Nutritive Value, Protein Quality and Acceptability of Rice Cakes Fortified with Legumes

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ABSTRACT

Leguminous flour are ideal ingredients for improving the nutritional value of bakery products because of their amino acid composition and fiber content. The aim of the study was to evaluate partial replacement of rice flour with chickpea, lentil, and white beans flours in preparing cakes in terms of protein quality and organoleptic properties. Rice cakes were prepared by supplementing with 20%and 40% of chickpea, lentil, and white beans flours. Supplementation resulted a significant different ($p<0.05$) increase in protein and amino acids contents especially in lysine and threonine contents, the most liming amino acids in rice flour cakes samples. Data of acceptability indicated that there the differences were increased in the mean scores for taste, color, odor, texture, and overall acceptability a significant different ($p>0.05$) in some cakes. The study recommends that using composite flour should be encouraged among food industries to produce good quality, acceptable and nutritious palatable cakes.

Keywords: Rice flour, legumes flour, protein quality, sensory evaluation.

INTRODUCTION

There are numerous protein-calorie malnutrition problems over the world particularly vulnerable groups including women and children. Legume may be helpful and play an important role in solving this problem. Legume protein is the essential protein suitable to complement the protein content present in cereals grains. In the addition, legume grains are familiar as they are a Legume protein is the essential protein suitable to completeness the protein contented Present important part of human food (Ribeiro and Melo 1990). So they are useful in advance the protein contented of the human food as they contain approximately three times more proteins than cereals (Karadavut and Genc 2010) and Amjad et al., 2006). Legumes considered together with cereals, the main plant source of a perfect protein in the human food. It is giventhat the nutritive value of protein depends upon the quality and quantity of the amino acids suitable to the body. Legume proteins can be successfully used in baked products to obtain a protein-enriched product with improved amino acid balance (Bojnanská et al. 2012; Mohammed et al. 2012).

Rice is one of the most frequently used cereals in gluten-free food products due to its low levels of sodium, protein, fat, fiber and high amount of easily carbohydrates (de la Hera et al. 2013). The enrichment of gluten-free baked products has proved to be necessary in gluten-free adherence diets, since consumers have generally a low intake of nutrients that have been associated to gluten-free diet (Torbica et al. 2010). Therefore, a recommendation was made regarding the nutritional adequacy of various gluten-free foods, and consumption of whole-grain or enriched products was encouraged. Gluten-free baked goods are mainly based on starchy compounds, and in consequence starch digestibility could be an important parameter when determining the nutritional quality of those products (Carey et al. 2018).

One of the most necessary properties of legume proteins is their high content of the essential amino acid lysine and their deficiency in Sulfur-containing amino acids, which cause them a great completeness to other well-known cereal proteins (rice) which are deficient in lysine, but have useful Sulfur amino acid content (Eggum and Beames 1983; Rochfort and Panozzo 2007). Legumes including chickpea, lentil and white beans are important crops because of their nutritional quality. They are rich sources of complex carbohydrates, vitamins and minerals (Wang et al. 2010) as well as dietary fibers. The present study was done to evaluate the sensory and quality attributes of rice flour cake substituted with legumes flours (chickpea, lentil and white beans flour).

MATERIALS AND METHODS

1. Materials

Rice flour, and legumes seeds (chickpea, lentil and white beans) sugar, butter, milk, egg, baking powder were purchased from the local market of EL-Behaira Governorate, Egypt.

2. Preparing of legumes flour blends

Legumes seeds (chickpea, lentil, and white beans) were soaked in distilled water for 12h at room temperature (25°C). The soaked seeds were dried in oven (105°C). Legumes seeds were milled; the flour was referred as white chickpea, lentil, and white beans flour. The coarse fraction was ground again in a laboratory mill. The obtained flour from the second milling was used to prepare the needed flour blends (Marero et al. 1988).

3. Preparing of blended flour

Preparation of blended flour was done by mixing the rice flour with each of chickpea, lentil, and white beans flours at two different ratios (20%and 40%). These two levels were chosen from higher percentages of legumes flour including 60, 80, and 100% which were excluded after a preliminary experiment. The level of 60% produced undesirable cakes, while 80% and 100% levels did not produce successful batter. The final flour of each type was blended to ensure the homogeneity of the mixture and was kept individually in polyethylene bags in the refrigerator for further usage (Krishnan et al. 2011).

