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Physiochemical, Nutritional and Technological Properties of Instant Porridge Supplemented with Mung Bean

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Abstract

The present study was undertaken to prepare instant porridge from some useful and available ingredients such as bulgur powder, potato, tomato, carrot, mung bean (unsoaked, soaked and germinated), then seasoned with onion, garlic, salt, black pepper, cumin and coriander to make B1, B2 and B3 formulas. Chemical, physical properties, amino acids and sensory evaluation of instant porridge formulas were determined. The data showed that B2 formula which contained soaked mung bean had the highest calories value, total essential amino acids, biological value and water absorption index (WAI) compared to the other formulas, also it is recorded the highest degree of lightness L^* values (82.39 and 56.65), least redness a^* values (0.98 and 1.45) and intermediate in yellowness b^* values (25.91 and 24.45) before and after rehydrated, respectively. Regarding to sensory evaluation, there was a significant increase in color, taste and overall acceptability in B2 compared to the other formulas. Based on these results, revealed that the soaked mung bean was a good source of essential amino acid and calories to enhance nutritional and technological quality of the resultant porridge.

Keywords

Mung Bean, Germination, Porridge, Nutritional Value, Sensory Evaluation

1. Introduction

Dried foods are considered instant food which preparation that meets the needs of consumers due to the changing conditions of modern life and the increase in the number of consumers who live alone and the lack of time to prepare meals, which led to an increase in request for these products. The advantages of dry foods are flavor stability in room temperature levels over long periods of time up to (6 - 12 months), and it is protected from enzymatic and oxidative activity damage [1].

The dried porridge is a semi-solid food [2]. It is prepared by adding flour to boiling water and stirring till it form homogenous thick gelatinized cluster free from agglomerate. Thick porridge is the source of calories, also recommended as a healthy food for the management of some non-communicable diseases such as type II diabetes [3]. Traditional porridge in developing countries is based on native wheat, rice, millet, sorghum, maize, cassava, and potato also, it is a suitable food for weaning infants and convalescent elderly due to easy digestibility [4].

Cereals are good source of carbohydrates and proteins, vegetables complement the vitamins, antioxidants, fiber and phytochemicals therefore, a balance of nutrients may be obtained by integration of cereals and vegetables in the number of products [5].

Legumes are used to prepare foods alone or with cereals because cereal proteins are deficient in some essential amino acids, while legumes are good sources of carbohydrates, proteins, minerals, and vitamins. Legumes are consumed after processing such as dehulling, soaking and germination, which lead to improve palatability of foods and increase the bioavailability of nutrients [6]. Germinated legumes are used as an alternative in the food, one of the advantages of seed germination reduce the anti-nutritional factors and increase in the bioavailability of vitamins, carbohydrates, and polyvalent minerals such as calcium, iron, and magnesium [7].

Mung bean (*Vigna radiata* L.) is cultivated widely in South East Asia because their grains are rich in protein. The main advantages of mung bean are that, a legume does not require fertilization for nitrogen, require a little water, has a short growth cycle (75 - 90 days) and grows well in dry and semi-arid conditions and it is often grown in agricultural rotation with crops cereals like wheat and rice [8]. Recently, mung bean has been incorporated successfully in the Egyptian agriculture to overcome the nutritional gap [9]. Department of Agronomy, National Research Centre produced variety (kawmy-1) has duration (90 - 110 days) during the ninety's under clay soil conditions. These efforts adopted mung bean as a summer crop for most varieties around mid-May, but it did not fit well for cultivation in maize-wheat cropping system. Therefore, Agricultural Research Station, National Research Centre, El Nubaria Province, El Behaira Governorate, Egypt successfully generated genotypes under newly reclaimed sandy soil conditions that can be cultivated after harvesting of early summer crops (cereals cultivation) [10].

Bulgur production and consumption are increased due to its low cost, long shelf life, ease of preparation, taste, color, flavor, aroma, texture, high nutritional and economic values, also it contain protein, fat, carbohydrate, ash, fiber, calcium and iron [11].

Cereals with legumes are considered complementary to nutritional quality due to the higher content of high biological value proteins [12]. Therefore, this research aims to prepare instant porridge formulas by adding soaked and germinated mung bean with some vegetables and estimating their chemical, physical, technological quality and sensory properties of the resulting porridge.

