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Preparing High Nutritional Value Rice Flakes by Untraditional Method

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ABSTRACT

The present study aimed to prepare crispy rice flakes with high nutritional value with untraditional method from broken rice flour (BRF). BRF produced by three grinding methods dry, wet, and semi-wet milling process was evaluated for physical properties and particle size. Semi-wet milled rice flour significantly has a higher percentage of small meshes particles so it was finer, lighter, and brighter than other samples. The bulk density ranged between 0.66-0.87 g/ml. This experiment was conducted on the quality characteristics of rice flakes that were prepared with chickpea or yellow lentil flour at 0, 10, 20, 30, 40, and 50% replacement of BRF. Chickpea and yellow lentil flour contains higher values in protein (24.53, 25.6%), fat (4.47, 1.3%), ash (4.5, 2.55%), and fiber (6.4, 3.27%) compared to the BRF. Sensory evaluation indicated significant ($p \leq 0.05$) improvement in crispness, taste, flavor and overall acceptability scores in puffed flakes produced from the replacement of BRF with chickpea or yellow lentil flour but 40% chickpea (C) and 40%yellow lentil (L) samples gave the highest score by the statistical analysis, so it was selected. Puffed flakes with 40% (C) showed the highest puffed flakes yield (93.25%), moreover, the control sample had the highest expansion volume (5.51ml/g) compared with other samples. For proximate chemical composition 40% (L) and 40% (C) puffed flakes contained the highest contents of protein (14.59- 13.99), ash (1.6- 2.72), fat (1.0- 2.67), and crude fiber (1.93- 3.85), respectively, compared with the control sample. The substituted puffed flakes (with yellow lentil or chickpea) show higher essential amino acids (36.1- 35.9), non-essential amino acids (56.9- 53.8), chemical score, biological value (100.9- 101.8), and minerals content compared with control.

Keywords: Broken rice, flakes, Chemical composition, physical characteristics, Chickpea or yellow lentil flour, bakery products.

1. Introduction

Rice (*Oryza sativa L.*) is used as the main food by more than 65% of the world's population. The production of rice reached about 509.87 million tons in 2020-2021 next to maize and wheat grains (Wafaa *et al.,* 2019; Fehrenbach *et al.,* 2022). During rice milling and polishing, about 15–20 % of broken rice by-products are produced. Broken rice is used as a value addition to various food industrial utilization with the advantages of low cost and wide availability. (Yihui *et al.,* 2022).

Broken rice flour is a favorite component to prepare gluten-free products, because of its tender taste, white color, easily digestible carbohydrates, and a lake of sodium and calcium which is suitable for patients with Celiac disease (Liyanaarachchi, 2021). However, commercial rice flour has wide variations in flour showing might exist if the varieties mix with the long grain and medium grain classes. In addition, the quality of rice flour may differ according to the methods used in preparing the flour. Also, the properties of starch present in the rice flour are influenced by various factors, thus produce rice flour with different physicochemical and functional properties (Rosniyana *et al.,* 2016).

In addition, broken rice flour cannot be used directly in bakery products without modifications since it lacks gluten protein. Moreover, various ingredients should be added to increase the nutritional

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and sensory values, and to improve the shelf-life of broken rice products (Seung *et al.,* 2012; Su-Kyung *et al.,* 2018; Ma Edelwina, 2020).

To improve the physicochemical and functional properties of broken rice flour different traditional and untraditional treatments could be applied to enhance the physicochemical and functionality of rice flour and starch (Amal, 2016). For instance, rice cakes made with untraditional methods like steaming, boiling, puffing, frying, and flaking can be consumed as a convenient food.

Steamed rice cake is very popular and prevalent in many different cuisines. Puffed rice cake is eaten as a substantial snack, remain a firm favorite amongst many consumers, and are a typical dish (Rutuja and Anurag 2017).

Flakes cereal is a processed food manufactured from cereals intended to be eaten as a snack. The grains commonly used are corn, wheat, rice, and oats, which are suitable for consumption with or without further cooking. Flakes made from grains are associated with a reasonable amount of dietary fiber which reduces the range of those diseases associated with little dietary fiber intake such as gastrointestinal disorders (Okafor *et al.,* 2017).

To increase the nutritional and sensory values, and to improve the shelf-life of rice cakes, various ingredients are added such as legumes or pulses (Seung *et al.,* 2012). Legume flour is a good source of replacing or combining with rice flour as it provides complex carbohydrates such as dietary fiber, and some vitamins and minerals and has a greater impact as a desirable protein source for food applications (Ng, *et al.,* 2018 and Clemente and Olias, 2017).

Lentil (*Lens culinaris*) forms an important constituent of traditional diets and is a functional food due to their high nutritional value, presence of bioactive components, antioxidants, and other phytochemicals that render health properties to lentil. Also, it is the most rapidly expanding pulse crop for direct human consumption (Nosworthy *et al.,* 2017).

