hygro lab CH-8303, Switzerland as mentioned by Cadden, (1988).

Microbiology analysis

Microbiological analysis including total bacterial count, yeasts and molds for the flour of formulas were determined at (zero time, two, four and six) months of storage at room temperature according to the methods of (ISO 21527-1, 2, 2008).

Peroxide value

Peroxide value for the flour of formulas was determined according to the method outlined in (AOAC, 2005).

Sugar syrup

About 600g sugar were added to 600 ml water and let to boil then some drops of lemon juice were added and the mixture boiled for 10 min.

Preparation of gluten-free basbousa product

Gluten-free basbousa product were prepared after each storage periods at (zero, two, four and six) months for the flour of formulas at room temperature. The dry ingredients of formulas were mixed with baking powder then ghee and yoghurt in control but water were added to the other formulas, after that the mixture was well homogenized by hand to obtain moist dough and put in the pan varnished well with small amount of ghee. The pan was baked in an oven at 180 ºC for 30-40 min. then hot sugar syrup was poured on the surface of the hot basbousa and was kept to cool 2 hr. before cutting according to Abd-ELmoteleb, (1995).

Texture Profile Analysis (TPA) of gluten-free basbousa product

Texture Profile of gluten-free basbousa product was measured by universal testing machine (Conetech, B type, Taiwan) provided with software according to Bourne, (2003). An aluminum (25 mm diameter) cylindrical probe was used in a TPA double compression test to penetrate to 50% depth, at 1 mms^{-1} speed test. Hardness (N), cohesiveness, gumminess (N), springiness and chewiness (N) were calculated from TPA graphic.

Sensory evaluation of gluten-free basbousa product

Sensory characteristics of gluten-free basbousa product was evaluated according to the method described by Al Shehry, (2015) which carried out by panel of ten experience guides from the staff of the Food Tech. Res. Institute, Agric., Res. Center, Giza, Egypt. Assigning scores for various qualities attributes such as general appearance, color, texture, taste, odor, Palatability. The panelists were asked to score the samples from 0 (for the worst) to 10 (for the best).

Total Caloric value of gluten-free basbousa product

Total calories of gluten-free basbousa product were calculated by (James, 1995) using the following equation:

$$Caloric\ value\ (Kcal/100g) = 4(\ protein) + 4(carbohydrate) + 9(fate)$$

Statistical Analysis

The obtained data were exposed to analysis of variance (ANOVA). Duncan is multiple range tests at (P ≤ 0.05) level was used to compare between means values according to Waller and Duncan, (1969).

Results

Chemical composition for the flour of gluten-free basbousa formulas

Chemical composition for the flour of formulas were shown in Table (2) the results indicated that the addition of sweet lupin in (F5 and F6) significantly increased of protein content, while the fat content in all the flour of formulas were ranged from (0.50 to 4.73 %), the highest amount of fat content was in F6 as well as F3 formula had contained the highest value of carbohydrates (90.84%) compared with other formulas.

The results in the same Table showed that the crude fibers content were significantly increased in F2 relative to the other formulas. These results are agreement with those obtained by (Mohammed ,2017) who found that lupin contained high levels of crude protein, crude fat and lower content of total carbohydrates compared with rice flour that distinguished by the highest value of total carbohydrates. Moreover, (Ibrahim *et al*., 2015) reported that rice flour had 90.53% carbohydrates. (Begum *et al*., 2013) stated that corn flour contain protein 9.08%, ash 1.60%; and crude fiber 1.25%, respectively.

Table 2: Chemical composition for the flour of gluten-free basbousa formulas (g/100g) on dry weight

Analysis treatment	Crude Protein	Crude Fat	Crude fiber	Ash	Total carbohydrates
F1	10.70 ^{c} ± 0.43	1.63 ^{d} ± 0.15	0.74 ^{c} ± 0.02	0.95 ^{d} ± 0.17	85.98 ^{b} ±0.62
F2	9.14 ^{d} ±0.43	3.03 ^{c} ± 0.54	1.06 ^{a} ± 0.12	1.25 ^{c} ± 0.04	85.52^{b} ±0.70
F3	7.66 ^{e} ± 0.29	0.50 ^{e} ± 0.04	0.46 ^{d} ± 0.07	0.54 ^{e} ± 0.05	90.84^{a} ±0.52
F4	16.74 ^{b} ± 0.04	3.42 ^{c} ± 0.06	0.54 ^{d} ± 0.03	1.28 ^{c} ± 0.03	78.02 ^{c} ±0.52
F5	17.45 ^{a} ± 0.12	4.11 ^{b} ± 0.05	0.94 ^{b} ± 0.04	1.79 ^{a} ± 0.04	75.71^{d} ±0.60
F6	17.34 ^{a} ± 0.33	4.73 ^{a} ± 0.04	0.75 ^{c} ± 0.03	1.57 ^{b} ± 0.02	75.61 ^{d} ±0.43