2. Materials and Methods

2.1. Materials

Raw Materials and Ingredients

Wheat bulgur, tomato, potato, carrot, black pepper, coriander, cumin, salt, onion and garlic powder were purchased from local market, Giza, Egypt. Mung bean Varity (Giza 1) was obtained from legume research department, Field Crops Research Institute, Agricultural Research Center.

2.2. Methods

2.2.1. Soaking and Germination Process of Mung Bean

Mung bean was sorted and washed with tap water, then soaked for 12 hr. at room temperature. The soaked mung bean was placed in wet cloth and left for germination 48 hr. at room temperature Yasmin *et al.* [13].

Unsoaked, soaked and germinated mung bean were cooked in boiling water at 100˚C for 45 min for unsoaked and 30 min for soaked and germinated mung bean then washed in cold water, then dried with hot air flow using air oven at 65˚C in the first four hours and then reduced to 50˚C till completely drying until constant weight. The dried samples were ground into powder using a grinder and sieved (250 micron) for identical size particles, then packed in polyethylene bags and kept in deep freezer for till using.

2.2.2. Preparation of Raw Materials and Ingredients

Potato, tomato and carrot were sorted and washed, then the potato and carrot were peeled and sliced in cubic form and blanched in hot water at 100˚C for 10 - 15 min, then the tomato was peeled. Wheat bulgur was soaked for 6 hr. then cooking in boiling water at 100˚C for 30 min. All ingredients washed in cold water after boiling process, then dried with hot air flow using air oven at 65˚C in the first four hours and then reduced to 50˚C till completely drying to constant weight. The dried samples were ground into powder using a grinder and sieved (250 micron) for identical size particles, then packed in polyethylene bags and kept in deep freezer for till using.

2.2.3. Preparing of Instant Porridge Formulas

All ingredients were spiced with onion and garlic powders, coriander, black pepper, cumin and salt to get three formulations of instant porridge, B1 had 30% unsoaked mung bean, B2 had 30% soaked mung bean and B3 contained 30% of the germinated mung bean as shown in Table 1. The obtained formulas were packed in polyethylene bags and kept in deep freezer for till using.

Table 1. Formulas of instant porridge (g/100g).

Formulas Ingredients	B1	B2	B3
Wheat Bulgur	20.0	20.0	20.0
Potato	25.0	25.0	25.0
Tomato	5.0	5.0	5.0
Carrot	14.0	14.0	14.0
Onion	1.20	1.20	1.20
Garlic	0.75	0.75	0.75
Salt	3.0	3.0	3.0
Black pepper	0.35	0.35	0.35
Cumin	0.35	0.35	0.35
Coriander	0.35	0.35	0.35
Unsoaked mung bean	30.0	-	-
Soaked mung bean for 12 hr.	-	30.0	-
Germinated mung bean for 48 hr.	-	-	30.0
Total	100.0	100.0	100.0

2.2.4. Chemical Composition

1) Chemical composition of dried instant porridge formulas

Moisture, crude protein, fat, crude fiber and ash contents were determined according to AOAC [14]. Total carbohydrates were calculated by difference.

2) Calories value

Calories value was calculated by James [15] as follows:

$$\text{calories value}(\text{Kca}/100\text{g}) = 4(\text{protein}) + 4(\text{carbohydrate}) + 9(\text{fat})$$

3) Amylose content

Amylose content was determined by the colorimetric method according to Kumari *et al.* [16].

4) Determination of amino acids profile

Amino acids profile were determined using an Amino Acid Analyzer (Biochrom 30) using the instruction manual according to AOAC [14].

5) Chemical score (CS)

Chemical score was calculated according to FAO/WHO [17].

$$\text{Chemical score}(\%) = (\text{EAA of crude protein}/\text{EAA of FAO/WHO}) \times 100$$

6) Biological value (B.V)

Biological value was positively correlated with the lysine concentration. It calculated according to Eggam *et al.* [18] as follows:

$$\text{Biological value}(\%) = 39.55 + 8.89 \times \text{lysine}(\text{g}/100\text{g protein}).$$

7) Minerals content

Minerals content were determined by using the flame photometer (Galien kamp, FGA 330, England) and Perkin Elmer Atomic Absorption Spectrophotometer.

(Model 80, England) as described in AOAC [14].

8) Determination of phytic acid content

The phytic acid content was determined according to Park *et al.* [19].

9) Tannins content

Tannin was determined by using the Vanillin-HCl method modified by Price *et al.* [20].