4. Preparing of cakes

Preparation of the fortified cake with each of the blended flour using 20% and 40% of each chickpea, lentil, and white beans individually was done according to Penfield and Campbell (1990)**.** The standard formula used is presented in Table 1. The backed cakes were removed from the pans and left for 1h at room temperature for cooling. The cake sample placed on coded white plastic plates and sealed with plastic wraps to prevent from drying till further evaluation.

5. Sensory evaluation of the cakes

The sensory characteristics were evaluated by 40 persons from staff and students of Faculty of Specific Education, Alexandria University. Parameters including taste, color, texture, odor and the overall acceptability. The 9-point hedonic scale ranging from 1(representing extreme dislike) to 9(representing extreme like) was used to evaluate the sensory attributes.

6. Proximate composition

Moisture, protein, ash and fat were determined following standard AOAC, with Anderson (2007). Total carbohydrates were calculated by difference. Amino acids were determined by using Eppendorf-Germany LC3000 Amino acid analyzer apparatus at the National Research center, Dokki, Cairo.

7. Protein quality

Due to the importance of the protein in the human diet it is important to scrutinize their protein quality by determining their amino acids contents, with emphasis on the essential amino acids. It is known that the nutritive value of protein depends upon the quality and quantity of amino acids convenient to the body. It is assumed that the chemical analysis reveals all the amino acids of the protein which liberated and absorbed from the gastrointestinal tract. In addition, it is important to estimate the amino acid pattern derived from the chemical analysis and compared to reference protein (Akeson and Stahmann 1964; Bukau et al. 2006) (Lotfy and Nawar, 2014). Amino acids were determined as mentioned above by using Eppendorf-Germany LC300 Amino acids analyzer apparatus at the National Research center, Dokki, Cairo.

8. Evaluation of amino acids pattern

Amino acid pattern was evaluated by using threonine as a unity, was done according to (Weikert and Schulze 2016).

9. Statistical Analysis

The statistical analysis was performed using the SPSS (Statistical Package for Social Sciences, USA) 25.0 software. Analysis of variance (ANOVA) of the data was conducted and means property values were separated ($p \leq 0.05$) with LSD test for the property values. Differences were considered significant at $p \leq 0.053$.

RESULTS AND DISCUSSION

1. Proximate chemical composition analysis of prepared cake

Chemical composition of rice and legumes flour are summarized in Table 2. Lentil flour contained considerably higher protein contain (24.2%), followed by chickpea flour (23.00%), then white beans flour which contained (22.7%) protein. It was found that white beans flour had higher content of ash (3.5 %) and moisture (10.1%) than rice flour (8.00 %). Ash, (0.7 %) and fat (0.6 %) were the lowest.

Table 1. Ingredients of the standard and experimental cakes prepared and 20 and 40%of each

Samples / Ingredients	A	B	C	D	E	F	G
Rice flour	150	120	90	120	90	120	90
Chickpea flour	-	30	60	-	-	-	-
Lentil flour	-	-	-	30	60	-	-
White beans flour	-	-	-	-	-	30	60
Milk	120	120	120	120	120	120	120
Sugar	190	190	190	190	190	190	190
Egg	125	125	125	125	125	125	125
Margarine	125	125	125	125	125	125	125
Vanilla essence	5	5	5	5	5	5	5
Baking powder	8	8	8	8	8	8	8

Table 2. Chemical composition of Rice flour and legumes flour

Sample	Ash	Moisture	Fat	Protein	carbohydrate
Rice	0.7	12	0.6	8.00	80.1
Chickpea	3.2	8.85	5.2	23.00	59.4
Lentil	2.7	9.3	2.4	24.2	63.8
White beans	3.5	10.1	1.6	22.7	62.2

On the other hand, rice had the highest content of carbohydrates (80%) and moisture content. The results of Mohammed et al. (2012) and Iqbal et al. (2006) on chemical composition of lentil seed flour are comparable with our results. Also, the data in Table 2 indicate that the combination of legumes with rice flour increased the ash, fat, and protein. On the other hand, the moisture and carbohydrates content were reduced. It can be observed that the highest increase in ash, fat, and protein contents were in the cakes of white beans, chickpea, and lentil, respectively (Alabi and Anuonye 2007), Shahzadi et al. (2005). reported that legumes with high protein content are widely used as composite flour in the production of bakery products, the protein content and quality of cake can be improved by substituting cereal with legumes.

2. Sensory evaluation

Sensory evaluations results of cake are presented in Table 3. The best acceptability was for experimental cakes (G) which containing 20% white beans followed by (B) containing 20% chickpea. The lowest liked one was cake (C) containing 40% chickpea followed by cake (E) containing 40% lentil. The results of the present study were in agreement with these of El-Beltagi et al. (2017) who reported that, organoleptic properties (color, odor, taste, texture and overall acceptability were improved in proportion of added chickpea and white beans flour. On the other hand Alabi and Anuonye (2007) reported that up to 50% of some legumes products could be added without significant loss in palatability.