F1= 100% wheat semolina (control), F2=100% coarse corn flour, F3= 100% coarse rice flour , F4= 30% lupin + 70% coarse rice flour, F5= 30% lupin + 70% coarse corn flour, F6= 30% coarse lupin flour +35% coarse rice flour +35% coarse corn flour, Means values (n=3) ±SD & Means with different letters are significantly different at *P≤ 0.05*.

Water and Oil absorption Capacity for the flour of gluten-free basbousa formulas

Water absorption capacity (WAC) represents the ability of a substance to associate with water and it is an important functional characteristic in the development of ready to eat food from cereal grains. The water and oil absorption capacity for the flour of formulas are reported in Table (3) the results revealed that the formulas which contained sweet lupin showed significantly higher values of (WAC) compared with the other formulas, F6 had contained the highest value (2.514 g/g) followed by F5 (2.328 g/g) and F4 (2.164 g/g) .The results were similar to these report by Adebayo *et al.* (2016) who suggested that the water absorbance capacity depends on capillary, pore size and charges of the protein molecules. (Shobha *et al.*, 2012) who mentioned that the water absorption depends on polar amino acids availability on the primary sites for protein /water interactions hence, the water absorption capacity depends on protein content, nature and type of proteins, hydrophilic properties of proteins, which in turn related to polar groups such as carbonyl, hydroxyl and amino groups. (Hoover and Sosulski, 1986) reported that the differences in WAC could probably be attributed to the variation in their granule structure, also engagement of hydroxyl groups to form hydrogen and covalent bonds between starch chains leading to low in WAC. Moreover (Bryant and Hamaker, 1997) observed that the starch hydroxyl sites in the corn might have been saturated resulting in the decreased water absorption. Crude protein and crude fiber contributed to higher water absorption (Paul and Ayernor, 2002).

Oil absorption capacity (OAC) in food products is an important functional property because it improves mouth feel, flavor and increases the palatability of foods. Results in the same Table showed that the highest value of (OAC) for F3 was (1.884) followed by F2 (1.826) relative to the other formulas that contain lupin. These results are agreement with (Ali *et al.,* 2016) who stated that Oil absorption capacity in rice was higher than corn. From the results it could be noticed that all different formulas which contained sweet lupin was low in (OAC) , this may be due to the effect of heat that causing degeneration of the protein which acts as a barrier prevent oil absorption as mentioned by (Alpaslan and Hayata,2010).

Table 3: Water and oil absorption capacity for the flour of gluten-free basbousa formulas (g/g)

Analysis / Treatment	WAC	OAC
F1	2.082^{cd} ±0.014	1.755^{c} ±0.032
F2	1.997^{d} ±0.014	1.826^{b} ±0.027
F3	1.694^{e} ±0.003	1.884^{a} ±0.019
F4	2.164^{c} ±0.119	1.740^{c} ±2.020
F5	2.328^{b} ±0.011	1.593^{e} ±0.014
F6	2.514^{a} ±0.025	1.657^{d} ±0.021

F1= 100% wheat semolina (control) , F2=100% coarse corn flour , F3= 100% coarse rice flour , F4= 30% lupin + 70% coarse rice flour , F5= 30% lupin + 70% coarse corn flour , F6= 30% coarse lupin flour +35% coarse rice flour +35% coarse corn flour, Means values (n=3) ±SD & Means with different letters are significantly different at $P \leq 0.05$.

Water activity for the flour of gluten-free basbousa formulas during storage period in (zero time and after six month) at room temperature

Water activity has several effects on food stability, palatability, and overall quality and has an effect on the shelf life of foodstuffs, (Sunyoto and Futiawati, 2012). It is considered to be an indication of the amount of free water in food and it measure the ability of microorganisms to grow in the product.