2.2.5. Physical Properties of Dried Instant Porridge Formulas

1) Water activity (a_w)

The water activity was measured using Rotronic Hygro lab CH-8303, Switzerland as mentioned by Cadden [21].

2) Color Measurement

External color was measured according to the method outlined by McGurie [22] using a hand-held Chromameter (model CR-400, Konica Minolta, Japan).

3) Water absorption index (WAI) and water solubility index (WSI)

WAI and WSI were determined as described by Silvia *et al.* [23]. One gram of dried instant porridge samples were suspended with 10 ml distilled water at room temperature for 30 minutes, gently stirred during this period and then centrifuge at 3000 rpm for 15 minutes. The supernatant liquid was poured carefully in to evaporating dish of known weight and dried at 110˚C to constant weight. The weight of the remaining gel was taken as WAI.

$$\text{WAI g/g} = \frac{\text{weight of remaining gel}}{\text{Weight of dry porridge sample}}$$

The amount of dried solids, recovered by evaporating the supernatant and expressed as percentage of dry solids was taken as WSI:

$$\text{WSI \%} = \frac{\text{weight of dried solid in supernatan}}{\text{Weight of dry porridge sample}} \times 100$$

4) Swelling power (SP)

SP determined with the method described by Oladele and Aina [24]. One gram of dried instant porridge samples were mixed with 10 ml distilled water in a centrifuge tube of known weight and heated at 90˚C for 30 min. This was continually shaken during the heating period. After heating, the suspension was centrifuged at 1000 rpm for 15 min. The supernatant was decanted and the weight of the porridge taken. The swelling power was calculated as:

$$\text{SP g/g} = \frac{\text{weight of the swollen porridge sample}}{\text{weight of dry porridge sample}}$$

5) Viscosity

The dried instant porridge formulas were placed in a water bath to maintain at 40˚C (the temperature at which viscosity measurement was taken). Brookfield viscometer DV-III ultra was used to measure the porridge viscosity (in centipoises, cps) using spindle at a shear rate of 50 rpm in 30 seconds. Brookfield Viscometer for all porridge formulas were measured according to Tizazu *et al.* [25].

2.2.6. Rehydration Ratio (RR)

RR was performed according to Huang *et al.* [26]. Two gram of dried instant porridge formulas were rehydrated in (20 ml) distilled water in a water bath at constant temperature and was agitated at constant speed. The samples were taken from the bath after 10 minutes and weight.

The rehydration ratio was defined as the ratio of weight of rehydrated samples to the dry weight of the samples. The rehydration ratio was calculated using weight of samples before and after rehydration as follows:

$$\text{RR ratio} = \frac{\text{W2} - \text{W1}}{\text{W1}}$$

W1 = the initial weight of the porridge samples;

W2 = the final weight of the porridge samples.

2.2.7. Preparing of Rehydrated Instant Porridge for Sensory Evaluation

The rehydrated instant porridge formulas were prepared according to Ocheme and Chinma [27]. 20 g of dried porridge was mixed with 100 ml of cold water to form slurry and stirred continuously for 10 min until the mixed completely converted into soft cooked porridge formed, at 100˚C to 120˚C. Then it was removed from the heater and allowed to cool to 30˚C to make ready to serve.

2.2.8. Sensory Evaluation of Rehydrated Instant Porridge

Sensory acceptability in terms of color, odor, taste and overall acceptability of porridge. The evaluation was carried out by ten panelists using hedonic scales in order to assess the acceptability of each product 1 to 9 (where 1 = very much disliked, 9 = very much liked,) according to Ocheme and Chinma [27].

2.2.9. Statistical Analysis

The obtained data were exposed to analysis of variance (ANOVA). Duncan is multiple range tests at ($P \le 0.05$) level was used to compare between means values according to Waller and Duncan [28].

3. Results and Discussion

3.1. Chemical Composition of Dried Instant Porridge Formulas

Data in **Table 2** showed that B1 formula had the lowest value of carbohydrate and amylose content, while B2 had the lowest value of ash and crude fiber. Our results agree with Wang *et al.* [29] who reported that the ash content after soaking was reduced. On the other hand the crude protein slightly decreased in B2 than B1, this might be due to leaching of soluble protein into soaking water [30]. While B3 was significantly decreased in fat, protein and calories value compared to B1 and B2, these reduction in protein and fat during the germination process may be due to the increased activity of the protease enzyme that breaks down the protein for use in growth sprouts [31] [32], the reduction in fat may be due to the oxidation of fats to carbon dioxide and water to produce the energy needed for germination [33] [34].