Chickpea (*Cicer arietinum* L.) is the third most important food legume and it is the most hypo-cholesterolemia agent. In addition, it is a valuable source of complex carbohydrates, dietary fiber, proteins, vitamins, and minerals and it is important constituent of daily diets in many countries. The impartation of desirable qualities and functionalities to food products by the addition of chickpea flour depends on the functional properties and characteristics of the flour (Yixiang *et al.,* 2014).

From the above mentioned reports, the objective of this study is utilize broken rice (as a by-product) to produce broken rice flour with high quality, to produce good quality and high nutrition rice puffed flakes inceptions with different percent of replacement of chickpea or yellow lentils flour and suitable for people with celiac disease.

2. Materials and Methods

2.1. Materials

Broken rice variety Sakha101, was obtained after the milling and polishing process of rice from the local milling processing unit, Rice Research and Training Center (RRTC) at Sakha Research Station, Kafr El-Sheikh Governorate, Egypt. Commercial rice flour Almarmar, chickpea, yellow lentil, salt, baking powder, oil, chili, and cumin were purchased from a local market, Al-Giza, Egypt. All chemicals used were of analytical reagent grade.

2.2. Methods

2.2.1. Rice flour preparation

Three methods of the grinding were adopted: dry, semi-dry, and wet grinding according to Prasad *et al.* (2012) with some modifications. In the dry grinding process, the broken rice was directly ground into flour using the mixer grinder. In semi-dry grinding, before grinding into semi-dry flour in the mixer grinder, the broken rice was soaked in water at 25±5 °C for 1 h, drained and spread on muslin cloth, and allowed to dry for 30-60 min at 25±5 °C on open air for the removal of surface moisture. The flour was dried overnight in a hot air oven at 40 °C to reduce the moisture. The dried sample was reground into fine flour. For wet milling, the broken rice was soaked for 5-6 h and then ground in the wet grinder or mixer grinder with water twice the weight of the rice. The slurry obtained was dried at 40 °C for 12 h to reduce the moisture content and then reground into fine flour.

2.2.2. Physical characteristics of rice flour

2.2.2.1. Mesh sieve particle size measurement

The particle size distribution was measured using sieve analysis. This method is performed by sifting a powder sample through a stack of wire mesh sieves, separating it into discrete size ranges. A sieve shaker is used to vibrate the sieve stack for a specific time. Vibration allows irregularly shaped particles to reorient as they fall through the sieves.

2.2.2.2. Color

The colorimetric measurements were measured in triplicate using a colorimeter (CR-10, Konica Minolta Sensing Inc., Japan) according to McGurie (1992). The color values were recorded as: L* = lightness (0 = black, 100 = white), a* (-a* = greenness, +a* = redness) and b* (-b* = blueness, +b* = yellowness).

2.2.3. Preparation of steamed rice cake

Chickpea and yellow lentil flour were used to replace 0, 10, 20, 30, 40, and 50% of rice flour (by weight) and they were mixed. All the ingredients were mixed, sieved, and steamed in a steam cooker for 30 min according to Min *et al.* (2017).

Untraditional steamed rice cake was prepared using white rice flour, chickpea or yellow lentil flour (500 g) as well as water (250 g) and salt (3 g). Salt and water were added to the rice flour and all materials were evenly mixed, followed by steaming for30 min. The steamed rice cake kneaded for 5 min after the heat was dissipated for additional 10 min to form flakes and cooled at room temperature for 3h and then baked.

2.2.4. Analytical methods

2.2.4.1. Proximate Analysis

Moisture, ash, crude protein, crude fiber, fat, and minerals contents of different rice samples (milled and flaked) were determined according to AOAC (2019). The nitrogen content was estimated by the Kjeldahl method, and the nitrogen conversion factor of the crude protein calculation was 6.25. The values obtained for protein, fat, and carbohydrate were used to calculate the energy content value of the samples as expressed AOAC (1995):

$$\text{Energy (kcal/100 g)} = \text{Protein}\times 4.0+\text{Fat}\times 9.0+\text{Carbohydrates}\times 4.0.$$

The amylose content was determined according to the method of Juliano *et al.* (1981) based on the blue color reaction with iodine.

2.2.4.2. Fractionation of Amino acids

The produced flaxes were subjected to hydrolysis using HCL (6 N) at 110C for 24 h. The acid was evaporated and the residue was dissolved in buffer (pH 2.2). The soluble amino acids were fractionated and determined using Amino Acid Analyzer (Biochrom 30) according to the method outlined in AOAC (2010).