The results from the water activity for the flour of formulas which stored for six months are illustrated in (Table 4). Results showed that all the given values of the water activity was ranged from (0.29 to 0.33) at zero time however after six months of storage ranged from (0.38 to 0.47). Therefore the data proved that the water activity that reflect the expected prolonging shelf life for all the flour of formulas was below 0.6, which is considered less than the level growth of any type of microorganisms.

From the above mentioned data it could predict the chemical stability and keeping safety as well as quality for the flour of gluten-free basbousa formulas. (Chirife *et al.*, 1996) reported that water activity has relation to chemical stability of dry food products and important reference for the shelf life of foods. (Abdullah *et al.*, 2000) recommended that rice flour and wheat flour can be stored at a_w of <0.65 and corn flour at 0.85 and no fungal growth occurred when stored for 6 months.

Table 4: Water activity (a_w) for the flour of gluten-free basbousa formulas during storage period in (zero time and after six months) at room temperature

Treatment \ Analysis	Water activity (a_w)	
	Zero time	Six months
F1	0.33 [a] ±0.004	0.47[a] ±0.01
F2	0.29 [d] ±0.002	0.43[ab] ±0.02
F3	0.29[d] ±0.005	0.43[ab] ±0.017
F4	0.29 [d] ±0.003	0.40 [b] ±0.017
F5	0.32[b] ± 0.004	0.42 [ab] ±0.05
F6	0.30 [c] ± 0.002	0.38[b] ±0.018

F1= 100% wheat semolina (control), F2=100% coarse corn flour, F3= 100% coarse rice flour , F4= 30% lupin + 70% coarse rice flour, F5= 30% lupin + 70% coarse corn flour, F6= 30% coarse lupin flour +35% coarse rice flour +35% coarse corn flour. Means values (n=3) ±SD & Means with different letters are significantly different at $P\leq 0.05$

Total count bacterial, yeast and mold for the flour of gluten-free basbousa formulas during storage periods at room temperature

Microbiological quality was measured by presence of microorganisms that considered the major factor affecting of the safety food and the organoleptic properties. The bacterial count considered as a suitable monitor for predicting the shelf life and also the water activity, which has a marked effect on the growth of microorganisms. The free or available water in food supports microbial growth and participates in chemical, enzymatic reactions and spoilage processes. The amount of free water is called water activity and it is more important for stability of food. At water activity less than 0.75 bacterial growth is inhibited but at less than 0.6 all growth is inhibited (Safefood 360, 2014).

Table 5: Microbiological analysis (cfu/g) for the flour of gluten-free basbousa formulas during storage periods at room temperature

Formulas	Total count bacterial (cfu/g)				Yeast &mold (cfu/g)			
	Storage periods (months)							
	Zero time	Two months	Four months	Six months	Zero time	Two months	Four months	Six months
F1	ND	ND	8×10^2	15×10^2	ND	7.0×10	6.0×10^2	21×10^2
F2	ND	3.0×10	11×10^2	28×10^2	ND	2.0×10	5.0×10^2	7.0×10^2
F3	ND	4.0×10	13×10^2	30×10^2	ND	2.0×10	7.0×10^2	11×10^2
F4	ND	ND	7.0×10^2	12×10^2	ND	3.0×10	4.0×10^2	9.0×10^2
F5	ND	ND	5.0×10^2	9.0×10^2	ND	ND	2.0×10^2	4.0×10^2
F6	ND	ND	3.0×10^2	4.0×10^2	ND	ND	1.0×10^2	2.0×10^2

F1= 100% wheat semolina (control), F2=100% coarse corn flour, F3= 100% coarse rice flour, F4= 30% lupin + 70% coarse rice flour, F5= 30% lupin + 70% coarse corn flour , F6= 30% coarse lupin flour +35% coarse rice flour +35% coarse corn flour, ND = not detected

Different microorganism (bacteria, mold and yeast) for the flour of formulas which stored at room temperature for six months were illustrated in Table (5). The results indicated that not detected of total count bacterial, yeast and mold at zero time of all formulas during the storage period. After two months total count bacterial were not detected in formulas F1 (control), F4, F5 and F6. Meanwhile yeast and mold were not detected in F5 and F6. After four months formula F6 had low value of the total count bacterial, yeast and mold that reached to 3×10^2 and 1×10^2 cfu/g respectively, followed by formula F5 which contained 5×10^2 and 2×10^2 cfu/g respectively.