Table 2. Chemical composition of dried instant porridge formulas on dry weight basis.

Samples	Ash (%)	Crude fiber (%)	Fats (%)	Protein (%)	Carbohydrates (%)	Calories value kcal/100g	Amylose (%)
B1	2.17 ^{a} ± 0.04	2.54 ^{a} ± 0.02	2.28 ^{a} ± 0.02	13.59 ^{a} ± 0.05	79.42 ^{b} ± 0.08	392.56 ^{b} ± 0.58	16.63 ^{c} ± 0.17
B2	1.86 ^{c} ± 0.01	1.88 ^{c} ± .01	2.03 ^{b} ± 0.01	13.04 ^{ab} ± 0.04	81.19 ^{a} ± 0.2	395.19 ^{a} ± 0.17	17.48 ^{b} ± 0.11
B3	2.01 ^{b} ± 0.03	2.23 ^{b} ± 0.06	1.60 ^{c} ± 0.03	12.75 ^{b} ± 0.03	81.41 ^{a} ± 0.02	391.04 ^{c} ± 0.36	19.11 ^{a} ± 0.30

B1: porridge formula + unsoaked mung bean, B2: porridge formula + soaked mung bean, B3:porridge formula + germinated mung bean, Values are mean of three replicates ± SD, means with different letters at the same column are significantly different at P ≤ 0.05.

3.2. Amino Acids, Chemical Score and Biological Value of Dried Instant Porridge Formulas

The essential amino acids are necessary for tissue protection and can't be synthesized by the body and an important index of protein quality in food product. Results presented in Table 3 showed that B3 formula had the lowest level in total essential and non-essential amino acids (30.90 and 50.29 g/100g protein, respectively) compared to B1 and B2, may be due to the consumption of amino acids in the formation of new tissues during growth.

Furthermore, B2 formula had the highest level of the total non-essential amino acids and total aromatic amino acids (Phenylalanine and Tyrosine) compared to the other formulas, may be due to the soaking process which caused an increase in the total non-essential amino acids than total essential amino acids, also the total aromatic amino acid was the highest than the other essential amino acids [30].

On the other hand the data in the same Table 3. Indicated that the all formulas were high in the total non-essential amino acids than the total essential amino acids as well as the total Phenylalanine and Tyrosine were high compared to the other essential amino acids.

Chemical score is a method for assessing the quality of a dietary protein in a diet, measured by the ratio of a gram of the limiting amino acid in a diet for the same amount of the identical amino acid in a reference diet multiplied in 100. From the same Table 3 observed that the chemical score of aromatic essential amino acids (phenylalanine and tyrosine) was the highest value compared to the other essential amino acids in all formulas.

The limiting amino acids of all formulas were lysine, may be due to contain the lowest of chemical score, where the limiting amino acid is known as the acid that had a low protein [35]. The reduction in lysine is due to the processing methods as soaking, cooking and germination [36].

The biological value described how well the body absorbs protein and measure the percentage of protein actually utilized in human body [37]. The results in Table 3 showed that B2 formula was the highest in the biological values 83.19% compared to the other formulas, may be due to contain high lysine content (4.91 g/100g protein), where the high lysine content was associated with an increase of the biological value [38].

Table 3. Amino acids, chemical score and biological value of dried instant porridge formulas g/100.