Then, the chemical score of essential amino acids (EAA) was relatively calculated according to FAO/ WHO (1990) using the following equation: -

$$\text{Chemical score (\%)} = \frac{\text{EAA in test protein sample}}{\text{EAA of FAO /WHO}}\times 100$$

Also, the biological value of the protein was calculated using the following equation according to Eggam *et al.,* (1979).

Biological value (%) as follows = 39.55+8.89x lysine (g/100g protein).

2.2.5. Sensory properties of puffed flakes

The flakes yield are used to prepare crispy puffed flakes by frying in oil or baking in the oven, in this study; it was baked in the oven at a temperature of 180ºC/10min to prepare crispy puffed flakes and subjected to organoleptic evaluation according to Bate *et al.* (1991). Puffed flakes were evaluated by 10 members of the Research Institute of Agricultural, Research Center, Egypt, on a scale from one (dislike highly) to five (like highly). They were asked to score the puffed flakes as follows: Appearance, Color, Odor, Taste, Crispy, and overall acceptability. All samples were coded and presented in a randomized arrangement.

2.2.6. Puffed rice flakes characteristics

The puffed flakes yield, expansion volume, expansion ratio, and bulk density were calculated according to Simsrisakul (1991) using the following equations:

$$\textbf{Flakes yield \%} = \frac{\text{(wt. of puffed flakes (g)}}{\text{(wt. of flakes rice(g)}} \times 100$$

$$\textbf{Expansion volume} = \frac{\text{vol. of puffed flakes (cm)}^3}{\text{wt. of flakes rice (g)}}$$

$$\textbf{Expansion ratio} = \frac{\text{vol. of puffed flakes (cm)}^3}{\text{vol. of flakes rice (cm)}^3}$$

$$\textbf{Bulk density (g/mL)} = \frac{\text{wt. of puffed flakes (g)}}{\text{vol. of flakes rice (cm)}^3}$$

2.2.7. Statistical analysis

All data were analyzed using Costat statistical software and were statistically analyzed for means values and standard deviations according to Snedecor and Cochran (1994). The data were subjected to a one-way analysis of variance (ANOVA) at $p \leq 0.05$ followed by Duncan's new multiple range tests to assess differences between samples' mean values.

3. Results and Discussion

3.1. Moisture, amylose content, physical properties and particle size of BRF

Moisture, amylose content, physical properties and particle size of rice flour are shown in table (1). The moisture content of these flours ranged from 9.89 – 11.92% which is good for maintaining flour quality (below 13%) (Rosniyana *et al.,* 2016). The results in Table (1) show also that, the amylose content of dry milled had significantly ($P \leq 0.05$) the lowest content (19.22%) compared to samples. The highest content for amylose was found in wet milled (21.38%) followed by semi-wet milled (21.36%). The highest bulk density was observed for wet milled rice flour (0.87g/ml) and lowest for commercial rice flour (0.66 g/ml).

The particle size of flour, measured as the mean particle diameter, is a critical factor in determining the flour's usefulness and application in further processing. Table 1 shows the particle size of commercial, dry, semi-wet, and wet rice flour samples. Results indicated that the average particle size of flour ranged from 0.125 to 0.300 mm, with semi-wet flour composed of the finest average particle size as compared to others. Particle size of commercial rice flour showed that less than 27% was retained on mesh 100 – 120, but of semi-wet milled rice about 92.9% of the particle was retained indicating more fines were produced. As compared to dry milled rice flour, the particle size distribution of semi-wet milled rice flour and wet milled rice flour had a higher percentage of the smallest particle retained on the bottom meshes, and the weight fraction of smallest particles was the highest than the other fraction in semi wet-milled rice flour, about 76.4% retained on mesh 120 indicating less fine particles were found. Phim *et al.,* (2020) suggested that the small particle size of flour might produce fine and massive textures of finished products.

Prasad *et al.,* (2012) stated that during the soaking process of semi- wet and wet-milling rice flour, protein matrix and other substances were leached out from the surface of starch granules, causing the structure of starchy endosperm to become loosen which resulted in the fine particles and less damaged starch.

Nevertheless, the average particle size of rice flour obtained in this study was bigger than findings reported by Noorlaila *et al.,* (2016) who showed that dry and semi-wet flour showed uni-modal distributions while wet flour displayed bimodal distributions. The wet flour showed to distinct size consisting of two particle types, with the size of 0.002 mm and 0.106 mm, due to different manner in the technique. While Adil *et al.,* (2018) indicated that the average particle size of the fine fraction of rice flour ranged from 0.279 to 0.297 mm.

Table (1) also shows the color measurements of different types of rice flour. Data revealed no significant ($P \leq 0.05$) reduction in lightness value (L*) in the dry milled (99.183) and wet milled (98.90), but semi-wet milled rice flour had significantly higher lightness (101.28) when compared to commercial rice flour (95.23).