Moreover total count bacterial, yeast and mold increased after six months in all the flour of formulas but it doesn't reach to the refuses limit. These results may be due to reduction in water activity of formulas during storage period.

Food safety, (2016) recommended that the legal limits microorganism of dried food more than 10^4 cfu/g up to less than or equal 10^6 cfu/g.

Also, (Eskin and Rebinson, 2001) who mentioned that the reduction of water activity often affects microbial growth, and it increases shelf life, all microbial activity, most fungi, most yeasts and most bacteria are inhibited at water activity below (0.6, 0.7, 0.8 and 0.9), respectively (Fellows, 2000).

Peroxide value for the flour of gluten-free basbousa formulas during storage periods at room temperature

The peroxide value reflects the storage quality of the product and is useful to measure the degree of oxidation in free fatty acids to production of peroxides, where the peroxides breaking down into volatile products responsible for undesirable odor and flavor which known rancidity (Ali Asma *et al.*, 2006).

Table (6) showed the peroxide value of the extracted oil from the flour of formulas during storage period. The results showed low peroxide value in all the flour of formulas and no rancidity was observed, the peroxide values were ranged from 0.011 to 3.15 meq/kg during storage period, these results were expected due to the low water activity for all the flour of formulas. These results indicated that the flour of gluten-free basbousa formulas were stable against oxidation after storage for six months at room temperature. Rancidity often becomes noticeable at peroxide value of 10–20% (Enamul *et al.*, 2013). The peroxide value of fresh oil and fats is usually below 10 meq/kg while for rancid oils and fats were above 20 meq/ kg. (Eagan and Kir, 1981). Also, (Raitio *et al.*,2011) reported that the very low value of water activity are related to lipid oxidation rates and he suggested to have optimal stability of lipids at the water activity between values of 0.2 and 0.4, oxidation rates increases with increasing water activity.

Table 6: Peroxide values for the flour of gluten-free basbousa formulas during storage periods at room temperature (meq/kg)

Analysis / Treatment	Peroxide value (PV)			
	Storage periods (months)			
	Zero time	Two months	Four months	Six months
F1	0.011 ±0.011^e	1.29 ±0.015^d	1.50 ±0.020^e	2.21 ±0.021^e
F2	0.134 ±0.002^c	1.38 ±0.015^c	1.88 ±0.011^c	2.71 ±0.020^c
F3	0.011 ±0.005^e	1.05 ±0.011^e	1.21 ±0.020^f	2.07 ±0.070^f
F4	0.123 ±0.003^d	1.31 ±0.020^d	1.72 ±0.030^d	2.51 ±0.031^d
F5	0.153 ±0.004^a	1.59 ±0.025^a	2.12 ±0.005^a	3.15 ±0.011^a
F6	0.144 ±0.003^b	1.47 ±0.020^b	1.96 ±0.015^b	3.02 ±0.036^b

F1= 100% wheat semolina (control), F2=100% coarse corn flour, F3= 100% coarse rice flour, F4= 30% lupin + 70% coarse rice flour , F5= 30% lupin + 70% coarse corn flour, F6= 30% coarse lupin flour+ 35% coarse rice flour + 35% coarse corn flour . Means values (n=3) ±SD & Means with different letters are significantly different at *P≤ 0.05*.
The peroxide value (PV) is expressed as meq/kg (milliequivalents of peroxide per kg oil).

Texture profile analysis of gluten- free basbousa product

Textural properties of food are important characteristics affecting consumer acceptance. After preparing of gluten-free basbousa product the texture profile were analysis. The results presented in

Table (7) shown TPA of gluten-free basbousa product, where the hardness decreased significantly for formula F3, while was increased non-significantly in formula F6 compared with the other formulas. On the other hand no significant differences between formulas F1, F2, F4 and F5 were observed.

Cohesiveness is the ability of a material to stick to itself, the results showed that no significant between all formulas, at P≤ 0.05.

Furthermore, gumminess indicates the energy required for disintegration the food to a state of readiness for swallowing. The TPA results showed non-significant differences in gumminess between F4, F5, F6 formulas while, it decreased significantly in formulas F1, F2 and F3 compared with the previous formulas.