samples	B1			B2			B3			
E.A.A	A.A of g/100g sample	A.A g/100g protein	Chemical score	A.A of g/100g sample	A.A g/100g protein	Chemical score	A.A of g/100g sample	A.A g/100g protein	Chemical score	FAO/WHO g/100g
Leucine	0.80	5.89	99.83	0.93	7.13	120.84	0.73	5.73	97.12	5.9
Valine	0.60	4.42	113.33	0.71	5.44	139.49	0.50	3.92	100.51	3.9
Lysine	0.59	4.34	96.44	0.64	4.91	109.11	0.55	4.31	95.78	4.5
Isolucine	0.46	3.38	112.66	0.53	4.06	135.33	0.37	2.90	96.67	3.0
Phenylalanin + Tyrosine (AAA)	0.60 0.40	4.42 2.94	245.33	0.71 0.43	5.44 3.30	291.33	0.50 0.36	3.92 2.82	224.67	AAA 3.0
Methonine + Cystine **(SAA)	0.19 0.26	1.39 1.91	150	0.20 0.23	1.53 1.76	149.55	0.15 0.15	1.18 1.18	107.27	SAA 2.2
Theronine	0.40	2.94	127.83	0.43	3.30	143.48	0.39	3.06	133.04	2.3
Hisitidine	0.29	2.13	142	0.36	2.76	184	0.24	1.88	125.33	1.5
Tryptophan	ND	ND		ND	ND		ND	ND	-	-
Total E.A.A	4.59	33.76	128.37	5.17	39.63	150.68	3.94	30.90	117.49	26.3
Chemical score (Lysine score)		96.44			109.11			95.78		
Limiting Amino acids		Lysine			Lysine			Lysine		
B.V		78.13			83.19			77.87		
Non-E.A.A										
Aspartic	1.45	11.13		1.72	13.20		1.22	9.57	-	-
Serine	0.48	3.68		0.59	4.52		0.56	4.40	-	-
Glutamic	2.73	20.95		2.82	21.63		2.54	19.92	-	-
Glycine	0.45	3.45		0.48	3.68		0.41	3.22	-	-
Alanin	0.51	3.91		0.57	4.37		0.45	3.53	-	-
Argnine	0.71	5.45		0.85	6.52		0.63	4.94	-	-
proline	0.80	6.14		0.77	5.90		0.60	4.71	-	-
Total Non –E.A.A	7.13	54.71		7.80	59.82		6.41	50.29	-	-

B1: porridge formula + unsoaked mung bean, B2: porridge formula + soaked mung bean, B3: porridge formula + germinated mung bean, EAA = essential amino acids, ND = not detected, B.V = biological value, AAA = aromatic amino acids, SAA = sulfur amino acids, FAO/WHO (2007).

3.3. Minerals of Dried Instant Porridge Formulas

Minerals are essential chemical elements that play a role in glucose homeostasis, the transmission of nerve impulses and enzyme cofactors in the body. Macro minerals are needed in large amounts, while trace minerals are needed in very small amounts. The minerals content of instant porridge formulas were presented in **Table 4**. B1 formula recorded the lowest content of minerals except K

Table 4. Minerals of dried instant porridge formulas (mg/100g).

Samples	Macro minerals				Trace minerals				
	P	K	Ca	Mg	Fe	Zn	Se	Cu	Mn
B1	194.57 ^{c} ± 0.43	1540.41 ^{a} ± 0.61	155.71 ^{c} ± 0.62	677.01 ^{c} ± 0.97	4.32 ^{c} ± 0.30	2.33 ^{c} ± 0.02	1.08 ^{c} ± 0.02	0.74 ^{b} ± 0.01	1.35 ^{c} ± 0.02
B2	206.86 ^{b} ± 0.82	1520.98 ^{b} ± 0.78	197.19 ^{b} ± 0.29	706.29 ^{b} ± 0.43	4.75 ^{b} ± 0.02	2.91 ^{b} ± 0.02	1.13 ^{b} ± 0.02	0.74 ^{b} ± 0.02	1.63 ^{b} ± 0.02
B3	220.89 ^{a} ± 0.94	1449.71 ^{c} ± 0.29	233.76 ^{a} ± 0.26	715.68 ^{a} ± 0.66	4.92 ^{a} ± 0.07	3.06 ^{a} ± 0.40	1.34 ^{a} ± 0.02	0.85 ^{a} ± 0.02	1.83 ^{a} ± 0.02

B1: porridge formula + unsoaked mung bean, B2: porridge formula + soaked mung bean, B3:porridge formula + germinated mung bean, Values are mean of three replicates ± SD, means with different letters at the same column are significantly different at P ≤ 0.05.

which recorded high (1540.41 mg/100g). Macro and trace minerals significantly increased in B3 formula except K that significantly decreased (1449.71 mg/100g) compared to the other formulas, this reduction may be due to soaking and germination.

The rising of minerals as a result to decrease anti-nutritional factors leached out during the soaking process and degraded during germination. Processing methods like, soaking, germination and cooking lead to decrease that the anti-nutritional factors and increase minerals bioavailability (Ca, Cu, Mn and Zn), nutritive value and enhance the digestibility [8] [39].

3.4. Phytic Acid and Tannin Content of Dried Instant Porridge Formulas

Anti-nutritional factors, such as phytic acid was has a negative charged which bond with positively charged divalent minerals ions making them unavailable for absorption and tannin are chemical compounds that affect digestion, bioavailability and limit the full benefit of nutrients in food.