From the same table a significant ($P \leq 0.05$) increase in positive values of a* (redness), was observed in all four types. For the values of b* (yellowness) commercial rice flour was the highest (7.55) followed by wet milled (6.16), semi-wet milled (4.61) and dry milled (4.18).

Rosniyana *et al.,* (2016) indicated that the sample particle size affected the color and that the smaller flour particles resulted in a smoother surface, so finer flour was brighter. So, broken rice flour obtained by semi-wet method was the best way to get finer and brighter rice flour with a higher yield.

Table 1: Moisture, amylose content, particle size, and color measurements of different milled rice flour.

Samples / Parameters	Commercial rice flour	Dry milled rice flour	Semi-wet milled rice flour	Wet milled rice flour
Moisture %	10.13±0.17^{c}	9.89±0.28^{d}	10.76±0.35^{b}	11.92±0.31^{a}
Amylose %	19.97±0.58^{b}	19.22±0.25^{b}	21.36±0.69^{a}	21.38±0.06^{a}
Bulk density (g/ml)	0.66±0.02^{a}	0.81±0.02^{b}	0.67±0.11^{a}	0.87±0.02^{c}
		Mesh sieve size		
20	2.0	0.2	0.0	2.3
30	20.7	3.6	2.5	10.9
50	36.1	35.1	3.1	37.6
80	14.3	46.2	6.5	31.0
100	16.7	4.3	21.5	10.5
120	10.2	10.6	66.4	7.7
		Color		
L*	95.23±0.98^{c}	99.18±0.15^{b}	101.28±0.49^{a}	98.90±0.59^{b}
a*	0.46± 0.04^{a}	0.61±0.04^{bc}	0.55±0.04^{b}	0.63±0.04^{c}
b*	7.55±0.32^{a}	4.18±0.04^{d}	4.61±0.04^{c}	6.16±0.52^{b}

Note(s): L* = lightness (0 = black, 100 = white), a* (-a* = greenness, +a* = redness) and b* (-b* = blueness, +b* = yellowness).
While 20 mesh (0.850mm),30 mesh (0.600mm),50 mesh (0.300mm), 80mesh (0.180mm),100 mesh(0.150mm) and120 mesh (0.125mm).
Data are presented as means ± SDM (n=3) & Means within a column with different letters are significantly different at $P \leq 0.05$.

3.2. Chemical composition of raw material

The chemical composition of broken rice flour, chickpea, and yellow lentil flour is shown in Table (2) on a dry weight basis. It could be noticed that broken rice flour had 7.47, 0.53, 0.52, 0.81, and 80.94% for protein, fat, ash, fiber, and carbohydrate, respectively. Although the value of broken rice is different from which reported by David *et al.* (2021), it has the same chemical composition as the polished one (Marco *et al.,* 2014). Ayman *et al.* (2019) found that the Egyptian rice variety Giza177 had 6.33% protein, 0.77% fat, 0.53% ash, and 0.83% crude fiber, which are near to our results.

As for chickpea flour, the value were 24.53, 4.47, 4.5, 6.4, and 50.93 for protein, fat, ash, fiber, and carbohydrate, respectively. This is in agreement with Yixiang *et al.*(2014) and Nadia *et al.* (2021) who reported that chickpea has values ranging from 20-25% protein, 3-5% fat, 3-4% ash, and 4-8% fiber. These results are in agreement with those obtained by Gadallah *et al.* (2017) who reported that the chickpea flour contained 23.26% crude protein, 6.20%fat, 1.91% ash, and 2.45% crude fiber.

Yellow lentils flour had a higher amount of protein (25.6%), which was higher than rice and chickpea flour, also, it contained 1.3, 2.5, 3.27, and 57.95 for fat, ash, fiber, and carbohydrate, respectively, which was similar to that reported in yellow lentil flour by Daniel *et al.* (2021) who indicated that yellow lentil flour contains 25.16% protein, 1.2% fat and 62.69%carbohydrate.

Husnain *et al.* (2019) observed that chickpea is a significant ($P \leq 0.05$) source of Ca, Mg, Fe, and K, the Mn, Zn, and P levels were higher in it compared with other legumes. Indeed, the mineral content of yellow lentils is comprised of relatively high levels of Fe, Zn, K, Mg, P, and Ca (Daniel *et al.,* 2021).

On the contrary, broken rice resulted in poor sources of Ca, Mg, Zn, and Fe (Zeinab 2017). The mineral content of chickpea and yellow lentils suggested being a good blend with broken rice to produce a good product with high nutritive value. Nadia *et al.* (2021) showed that the incorporation of chickpea in cereal-based food products improves nutritional value and some organoleptic characteristics of food products.