Springiness is defined as food shape recovery between the end of the first bite and the beginning of the second one; where it decreased significantly in F3 formula that had the lowest value (0.77), meanwhile there no significant between the other formulas.

Chewiness is known as the energy required to masticate, the result showed that F3 formula recorded the highest decrease in Chewiness (6.65) compared with other formulas. It could be noticed that lupin flour which used with rice and corn in gluten free basbousa in formulas F4, F5 and F6 showed non-significant differences in chewiness compared with (control) F1. These results are in agreement with (Majzoobi *et al.*, 2013) who stated that the presence of protein reduce the free water and hence increase hardness. Increasing the rice flour generally decrease hardness and increase cohesiveness (Ying *et al.*, 2007). Also (Chueamchaitrakun *et al.*, 2011) found that the absence of gluten increase the movement of water from the crumb to crust, resulting in hardness crumb.

Table 7: Texture profile analysis of gluten- free basbousa product

Analysis / Treatment	Hardness (N)	Cohesiveness	Gumminess (N)	Springiness	Chewiness (N)
F1	8.60 ± 0.41 ab	1.04 ±0.01 a	8.94 ± 0.36b	0.91 ±0.08 a	8.15 ± 0.36 a
F2	8.53 ±0.56 ab	1.05 ±0.05a	8.95 ± 0.34b	0.89 ±0.04a	7.95 ±0.34a
F3	8.12 ±0.03 b	1.07 ±0.04a	8.68 ± 0.43b	0.77 ±0.03b	6.65 ±0.36 b
F4	8.64 ±0.78 ab	1.13 ±0.43 a	9.76 ± 0.53 a	0.85 ±0.04 a	8.29 ± 0.43a
F5	8.84 ±0.44 ab	1.11 ±0.36 a	9.81 ±0.43a	0.85 ±0.01a	8.35 ±-0.28 a
F6	9.31 ±0.46 a	1.07 ±0.03a	9.96 ±0.43a	0.85 ±0.05 a	8.42 ±0.36 a

F1= 100% wheat semolina (control), F2=100% coarse corn flour, F3= 100% coarse rice flour , F4= 30% lupin + 70% coarse rice flour , F5= 30% lupin + 70% coarse corn flour, F6= 30% coarse lupin flour +35% coarse rice flour +35% coarse corn flour, values are means (n=3) ±SD & Means with different letters are significantly different at *P≤ 0.05*

Sensory evaluation of gluten -free basbousa product during the different periods of storage (zero, two, four and six) months for formulas at room temperature

Basbousa is considered one of dessert products for Egyptian people, either homemade or produced on commercial scale. The flour for formulas of gluten-free basbousa and control were stored for six months at room temperature before prepare basbousa product.

Table (8) illustrated the sensory evaluation for basbousa product which prepared from the flour of formulas stored for six months, the results from (zero time to six months) showed that there are no significant difference in general appearance and odor in all formulas compared to F1 (control) and no observed undesirable odor or rancidity in all basbousa product, this may be due to low of peroxide value.

In the same Table it was observed that formula F3 had the lowest values in color and texture than other formulas. F2 and F5 formulas had the lowest value of taste score and there were significant differences compared to F1 (control), while was increased non-significantly in F3, F4 and F6. Also, results showed that no significant differences between formulas F3, F4, F5 and F6 in Palatability, while was decreased non-significantly compared to F1, formula F2 had the lowest score compared to the other formulas.

From the results of the sensory evaluation, formulas F3, F4, F6 had the best sensory characteristics compared to all formulas while decreased non-significantly with F1 (control). (Levent and Bilgicli, 2011) concluded that gluten-free cake could be produced with satisfactory results by the addition of lupin flour up to 30%.

Table 8: Sensory evaluation of gluten -free basbousa product after storage periods at (zero, two, four and six) months for formulas at room temperature