The results in Figure 1 and Figure 2 illustrated that B3 formula had the highest reduction in phytic acid and tannin content (0.40% and 0.09%), respectively followed by B2 formula (0.63% and 0.21%), respectively. The reduction of Polyphenols (tannin) and phytic acid could be attribute to leach them with soaking water, also due to the increasing activity of phytase which responsible for the hydrolysis of phytic acid during traditional processing techniques such as soaking and germination [8] [36] [40] [41].

3.5. Physical Properties of Dried Instant Porridge Formulas

3.5.1. Moisture Content and Water Activity

Water has effects on food stability, palatability and quality, also has an effect on the shelf life of foodstuffs, furthermore moisture content can effect on the physical properties such as hardness, clotting in powder product. The results of the moisture content and water activity for the dried porridge formulas are illustrated in Table 5. The results showed that all the given values of the moisture content were ranged (6.43% - 6.77%). B1 formula significant decreased in moisture content, while both B2 and B3 were high moisture content (6.77% and 6.64%), respectively but it was within the permissible limits. The dried materials are considered more quality when the moisture content was less than 10% [42]. The microorganisms cannot growth when moisture content is below 8% in dehydrated food, however if the moisture content is over 18% some microorganisms may be increased gradually [1].

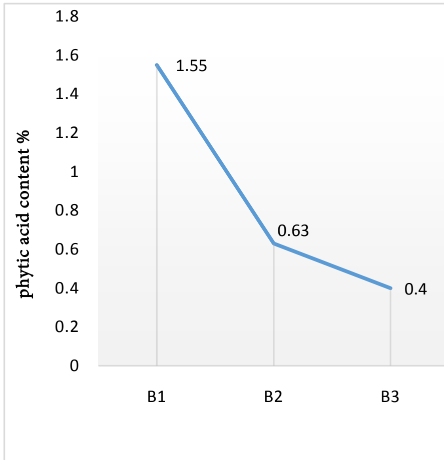

Figure 1. Phytic acid content % of dried instant porridge formulas.

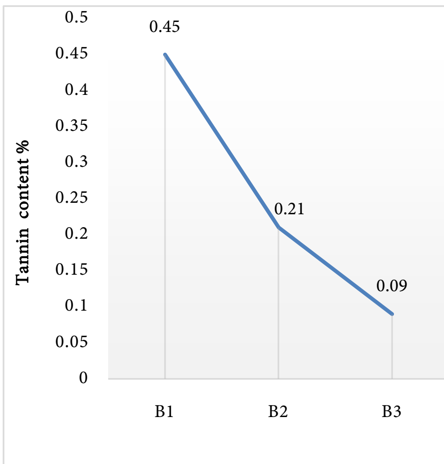

Figure 2. Tannin content % of dried instant porridge formulas.

Table 5. Moisture content and water activity of dried instant porridge formulas.

Samples	Moisture content (%)	Water activity (a_w)
B1	6.43 ^{b} ± 0.02	0.42 ^{a} ± 0.01
B2	6.77 ^{a} ± 0.03	0.44 ^{a} ± 0.03
B3	6.64 ^{a} ± 0.03	0.43 ^{a} ± 0.02

B1: porridge formula + unsoaked mung bean, B2: porridge formula + soaked mung bean, B3:porridge formula + germinated mung bean, Values are mean of three replicates ± SD, means with different letters at the same column are significantly different at P ≤ 0.05.

Water activity is a measure of free water in food which leads to the growth of various microorganisms; also it is related to the chemical stability of dried food products and important reference for the shelf life of foods [43]. The results from the same Table 5 showed that the water activity of the all formulas was not high, water activity was ranged (0.42 - 0.44) that is considered less than the level growth of any microorganisms. The reduction of water activity often effects of microbial growth and it increases the shelf life [44]. The least water activity value for growth of all microorganisms in food was at less than 0.6 [45].

3.5.2. Color Characteristics of Dried and Rehydrated Instant Porridge Formulas

Color is one of important quality attributes to the overall acceptance of the food product. The degree of lightness, redness and yellowness of dried and rehydrated porridge formulas are shown in Table 6. B2 formula recorded the highest degree of lightness L^* values (82.39 and 56.65), least redness a^* value (0.98 and 1.45) before and after rehydrated, respectively compared to B1 and B3 formulas. While B1 recorded the lowest degrees in lightness L^* and the highest degrees of redness a^* before and after rehydrated. On the other hand B3 had the lowest degrees in yellowness b^* after rehydrated (24.14). The lightness L^* were high in B2 then B3 may be due to remove some pigments during soaking treatment, where the water soluble polyphenols leaching out in water after soaking process, also heat processes caused significant reduction in polyphenol contents [46].