3. Amino acids contents

Amino acids contents of cakes are shown in Table 4. The data revealed that supplementation caused increases in all amino acids contents. The ratios between the TEAA to the TNEAA are closely similar in all cases. When considering the increase in individual amino acids it can be noticed from Table 4 that the amino acids leucine and isoleucine were the highest in the case of white beans supplements. The trend in the EAA increased in all experimental cakes compared with rice control cake. Supplementation with chickpea caused the highest increase in threonine, aromatic amino acids, total sulfur amino acids and valine. Also increase TEAA and TNAA were the highest. In the case of lentil supplementation, it causes increase in lysine only.

4. Nutritional quality

Protein quality is affected by essential amino acid composition, amino acid imbalance, digestibility and biologic accessibility of the amino acids and by the anti-nutritional activity of some components of the seeds (Deshpande and Damodaran 1990), (Lotfy and Nawar, 2014). In general, legumes are rich in lysine, but deficient in sulfur containing amino acids (methionine and cystine). The data in Table 5 revealed that amino acids content of legumes flour cakes was higher than rice cake. These results are agreed with those of Bhatty et al. (1976) who studied the quality of protein using the chemical score method, they found that the protein quality of chickpea, lentil, and white beans flours were rich in essential amino acids (isoleucine, lysine, and total aromatic amino acids) compared with the reference pattern, while cereals such as rice are low in (lysine and total protein content). However, leucine, total sulfur amino acids, threonine, and valine were slightly deficient in chickpea and white beans protein, also lentil is deficient in sulfur containing amino acids (methionine and cystine) compared with the reference pattern.

Table 3. Sensory evaluation of cakes made by rice flour with legumes flour

Cake	Color	Taste	Odor	Texture	Acceptability
A	$3.6^{e} \pm 2.31$	$3.0^{e} \pm 2.70$	$1.67^{f} \pm 0.57$	$2.6^{d} \pm 1.91$	$3.6^{d} \pm 1.5$
B	$8.0^{a} \pm 2.73$	$7.0^{a} \pm 2.13$	$7.0^{b} \pm 2.86$	$7.0^{a} \pm 2.8$	$7.0^{b} \pm 2.9$
C	$4.0^{d} \pm 3.5$	$3.0^{e} \pm 2.15$	$3.0^{e} \pm 3.20$	$3.0^{c} \pm 3.3$	$3.0^{e} \pm 2.9$
D	$6.0^{c} \pm 2.57$	$5.0^{c} \pm 19.0$	$6.0^{c} \pm 1.60$	$6.0^{b} \pm 2.70$	$6.0^{c} \pm 2.3$
E	$3.8^{d} \pm 2.6$	$3.6^{d} \pm 2.5$	$4.9^{d} \pm 2.30$	$3.2^{c} \pm 2.2$	$3.0^{e} \pm 2.3$
F	$7.0^{b} \pm 2.11$	$6.0^{b} \pm 2.75$	$7.0^{b} \pm 2.9$	$6.0^{b} \pm 2.75$	$7.0^{b} \pm 2.11$
G	$6.8^{b} \pm 1.77$	$7.7^{a} \pm 1.04$	$8.7^{a} \pm 1.51$	$7.4^{a} \pm 1.06$	$8.2^{a} \pm 1.04$

Values are mean of three replicates and are given as mean ± standard error. Different letters in the same column indicate significant differences according to LSD test ($P \leq 0.05$).

(A) controlrice 100%, (B) rice + chickpea 20%, (C) rice + chickpea 40%, (D) rice + lentil 20%, (E) rice + lentil40%, (F) rice + white beans 20%, (G) rice + white beans 40%

Table 4. Amino acids contents of experimental cakes (mg\100mg sample)

Cakes / EAA	Rice control	80%RF+20%CF	80%RF+20%LF	80%RF+20%WBF
Isoleucine	0.44	0.64	0.61	0.65
Leucine	0.96	1.29	1.24	1.34
Lysine	0.33	0.68	0.69	0.55
Threonine	0.35	0.54	0.52	0.50
Total aromatic	1.08	1.49	1.31	1.47
Total sulfur	0.42	0.53	0.38	0.52
Valine	0.63	0.89	0.80	0.86
TEAA	4.2	6.07	5.45	5.88
TNAA	6.48	9.55	8.55	9.39
TEAA/TNEAA	0.64	0.63	0.64	0.62

Mean followed by different letters in the same column RF: Rice flour, CF: chickpea flour, LF: lentil flour, WBF: white beans flour and EAA: Essential amino acids.