	General appearance	Color	Texture	Odor	Taste	Palatability
Zero time						
F1	8.2±1.47 [a]	9.35±0.94 [a]	9.1±0.87 [a]	9.25±0.79[a]	9.55±0.73[a]	9.65±0.66 [a]
F2	6.9±1.00 [a]	8.8±1.03[ab]	8.1 ±1.30 [ab]	9.15±1.00[a]	8.30±0.97[b]	8.65±1.00[b]
F3	7.9±1.66 [a]	7.8±1.11[b]	7.45 ±1.30 [b]	8.95±1.67[a]	8.55±1.14[ab]	8.8±0.88 [ab]
F4	7.9±1.28 [a]	8.55±1.34 [ab]	7.95 ±1.34 [ab]	8.85±1.41[a]	8.95±1.03[ab]	9.1±0.96[ab]
F5	6.9±1.66 [a]	9.95±1.25[a]	8.2 ±0.91 [ab]	8.65±1.91[a]	8.45±1.17 [b]	8.9±1.17 [ab]
F6	7.3±1.63 [a]	9.39.±0.70 [a]	8.25 ±1.33 [ab]	8.80±1.91[a]	8.55±1.07[ab]	9.3±0.71 [ab]
After Two Months						
F1	8.7±1.82 [a]	9.3±0.94 [a]	8.1±1.19[a]	9.1±1.10 [a]	9.1±0.73[a]	9.45.±0.68 [a]
F2	8.0±1.69 [a]	8.4±1.57 [ab]	7.6±2.01[ab]	8.8±1.31[a]	6.8±1.33 [b]	8.0 ±1.41 [b]
F3	8.5±1.35 [a]	7.5±1.71 [b]	6.2±1.61[b]	8.4 ±1.57[a]	7.6±1.42[ab]	8.45±1.03[ab]
F4	7.9±1.52 [a]	8.1±1.96 [ab]	6.9±2.02[ab]	8.4 ±1.26 [a]	8.6±4.19 [ab]	8.50 ±1.0 [ab]
F5	7.2±1.13 [a]	7.9±1.52 [ab]	7.4±1.64[ab]	8.0 ±1.63 [a]	6.6±1.26[b]	8.5 ±1.43[ab]
F6	7.6±1.42 [a]	8.95±1.06 [ab]	7.5±2.06[ab]	7.7±1.76 [a]	7.8±0.94[ab]	8.5 ±1.08 [ab]
After four Months						
F1	9.4±1.07 [a]	9.4±1.07[a]	9.65 ±0.67 [a]	9.35±0.88[a]	9.45±0.71[a]	9.4±0.69 [a]
F2	9.1±0.99[a]	9.1±0.99[ab]	9.0 ±0.62 [ab]	8.8±0.94 [a]	8.20±0.97[b]	8.15±1.20[b]
F3	8.5±1.43[a]	8.25 ±1.35[b]	8.4 ± 1.07 [b]	9.25±0.79 [a]	8.47±1.11[ab]	8.95±0.89 [ab]
F4	8.25±0.97 [a]	8.5 ±1.43[ab]	9.35±0.62 [a]	9.0±0.94 [a]	8.85±1.01[ab]	8.35±1.45[ab]
F5	8.25±1.35 [a]	8.35 ±0.85[ab]	9.2 ±0.75 [a]	9.05±1.06 [a]	8.35±1.14 [b]	8.65±1.56 [ab]
F6	8.25±0.97 [a]	8.6±0.69 [ab]	9.35 ±0.57 [a]	9.15±0.97 [a]	8.45±1.03[ab]	8.35±1.05[ab]
After six Months						
F1	9.5±0.70 [a]	9.75±0.66 [a]	8.65±0.68 [a]	9.4±1.47 [a]	9.54±0.69[a]	9.45 ± 0.687[a]
F2	8.95±1.01 [a]	8.90±0.88 [ab]	7.9±1.19 [ab]	9.1 ±1.02 [a]	8.29±0.95[b]	7.95±1.86 [b]
F3	8.75±1.31 [a]	8.75±1.00 [b]	7.65±1.02 [b]	8.8 ±0.69 [a]	8.54±1.09[ab]	9.05±1.49 [ab]
F4	9.0±1.05 [a]	9.0±1.17 [ab]	7.8±1.00 [ab]	8.7 ±1.33 [a]	8.94±1.01[ab]	8.25 ± 1,65[ab]
F5	8.75±1.18 [a]	9.20±0.96 [ab]	8.1±1.06 [ab]	8.55 ±1.30 [a]	8.44±1.12 [b]	8.35 ±1.29 [ab]
F6	8.9±0.99 [a]	9.20±1.04 [ab]	8.1±0.98 [ab]	8.75 ±1.27 [a]	8.57±1.01[ab]	8.8±0.82 [ab]

F1= 100% wheat semolina (control), F2=100% coarse corn flour, F3= 100% coarse rice flour , F4= 30% lupin + 70% coarse rice flour , F5= 30% lupin + 70% coarse corn flour , F6= 30% coarse lupin flour +35% coarse rice flour +35% coarse corn flour. Means values (n=10) ±SD & Means with different letters are significantly different at *P≤ 0.05*.