Moreover observed a reduction in the degree of lightness L^* and yellowness b^* as well as the rising degree of redness a^* after rehydrated for all formulas, the variation in color among the porridge before and after rehydrated may be attributed to reducing sugars which promotes Millard browning reaction during the heat processes, which contribute to color changes. Millard reaction is responsible for changes in food color, organoleptic properties [47].

3.5.3. Water Absorption Index (WAI) and Water Solubility Index (WSI) of Dried Instant Porridge Formulas

WAI and WSI are the parameters to describe the hydration properties of porridge. WAI measures the volume of starch granules after swelling in excess water [5]. WAI and WSI of the porridge formulas are listed in Table 7. Where WAI ranged (5. 32 - 6. 62 g/g), B2 formula had the highest WAI followed by B3, while B1 was the lowest.

Table 6. Color characteristics of dried and rehydrated instant porridge formulas.

	The dried instant porridge formulas			The rehydrated instant porridge formulas		
Samples	L^*	a^*	b^*	L^*	a^*	b^*
B1	79.91 ^{c} ± 0.35	3.88 ^{a} ± 0.27	28.38 ^{a} ± 0.05	51.35 ^{c} ± 0.41	4.77 ^{a} ± 0.17	25.56 ^{a} ± 0.35
B2	82.39 ^{a} ± 0.15	0.98 ^{c} ± 0.12	25.91 ^{b} ± 0.05	56.65 ^{a} ± 0.10	1.45 ^{c} ± 0.05	24.45 ^{b} ± 0.05
B3	81.51 ^{b} ± 0.20	1.75 ^{b} ± 0.04	27.40 ^{a} ± 0.06	53.55 ^{b} ± 0.23	1.87 ^{b} ± 0.05	24.14 ^{c} ± 0.33

B1: porridge formula + unsoaked mung bean, B2: porridge formula + soaked mung bean, B3:porridge formula + germinated mung bean, Values are mean of three replicates ± SD, means with different letters at the same column are significantly different at P ≤ 0.05. L*:= lightness (100) to darkness (zero); a*: redness (+) to greenness (-); b*: yellowness (+) to blueness (-).

Table 7. Water absorption Index and water solubility Index of dried instant porridge formulas.

Samples	WAI (g/g)	WSI (%)
B1	5.32 ^{c} ± 0.09	22.5 ^{a} ± 0.30
B2	6.62 ^{a} ± 0.02	17.15 ^{b} ± 0.30
B3	5.55 ^{b} ± 0.03	16.12 ^{c} ± 0.20

B1: porridge formula + unsoaked mung bean, B2: porridge formula + soaked mung bean, B3: porridge formula + germinated mung bean, Values are mean of three replicates ± SD, means with different letters at the same column are significantly different at P ≤ 0.05. L*:= lightness (100) to darkness (zero); a*: redness (+) to greenness (-); b*: yellowness (+) to blueness (-).

WSI measures the amount of soluble degradation from the starch, which is often used as an indication of degradation of starch molecules and dextrin [48]. Also, it is indicated of water penetration ability into starch granules [49]. From the same Table WSI ranged (16.12% - 22.5%), where B1 formula recorded the highest of WSI compared to B2 and B3. WAI increased and WSI decreased with increase in feed moisture content [50] and [5].

3.5.4. Swelling Power (SP) and Viscosity of Dried Instant Porridge Formulas

Swelling is originally a property of the amylopectin, which is regulated the crystallization of the starch before full gelatinization [51]. SP is the ability of flours to increase in volume, it is also considered as a quality criterion in some food formulations and it is an index of bonding between molecules within starch granules [52]. Results in **Table 8** showed that the SP ranged (5.11 - 6.79 g/g), where B3 formula had the lowest value, while B1 had the highest value. The rising of SP may due to lower the amylose content, where the swelling power showed weak negative correlation with amylose content, also the starch high in swelling contains low amylose [53].

Table 8. Swelling power (SP) and viscosity of dried instant porridge formulas.