Husnain *et al.* (2019) and Rajib *et al.* (2020) mentioned that the essential and non-essential amino acid content is significantly ($P \leq 0.05$) higher in chickpea and yellow lentils than in rice flour. Chickpea and yellow lentil proteins are rich in lysine but deficient in sulfur amino acids (methionine and cysteine), whereas cereal proteins are deficient in lysine but contain adequate levels of sulfur amino acids. This complementarity provides a balance in the amino acid content that could improve the nutritional value of proteins, hence the interest of the cereal-legume association.

Table 2: Chemical composition of raw material

Parameters	BRF	Chickpea flour	Yellow lentils flour
Moisture (%)	9.73±0.058^a	9.17±0.058^c	9.38±0.03^b
Protein (%)	7.47±0.058^c	24.53±0.25^b	25.60±0.44^a
Fat (%)	0.53±0.042^c	4.47±0.35^a	1.30±0.15^b
Ash (%)	0.52±0.04^c	4.50±0.40^a	2.50±0.20^b
Fiber (%)	0.81±0.02^c	6.40±0.26^a	3.27±0.21^b
Carbohydrate (%)	80.94±0.01^a	50.93±0.05^c	57.95±0.06^b
	Minerals contents (mg /100g)		
Copper	-	0.66	0.5
Iron	1.50	4.31	7.5
Zink	1.20	2.76	4.8
Magnesium	3.30	79.00	122.0
Sodium	23.0	24.00	6.0
Potassium	74.0	718.0	955.0
Phosphorus	0.12	252.0	451.0
Calcium	20.0	57.00	56.0
Manganese	-	21.30	1.4.0

Amino Acids(g/100g protein)

Essential Amino Acids	Broken Rice	Chickpea	Yellow lentil	Non-essential Amino Acids	Broken Rice	Chickpea	Yellow lentil
Lysine	1.2	6.5	6.7	Glutamic	4.2	16.8	16.1
Methionine + cystine	2.2	2.7	2.0	Aspartic	3.1	11.6	10.7
Isoleucine	1.8	3.8	4.1	Proline	1.7	4.4	3.8
Leucine	4.5	7.0	7.2	Alanine	5.3	4.1	4.2
Phynylalanine	0.7	5.5	5.0	Glycine	2.2	3.6	4.1
Tyrosine	3.2	2.9	2.5	Serine	4.4	4.8	4.7
Threonine	1.5	3.7	3.7	Arginine	1.5	9.0	7.8
Valine	2.5	4.0	4.7	Histidine	1.6	2.6	2.4
Total essential amino acids	17.6	36.1	35.9	Total Non-essential amino acids	24	56.9	53.8

Data are presented as means ± SDM (n=3) & Means within a column with different letters are significantly different at $P \leq 0.05$

3.3. Sensory evaluation of produced puffed rice flakes.

Sensory evaluation of puffed rice flakes from different blends of rice, chickpea, and yellow lentil flour is shown in Table (3). Statistical analysis data for panelist scores of puffed flakes containing different levels of chickpea, yellow lentil, and rice puffed flours were got to choose the highly accepted chickpea and yellow lentil flour suitable for producing high quality. Results in a table (3) showed that no significant ($P \leq 0.05$) differences were observed in color, flavor, and overall acceptability between controlled puffed flakes and those containing different levels of chickpea or yellow lentil flour.

Also, results showed that replacing up to 40% of rice flour with chickpea or yellow lentil flour in flakes formula didn't have any significant ($P \leq 0.05$) effects on color, flavor, and overall acceptability of flakes. A significant ($P \leq 0.05$) increase in taste was observed when increasing the chickpea or yellow lentil flour up to 40% levels.

Flakes of chickpea or yellow lentil flour replacement levels of 40% had significantly ($P \leq 0.05$) higher crispness, taste, color, flavor, and overall acceptability when compared to the control flake and they were acceptable sensory characteristics.

Nadia *et al.* (2021) showed that partial substitution of wheat flour with chickpea flour improves the protein content and nutritional value of food products made therefrom (e.g., pasta, bread, and other baked goods) and in some cases can enhance the rheological, functional, and sensory properties of such products.

Ng *et al.* (2018) observed that formulations with the presence of chickpea flours in the instant noodles received highly favorable ranks. This may be explained by the unique nutty flavor of chickpeas. From the above results, it could conclude that rice flakes with 40% of yellow lentils or chickpea replacement are the highest acceptability compared with other samples.