Table 5. Amino acids pattern using threonine as unity compared to egg protein as a reference.

Amino acids	Rice control	80%RF+20%CF	80%RF+20%LF	80%RF+20%WBF	egg
Isoleucine	1.26	1.19	1.17	1.33	1.23
Leucine	2.74	2.39	2.38	2.73	2.01
Lysine	0.94	1.26	1.33	1.12	1.57
Total aromatic	3.08	2.76	2.5	3	2.4
Total sulfur	1.2	0.98	0.73	1.06	1.27
Valine	1.8	1.65	1.54	1.76	1.66
Threonine	1	1	1	1	1

Mean followed by different letters in the same column RF: Rice flour, CF: chickpea flour, LF: lentil flour, WBF: white beans flour.

Therefore, the present study results show that the white bean, chickpea, and lentil are could complements to cereal protein which is low in lysine as reported by (Alabi and Anuonye 2007; Shahzadi et al. 2005). So, when a composite flour is prepared by blending rice and legumes in proper proportion can provide the body with the required amino acids.

Concerning none essential amino acids NEAA, they are important for the body. Though the body can synthesis them but their presence spare the EAA for their functions instead of using them in making NEAA. The NEAA as reported by Lotfy and Nawar (2016) and Nawar(2004).

5. Amino acids pattern of cakes

Amino acids pattern of prepared cakes was presented in Table 5. The data show that the pattern of amino acids of the control and experimental cakes as compared to that of egg protein as a good quality protein highly utilized to the body. In other words, studying the effect of supplementing rice flour with legumes flour on its protein quality.

Gómez et al. (2008) studied, the influence of the total or partial replacement of wheat flour by chickpea flour on the quality characteristics of two kinds of cake was analyzed. The effects of the chickpea variety and the kind of flour used (white or whole) were also considered. Volume, symmetry, chroma, and crust and crumb L^* diminished when increasing the amount of chickpea flour. The replacement of wheat flour by chickpea flour also induced an increase in the initial firmness but cohesiveness and resilience diminished, increasing the tendency to hardening. Among the studied varieties, Pedrosillano and Sinaloa produced cakes with the highest volume. Those varieties also gave layer cakes with the lowest firmness, gumminess and chewiness. White flours produced sponge cakes with higher volume and symmetry than whole flours. No significant differences, however, were observed in layer cakes between white and whole flours. In both layer and sponge cakes, white flour produced cakes with lower firmness, gumminess and chewiness than whole flours.

CONCLUSION AND RECOMMENDATIONS

It has been observed that it is possible to use legumes flour mixed with rice flour in the making of different kinds of cakes. Nevertheless, in general, when the substitution percentage of rice flour by legumes flour increased, the decrease in cake volume and symmetry is observed, the texture became firmer, more gummy and less cohesive. The nutritional value of prepared cake was higher than control cake, also the good acceptability in sensory evaluation from all taste panel participants.

REFERENCES

Akeson WR, Stahmann MA (**1964**). A pepsin pancreatin digest index of protein quality evaluation. The Journal of nutrition **83(3)**: 257-261

Alabi M, Anuonye J (**2007**). Nutritional and sensory attributes of soy-supplemented cereal meals. Journal of AOAC International **(2007)90(4)**: 1073-1083

Amjad I., A.K. Iqtidar, A. Nadia and M.S. **2006**. Nutritional quality of important food legumes. Food Chem., **97**: 331–335

Bhatty R, Slinkard A, Sosulski F (**1976**). Chemical composition and protein characteristics of lentils. Canadian Journal of Plant Science **56(4)**: 787-794

Bojnanská T, Francáková H, Lísková M, Tokár M (**2012**). Legumes-The alternative raw materials for bread production. The Journal of Microbiology, Biotechnology and Food Sciences **1**: 876

Bukau B, Weissman J, Horwich A (**2006**). Molecular chaperones and protein quality control. Cell **125(3)**: 443-451

Carey M, Donaldson E, Signes-Pastor AJ, Meharg AA (**2018**). Dilution of rice with other gluten free grains to lower inorganic arsenic in foods for young children in response to European Union regulations provides impetus to setting stricter standards. PloS one **13(3)**: e0194700

De la Hera E, Gomez M, Rosell CM (**2013**). Particle size distribution of rice flour affecting the starch enzymatic hydrolysis and hydration properties. Carbohydrate polymers **98(1)**: 421-427