Samples	SP (g/g)	Viscosity (CP)
B1	6.79 ^{a} ± 0.03	4793 ^{a} ± 11.54
B2	6.46 ^{b} ± 0.02	3999 ^{b} ± 12.50
B3	5.11 ^{c} ± 0.04	3243 ^{c} ± 11.71

B1: porridge formula + unsoaked mung bean, B2: porridge formula + soaked mung bean, B3: porridge formula + germinated mung bean, Values are mean of three replicates ± SD, means with different letters at the same column are significantly different at P ≤ 0.05.

The viscosity is an important characteristic of liquid foods in many food processing, the rheological behavior of foods during processing is useful for quality control purposes [54]. In **Table 8**, the viscosity of porridge formulas ranged (3243 - 4793 CP), where B1 formula significantly increased compared to B2 and B3. Whereas, B3 had the lowest value of viscosity followed by B2 formula. The reduction in viscosity of B2 and B3 may refer to soaked, germination, raising moisture and amylose content. At high moisture content, the viscosity of the starch would be low [55]. Composite flour made from germinated and soaked cereals significantly lower in viscosity [56]. The differences in final viscosity could be due to variations in amylose content, where the viscosity negatively correlated with amylose content. Low amylose content of starch is associated with higher viscosity [53].

3.6. Rehydration Ratio of Dried Instant Porridge Formulas

The rehydration ratio indicates the ability of dried materials to absorb water and to hold soluble solids inside the dried material. Also, it is a considered an important characteristic of many products, which later preparation for consumption [57] and used it as a quality characteristic of the dried product [58].

The rehydration ratio of the dried porridge formulas increased significantly in B1 formula compared to the other formulas shown in **Figure 3**, this may be attributed to the limited initial moisture [59]. Also, due to lower water activity and water content [1].

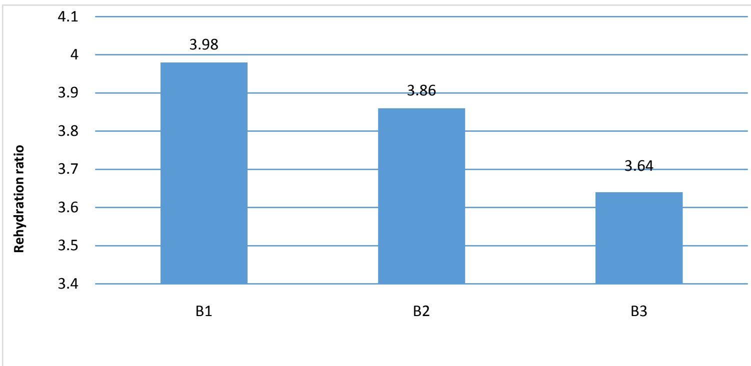

Figure 3. Rehydration ratio of dried instant porridge formulas.

3.7. Sensory Evaluation of the Rehydrated Instant Porridge Formulas

Sensory Evaluation is a good way to solve problems associated with food acceptance. The end product should be free from unacceptable taste and odor [60].

Sensory evaluation of the rehydrated instant porridge according to color, taste, odor and overall acceptability were illustrated in **Table 9**. There were a significant increase in color, taste and overall acceptability in B2 formula compared to the other formulas, the lighter color made them more acceptable, where consumers are used to this color in the food [27].

Table 9. Sensory evaluation of the rehydrated instant porridge formulas.

Samples	Color (9)	Odor (9)	Taste (9)	Overall acceptability (9)
B1	7.6 ^{b} ± 0.52	7.8 ^{a} ± 0.73	6.6 ^{b} ± 0.76	7.4 ^{b} ± 0.51
B2	8.4 ^{a} ± 0.51	8.4 ^{a} ± 0.53	7.6 ^{a} ± 0.65	8.2 ^{a} ± 0.42
B3	7.5 ^{b} ± 0.47	8.0 ^{a} ± 0.66	6.8 ^{ab} ± 0.89	7.4 ^{b} ± 0.52

B1: porridge formula + unsoaked mung bean, B2: porridge formula + soaked mung bean, B3: porridge formula + germinated mung bean, Values are mean of ten replicates ± SD, means with different letters at the same column are significantly different at P ≤ 0.05.

4. Conclusion

The results of this study revealed that B3 formula which contained soaked mung bean was a good source of calories, essential amino acid to enhance biological value, nutritional and technological quality of the resultant porridge. Therefore, we advise to expand mung bean cultivation in Egypt as a new variety because it has high nutritional value, good source of energy, protein and minerals and comparatively cheap compared to meat, also can be useful as high energy foods for the patients, the poor and the needy.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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