Table 3: Sensory evaluation of produced puffed rice flakes

Samples NO.	Crispness (5)	Taste (5)	Color (5)	Flavor (5)	Overall acceptability (5)
1	3.10 ± 0.57^{e}	3.64 ± 0.25^{f}	4.55 ± 0.44^{c}	4.85 ± 0.24^{a}	4.55 ± 0.37^{b}
2	3.75 ± 0.35^{d}	3.95 ± 0.37^{de}	4.65 ± 0.47^{bc}	4.90 ± 0.21^{a}	4.75 ± 0.35^{ab}
3	4.25 ± 0.35^{bc}	4.20 ± 0.48^{cd}	5.00 ± 0^{a}	4.95 ± 0.16^{a}	4.80 ± 0.26^{a}
4	4.55 ± 0.37^{ab}	4.45 ± 0.28^{bc}	4.95 ± 0.16^{a}	5.00 ± 0^{a}	4.85 ± 0.24^{a}
5	4.80 ± 0.35^{a}	4.75 ± 0.26^{ab}	5.00 ± 0^{a}	4.85 ± 0.24^{a}	4.95 ± 0.16^{a}
6	4.81 ± 0.25^{a}	4.62 ± 0.18^{b}	4.98 ± 0.21^{a}	4.81 ± 0.17^{a}	4.88 ± 0.32^{a}
7	3.60 ± 0.22^{d}	3.85 ± 0.24^{ef}	4.85 ± 0.24^{ab}	4.80 ± 0.26^{a}	4.90 ± 0.21^{a}
8	3.90 ± 0.29^{cd}	4.10 ± 0.32^{de}	5.00 ± 0^{a}	4.85 ± 0.24^{a}	4.90 ± 0.21^{a}
9	4.20 ± 0.35^{bc}	4.25 ± 0.43^{cd}	5.00 ± 0^{a}	4.85 ± 0.24^{a}	4.80 ± 0.26^{a}
10	4.75 ± 0.35^{a}	4.60 ± 0.21^{ab}	4.95 ± 0.16^{a}	4.90 ± 0.21^{a}	4.95 ± 0.16^{a}
11	4.70 ± 0.27	4.62 ± 0.19^{ab}	4.91 ± 0.11^{a}	4.88 ± 0.28^{a}	4.90 ± 0.18^{a}

Where:(1) control 100% rice, (2)90% rice + 10% C, (3) 80% rice +20% C, (4) 70% rice +30% C, (5)60% rice+ 40% C,(6)50 % rice+50% C, (7)90% rice+10% L, (8)80% rice+ 20% L, (9)70%rice+30%L, (10)60% rice+40%L,(11)50% rice+50% L.

Data are presented as means ± SDM (n=3) & Means within a column with different letters are significantly different at $P \leq 0.05$.

3.4. Quality characteristics of highly accepted puffed flakes

The quality characteristics of puffed flakes with 40% of chickpea or yellow lentil with the highest acceptability are presented in Table (4). Flakes sample 40%C showed the highest puffed flakes yield (93.25%) followed by 40%L (84.25%) and the control sample (75.36%). Moreover, the control sample had the highest expansion volume (5.51cm^3/g) compared with other samples, meanwhile, 40%C (4.32 cm^3/g) was close to 40%L (4.75 cm^3/g). There were no significant *($P \leq 0.05$)* differences in expansion ratio character for 40%L compared to 40% C. However, 100% rice had the lowest expansion ratio. On the other hand there were significant differences in bulk density character between 100% rice and the other two samples, 40%C and 40% L. 40%C seemed to have greater puffed flakes yield than control. The samples with the highest values for puffed flakes yield, expansion volume, and expansion ratio and bulk density were 40% Cand 40%L, respectively.

Table (4) shows the color measurements of control, 40% C, and 40%L. Data revealed a significant reduction in lightness value (L^*) in 40%C and 40%L, this reduction was due to adding both yellow lentils and chickpeas to the formula.

As shown in Table (4) 40%C had significantly lower lightness (L^*) and higher redness (a^*) and yellowness (b^*) when compared to control. Mo'ez *et al.* (2013) found that dark-colored legumes such as yellow lentils possess higher phenolic content and antioxidant activities than the pale colored ones. From the same Table significant increase in positive values of *a** (redness), and *b** (yellowness), was observed when replacing rice flour with yellow lentils or chickpeas.

Moreover, as for *a** and *b** values the increasing trend can be seen might be explained by the increased protein content of the formulations. The significant difference between each formulation might be attributed to the notable differences in the protein content of each formulation (Ng *et al.,* 2018).