Chemical composition of gluten- free basbousa product

Table (9) exhibits the chemical composition of gluten- free basbousa product (g/100g) on dry weight .The results showed that F6 formula had significant increase in crude protein and fat followed by F5 and F4 formulas respectively, due to the addition of 30% lupin which increases protein content. The significant increase in total carbohydrate was in F3 formula. While formula F2 was recorded the highest ash and crude fibers content. Our present findings are in accordance with (Levent and Bilgicli, 2011) who mentioned that lupin addition increases protein content approximately two times. Also (Abdel-Haleem and Hafez, 2015) approved that rice had high amount of total carbohydrates.

In the same table the total caloric value (T.C.V.) ranged from 872.74 up to 887.56 Kcal /100g basbousa which contained 100 ml sugar syrup based on 387 kcal/100 sugar (USDA, 2017). From calculated total caloric value , it could be noticed that each 100 g of formula F6 had the highest content of total caloric and protein compared with the other formulas, which provide 55.47 % of energy (calculated as1600 Kcal/day) and 44.26 % of protein (calculated as 43 g/day) from the RDI for children aged 7-9 year (FAO/WHO/UNU,1985).

Table 9: Chemical composition of gluten- free basbousa product (g/100g) on dry weight

Analysis / Treatment	Crude Protein	Crude Fat	Crude fiber	Ash	Total carbohydrates	*Caloric Value Kcal/100g	**T .C.V Kcal/100g
F1	16.17^{d} ±0.02	18.94^{c} ±0.05	0.70^{c} ±0.05	0.99 ^{e} ±0.085	63.20^{c} ±0.061	487.94 ^{c} ±2.19	874.94 ^{c} ±2.19
F2	9.50^{e} ±0.02	21.20^{b} ±0.40	1.10^{a} ±0.182	2.16^{a} ±0.041	66.04 ^{b} ±0.419	492.96 ^{bc} ±4.42	879.96 ^{bc} ±4.42
F3	8.57^{f} ±0.03	18.30^{d} ±0.20	0.49 ^{d} ±0.05	0.95^{e} ±0.015	71.69 ^{a} ±0.156	485.74 ^{c} ± 4.93	872.74 ^{c} ± 4.93
F4	18.04^{c} ±0.14	20.28^{c} ±0.506	0.60 ^{cd} ±0.05	1.64^{d} ±0.050	59.44^{d} ±0.551	492.44 ^{bc} ±3.92	879.44 ^{bc} ± 3.92
F5	18.56^{b} ±0.05	21.42^{b} ±0.07	0.74 ^{bc} ±0.035	1.78^{c} ±0.011	57.5^{e} ±0.050	497.02 ^{ab} ±1.97	884.02 ^{ab} ±1.97
F6	19.03^{a} ±0.066	22.44^{a} ±0.304	0.88^{b} ±0.041	2.03^{b} ±0.06	55.62^{f} ±0.222	500.56 ^{a} ±4.27	887.56 ^{a} ±4.27

F1= 100% wheat semolina (control) , F2=100% coarse corn flour , F3= 100% coarse rice flour , F4= 30% lupin + 70% coarse rice flour , F5= 30% lupin + 70% coarse corn flour , F6= 30% coarse lupin flour +35% coarse rice flour +35% coarse corn flour , values are means (n=3) ±SD & Means with different letters are significantly different at $P \leq 0.05$.
*caloric value of basbousa (100g) without syrup, **T.C.V = total caloric value of basbousa (100g) with syrup based on 387 kcal/100 sugar, USDA [42].

Conclusion

From this study it could be concluded that the substitution of rice or corn coarse with 30 % lupin can be effectively used to prepare high nutritional value of gluten- free basbousa. The prepared gluten-free basbousa is characterized as high protein, energy contents and acceptable for sensory characteristics. Moreover the gluten- free basbousa formulas could be stored for six months at room temperature, with no observed rancidity during storage period. Therefore, we recommend further study to determine the feasibility of producing the gluten-free basbousa commercially at a large scale to be accessible for people suffering from celiac disease.

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