Deshpande S, Damodaran S (**1990**). Conformational characteristics of legume 7S globulins as revealed by circular dichroic., derivative uv absorption and fluorescence techniques. Chemical Biology & Drug Design **35(1)**: 25-34

Eggum B, Beames R (**1983**). The nutritive value of seed proteins Seed Proteins. Springer, p 499-531

El-Beltagi HS, El-Senousi NA, Ali ZA, Omran AA (**2017**). The impact of using chickpea flour and dried carp fish powder on pizza quality. PloS one **12(9)**: e0183657

Gómez M, Oliete B, Rosell CM, Pando V, Fernández E (**2008**). Studies on cake quality made of wheat–chickpea flour blends. LWT-Food Science and Technology **41(9)**: 1701-1709

Lotfy, T. M. R. and Nawar, I. A. (**2014**). Codification of food and meal management. Bostan El-Marefakafer-eldawar (In Arabic).

Lotfy, T. M. R. and Nawar, I. A. (**2016**). Introduction to Home Economics. Dar El-Marefa Al-Gameea, Alexandria (In Arabic).

Karadavut U, Genc A (**2010**). Relationships between chemical composition and seed yield of some lentil (Lens culinaris) cultivars. International Journal of Agriculture and Biology **12(4):** 625-628

Krishnan R, Dharmaraj U, Manohar RS, Malleshi N (**2011**). Quality characteristics of biscuits prepared from finger millet seed coat based composite flour. Food Chemistry **129(2)**: 499-506

Marero L, Payumo E, Aguinaldo A, Homma S (**1988**). Nutritional characteristics of weaning foods prepared from germinated cereals and legumes. Journal of food science **53(5)**: 1399-1402

Mohammed I, Ahmed AR, Senge B (**2012**). Dough rheology and bread quality of wheat–chickpea flour blends. Industrial Crops and Products **36(1)**: 196-202

Nawar, I. A., **2004**. Food and nutrition. Dar EL-Marefa Al-Gameea, Alexandria (In Arabic).

Penfield MP, Campbell AM (**1990**). Experimental food science. Academic press

Ribeiro R, Melo I (**1990**). Composition and nutritive value of chickpea. Options Méditerranéennes-Série Séminaires **9**: 107-111

Rochfort S, Panozzo J (**2007**) Phytochemicals for health, the role of pulses. Journal of agricultural and food chemistry **55(20)**: 7981-7994

Shahzadi N, Butt MS, Sharif K (**2005**). Rheological and baking performance of composite flours. International Journal of Agriculture and Biology (Pakistan)

Torbica A, Hadnađev M, Dapčević T (**2010**). Rheological, textural and sensory properties of gluten-free bread formulations based on rice and buckwheat flour. Food hydrocolloids **24(6-7)**: 626-632

Wang N, Hatcher D, Tyler R, Toews R, Gawalko E (**2010**). Effect of cooking on the composition of beans (Phaseolus vulgaris L.) and chickpeas (Cicer arietinum L.). Food Research International **43(2)**: 589-594

Weikert C, Schulze MB (**2016**). Evaluating dietary patterns: the role of reduced rank regression. Current Opinion in Clinical Nutrition & Metabolic Care **19(5)**: 341-346

الملخص العربى

القيمه الغذائيه وجودة البروتين والتقبل لكيك الأرز المدعم بالبقوليات

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إستهدف البحث إعداد كيك مدعم بدقيق الحمص والعدس والفاصوليا البيضاء مع دقيق الأرز بنسب ٢٠ – ٤٠% وتحليل الخصائص الكيميائيه لدقيق البقوليات والأرز والأحماض الأمينيه مثل الليثين ويحتوى على نسب عاليه من الأحماض الكبريتيه ومن جانب آخر تعتبر البقوليات مصدر غنى بالبروتين حيث تحتوى على نسب عاليه من الليثين ولكنها تحتوى على نسبه منخفضه من الأحماض الكبريتيه (الميثونين – السيستين). أوضح التدعيم زيادة فى الأحماض الأمينيه خاصة الليثين والميثونين لعينات الكيك.

أوضحت نتائج تقييم الخصائص الحسيه للعينات القبول العام والتذوق والشكل فى عينات الكيك المعده بنسبة ٢٠% من خليط دقيق الرز مع الحمص ودقيق الأرز مع العدس.

الكلمات الدليلية: دقيق الأرز – دقيق البقوليات – جودة البروتين – الأحماض الأمينيه – الخصائص الحسيه.