Table 4: Quality and color characteristics of highly accepted puffed flakes

Puffed flakes samples	Puffed flakes yield %	Expansion Volume (cm^3/g)	Expansion ratio	Bulk density (g/ cm^3)	Color		
					*L**	*a**	*b**
control	$75.36^c \pm 0.70^c$	5.51 ± 0.43^a	3.08 ± 0.74^b	0.25 ± 0.04^c	74.69 ± 0.48^a	1.92 ± 0.04^b	12.49 ± 0.21^c
40% L	84.25 ± 1.76^b	4.75 ± 0.27^b	4.85 ± 0.36^a	0.36 ± 0.04^b	58.92 ± 0.79^c	2.79 ± 0.21^a	21.26 ± 0.12^a
40%C	93.25 ± 1.19^a	4.32 ± 0.41^b	4.64 ± 0.09^a	0.45 ± 0.04^a	63.91 ± 0.78^b	2.06 ± 0.09^b	19.02 ± 0.5^b

Data are presented as means ± SDM (n=3) & Means within a column with different letters are significantly different at *P ≤ 0.05.*

3.5. Proximate chemical composition of highly accepted puffed flakes

The proximate chemical composition of different puffed flakes samples is shown in Table (5), there were significant (*P ≤ 0.05*) differences in the protein contents of control puffed flakes (6.36%) and other samples, which were (14.59 and 13.99%) for puffed flakes 40%L and puffed flaked 40%C, respectively. Puffed Flakes 40%C contained the highest contents of ash, fat, and crude fiber compared with that other different puffed flakes samples. In addition, there were significant differences in the nutrient contents of all samples. The results of analyzing crude protein showed that samples containing chickpea or yellow lentils are higher than the 100 %rice control sample as expected. The sample with 40%L had a higher amount of protein (14.59%) followed by 40%C (13.99%), which was a 6.36%, in control sample. These findings agree with Iwe *et al.* (2016) who reported that the protein content of the blends increased with every level of legume flour substitution. This increase was expected because legume flours contain more protein than rice flour hence the attendant synergistic effects of protein complementation.

Table 5: Proximate chemical composition of highly accepted puffed flakes

Samples	Moisture (%)	Crude Protein (%)	Crude fiber (%)	Ash (%)	Fat (%)	Total Calories
control	9.49 ± 0.27^a	6.36 ± 0.14^b	0.78 ± 0.03^c	0.56 ± 0.05^c	0.66 ± 0.05^c	767.34 ± 0.98^a
40%L	9.55 ± 0.23^a	14.59 ± 0.54^a	1.93 ± 0.08^b	1.60 ± 0.07^b	1.00 ± 0.08^b	704.39 ± 0.95^b
40%C	9.52 ± 0.04^a	13.99 ± 0.49^a	3.85 ± 0.09^a	2.72 ± 0.11^a	2.67 ± 0.15^a	671.89 ± 0.98^c

Data are presented as means ± SDM (n=3) & Means within a column with different letters are significantly different at P ≤ 0.05.

Galani *et al.* (2017) reported that supplementation with a very high protein crop suitable as weaning foods is necessary to solve the starvation and obesity problems in the world. This supplementation was a formulation of cereal legume blends for children of weaning age.

The ash contents of the samples ranged between 0.56 and 2.72%. The control had the lowest, while 40%C had the highest value. This result agreed with Hamid *et al.* (2019) who reported that it may be attributed to the high ash content of legumes which had a greater effect on the rice flakes. In addition, there were no significant differences in the moisture contents of the samples. For crude fiber and fat content 40%C contained highest values (3.85- 2.67%) followed by 40%L (1.93-1.0) and control sample (0.78- 0.66%). Also, for total calories, there were significant differences between samples in which control (767.34) exhibited the highest value followed by 40%L (704.39) and at last 40%C (671.89).

3.6. Amino Acids (g/100g protein) of highly accepted puffed flakes

These for, amino acid composition, chemical score, and biological value of produced puffed flakes were determined in comparison with the control one (Table 6). The obtained results revealed that 40% L showed higher amounts of essential and non-essential amino acids compared with control. The total essential amino acids were found in the amount of 36.1g/100g protein for 40%L which was about 17.6 for control, followed by 40%C, which were 35.9. 40%L is characterized by the highest amount of methionine, leucine, glutamic, aspartic, proline, serine, arginine, and histidine by about 2.8, 7.7, 17.2, 11.9, 4.9, 5.1, 9.9 and 2.7 (g/100g protein), respectively.

Chemical scores reflect the amount requirements of the essential amino acids as reported by FAO/WHO (2007) which ranged from 1.0% to 80%, 47.54% to 146.43%, and 47.54% to 157.14% for the control, 40%L and 40%C, respectively. The highest value is related to the amount of the essential amino acid. Total nonessential amino acids showed values of 24, 56.9, and 53.8 g/100g proteins for rice, yellow lentil and chickpea puffed flakes, respectively. The increases in essential and nonessential amino acids reflect the protein content and quality of yellow lentil and chickpea substitution. The biological value reached its maximum value (101.8%) for 40%C and 100.9% for 40%L which was about 51.9% for control. This means that chickpea and yellow lentil protein are easily digested and utilized.

Table 6: Amino acids composition (g/100g protein) of highly accepted puffed flakes

Essential Amino Acids	Control	40%L	40%C	FAO/ WHO*	Chemical score control	Chemical score 40%L	Chemical score 40%C	Non-essential Amino Acids	Control	40%L	40%C
Lysine	1.4	6.9	7.0	5.8	24.14	118.9	120.7	Glutamic	4.3	17.2	16.7
Methionine + cystine	2.5	2.8	2.2	2.5	1.00	112.00	88.00	Aspartic	3.7	11.9	10.9
Isoleucine	1.9	4.1	4.4	2.8	40.77	146.43	157.14	Proline	2.1	4.9	4.7
Leucine	4.9	7.7	7.5	6.6	74.24	116.70	113.64	Alanine	5.6	4.5	4.6
Phenylalanine	0.8	5.7	5.8	6.3	12.70	90.48	92.06	Glycine	2.5	3.8	4.7
Tyrosine	3.5	2.9	2.9	6.1	57.38	47.54	47.54	Serine	4.9	5.1	4.9
Threonine	1.5	4.3	4.4	3.4	44.12	126.47	129.41	Arginine	1.6	9.9	8.3
Valine	2.8	4.6	4.9	3.5	80.00	131.43	140.00	Histidine	1.6	2.7	2.6
Total essential amino acids	17.6	36.1	35.9	_	_	_	_	Total Non-essential amino acids	24	56.9	53.8
Biological value%	51.9	100.9	101.8	-	-	-	-	-	-	-	-

3.7. Minerals contents (mg /100g) of highly accepted puffed flakes

Minerals contents (mg /100g) of produced puffed flakes are presented in Table (7). Concerning minerals, the substituted flakes (with chickpea or yellow lentil) show a higher content of different minerals compared with the control, the minerals content were 0.60, 7.65, 4.91, 124.60, 11.00, 960.00, 451.40, 60.60 and 1.74 mg /100g for Cu, Fe, Zn, Mg, Na, K, P, Ca and Mn respectively, for 40% L, as for the 40%C it's were 0.67, 4.40, 2.81, 81.70, 29.00, 722.00, 252.40, 61.60 and 21.65 mg/100g, respectively. This means that the produced flakes are characterized by high nutritive value.

Zeinab (2017) and Madar and Stork (2002) reported that legumes may provide sufficient amounts of minerals to meet human requirements. The values of mineral content are lower than the values recommended by the United States Recommended Dietary Allowance (UNRDA). The results presented here exhibited that each 100g of the formulated samples can provide about 44 – 76.5% of the USRDA requirement of iron, 23.42-40.92% of the USRDA requirement of Zn, 29.18-44.5% of the RDA requirement of Mg, 2.2-5.8% of the RDA requirement of Na, 6.06-6.16% of the USRDA requirement of Ca and 87-10 times of the RDA requirement of Mn. On the other hand, the values of Potassium K contents represent about 144 to 192 times RDA requirements (5mg/100g). Therefore, these flakes cereal- legume blends products with high nutritional value especially protein and mineral contents can be used by both adults and children alike because they are considered to be healthier types of ready-to-eat food (Rehab *et al.,* 2017).

Table 7: Minerals contents (mg /100g) of highly accepted puffed flakes

Element	Control	40%L	40%C	USRAD*
Copper Cu	0.20	0.60	0.67	-
Iron Fe	1.70	7.65	4.40	10-15
Zink Zn	1.36	4.91	2.81	12-15
Magnesium Mg	3.40	124.60	81.70	280-350
Sodium Na	28.00	11.00	29.00	500
Potassium K	79.00	960.00	722.00	3-5
Phosphorus P	0.13	451.40	252.40	-
Calcium Ca	22.40	60.60	61.60	1000
Manganese Mn	0.40	1.74	21.65	2-5

*UNRDA- Recommended Dietary Allowance day (mg/kg body weight/day).

4. Conclusion

Different grinding methods indicated variations in Moisture, amylose content, particle size, and color measurements characteristics of broken rice flours. The semi-dry and wet grinding methods resulted in smaller particle size. Broken rice flour obtained by semi wet method was the best way to get finer and brighter rice flour with higher yield. Produce high nutritional puffed rice flakes with chickpea or yellow lentil flour at 40% replacement of broken rice flour.

This study showed that nutritious flakes rice can be produced from blends of rice with yellow lentil or chickpeas. The results showed that formulated samples at 40% replacement of broken rice flour were found to be satisfied acceptable, high in protein contents (13.99% to 14.59 %), crude fiber (1.93% to 3.85) and ash content (1.60% to 2.72%). Moreover, these blends were high in amino acids and minerals. Therefore, these cereal- legume blends products can be used by both adults and children alike because they are considered to be healthier types of ready to eat foods. Thus these products can be used as food ingredients for people with gluten-related diseases (Celiac disease).

It can be recommended that, it could utilize broken rice flour (by product) to produce high nutrition rice puffed flakes inceptions with 40% replacement of chickpea or yellow lentil flour.

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