

Chemical and Nutritional Assessment of Burghul Grains (*Triticum Durum L.*)

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ABSTRACT

The present investigation was carried out in an attempt to clearly the chemical and nutritional assessment of Burghul grains as a functional food. The study included the determination of proximate chemical composition, starch, minerals, dietary fibers, vitamins composition, and the amino acid pattern. Meanwhile, computation of the chemical scores of its protein (CS). The results showed that the components of Burghul grains had 9.51 % of crude protein, 5.31% of crude extract ether, 1.27% of total ash and 1.21 of crude fibers and 82.79% of digested carbohydrates. Also, starch content of Burghul grains was 80.02%. The dietary fibers content was: 36.78% for NDF and 2.21% for ADF, (On dry weight of dry basis).

Mineral composition of Burghul grains showed that the calcium content was the highest among the studied minerals being (1186.38 mg/kg) followed by magnesium (752.45 (mg/kg.) (On dry weight of dry basis). Moreover, it was found that Burghul grains were high in folic acid content 14.38 mg/100gm) and niacin (7.40 (mg/100gm), while, it was low in pyridoxine (0.14 (mg/100gm).

The protein of Burghul grains contain 18 amino acids including all the essential amino acids. For the nonessential amino acids glutamic acid and proline were found in highest amount among all the amino acids pattern being (32.90 g/100g protein) and (12.10 g/100g protein). As for the essential amino acids, leucine and valin were the high amounts, 5.90 g/100g protein, 4.10 g/100g protein, respectively, comparing with FAO /WHO pattern (2007). Lysine was found to be the first limiting amino acid (0.56) which is typical for cereals.

Key words: Burghul, Chemical composition, Minerals, Vitamins, Dietary fibers, Amino acid.

INTRODUCTION

Burghul is an ancient product, commonly produced from durum wheat (*Triticum durum*). It is a traditional food material for Turkish, Arabic, North African and East European communities and important because of its nutritional and economical value. (Bayram, *et al.*, 2004) It is almost a whole grain product and generally produced with the steps of cleaning, cooking, drying, tempering, milling, debranning and sizing. (Yildirim, *et al.*, 2008). Burghul is a nutritious product with a

pleasant, nut-like flavour. (Hayta, 2002). It can be used either as a ready-to-eat food or a semi-ready-to-eat food (Bayram, *et al.*, 2007). Burghul is rich in dietary fibers, vitamin B₁, B₂ and phenolic compounds, and health protection effect against cardiovascular and heart diseases (Ozvural and Vural , 2008). Moreover, high amounts of minerals (phosphorus, zinc, magnesium and selenium) and cellulose fibre in bulgur have been related to the protection against constipation and colon cancer (Ranum, 1996). Durum wheat is preferred for Burghul production (Bayram, *et al.*, 2004). In different region of the world and also Turkey, triticale (Singh, and Dodda, 1979) corn (Elgün *et al.*, 1990), barely (Köksel, *et al.*, 1999) rye and soybean (Bayram *et al.*, 2003) are also used for burghul production instead of durum wheat.

The consumption of Burghul is approximately 2.5 and 2.0 times higher than that of pasta and rice in Turkey, respectively. High nutritional value, long shelf life and low price of bulgur increased the demand in new and developing markets all over the world (Bayram and Oner, 2005). (Kadakil, *et al.*, 2007; Ozboy and Koksel, 2001). Such a high demand indicates the significance of Burghul in the diet and technological advancements are needed to enhance the quality of Burghul. Durum wheat is the hardest of all wheat varieties and used in making products such as pasta and Burghul due to its high protein, high gluten strength and uniform golden color. Many nutrients leach out of wheat, but nutrients are absorbed back into the grain during the bulgur production. Losses of water-soluble nutrients like vitamins are prevented. Burghul digestibility increases due to coagulated protein and gelatinized starch. The excess nitrogenous substances are caused by the hard structure of starch fused with protein. This is a desirable feature in Burghul because of resistance to insect, mites and microorganisms, and long shelf life. Also, Burghul is a natural food because no chemicals or additives are used in processing. (Certel, 1990)(Bayram, 2005). Burghul grains is popular for most of Mediterranean and North African regions. So,

the aim of this study is to evaluate the chemical and nutritional characteristic of Burghul grains.

MATERIALS AND METHODS

Materials:

5 kilogram of Burghul grains (*Triticum durum L.*) variety (Turkey) was purchased from Carrefour in Alexandria city, Egypt. The grains were cleaned and sieved by hands to be free from sands, stones and other foreign materials, packed in polyethylene bag and kept at 4-5 °C. The grains were ground using electronic mill.

Methods:

Physical analysis

One thousand seed weight, 1000 seed volume was determined according to (Williams *et al.*, 1983). Seed weight was calculated as the mean weight of 1000 undamaged burghul seeds. For the determination of seed volume, seeds were transferred to a 250 ml measuring cylinder, and 100 ml distilled water were added. Seed volume was determined as total volume minus 100. Density (g/mL) was then determined by dividing the weight of the bulgur by its volume, using the following formula:

$$\text{Density} = \text{seed volume} / \text{seed weight}$$

Diameter of burghul seeds were determined by Digital Caliper, five reading of each diameter were recorded. Color measurement was estimated using lovibond tintometer. An average of 3 measurements for (yellow), (red), and (blue) values were recorded.

Determination of Proximate Composition:

Proximate compositions of the Burghul samples were determined according to the international analysis of official methods [AOAC, 2000]. The moisture content was determined by drying samples in an oven at 105°C, Crude protein percentage was determined using the Kjeldahl method and the percentage nitrogen (%N) obtained was used to calculate the percentage crude protein using the relationship % Crude Protein = % N X 6.25. Ether extract percentage was determined using Soxhlet system. The percentage of ash (%) was determined by incinerating the samples in a muffle furnace at 550°C for 4hrs. The ash was cooled in a desiccator and weighed. Crude fiber percentage (% CF) was determined by dilute acid and alkali hydrolysis. Dietary fibers were determined according to the method of AOAC (1990). Digested carbohydrate was calculated by difference including fiber.

Digested carbohydrate % = 100- (Moisture% +Protein% +Fat% +Fiber% +Ash %). Starch and dietary fibers were determined according to the method of AOAC (1990). All the determinations were done in triplicate and the results were expressed as the average

value. Also, the results are reported on a wet matter basis and dry matter basis.

Determination of Mineral Content:

Mineral contents of Burghul was carried out according to the method (Chapman, and Pratt, 1961). All minerals were determined by atomic absorption spectrophotometer (Varian Spectra – AA 220).

Determination of Vitamins

HPLC technique as described by (Aslam, *et al.*, 2008) for the separation and was used quantification of folic acid, niacin, Pyridoxine, by a reversed-phase chromatographic method.

Determination of Amino Acids Composition

Amino acids were determined by Ion – exchange column chromatography technique, according to the method described by (Moore, *et al.*, 1958) by using Spackman Amino acid Analyzer Model 120B. The samples were hydrolyzed using 6 N HCL for 18 hours in an autoclave at 15 psi. Tryptophan was determined using 4 N sodium hydroxide for 14- 16 hours at 110 °C.

Computation of Chemical Score (CS)

The amino acid score is defined as the concentration of the limiting amino acids in the food protein and is expressed as follow:

$$cs = \frac{\text{mg of essential amino acid in 1gm test protein} \times 100}{\text{essential amino acid in 1gm reference protein of mg}}$$

According to (Bhanu, *et al.*, 1991).

Statistical Analysis: The data were expressed as mean \pm standard deviation.

RESULTS AND DISCUSSION

Physical Properties of Bulgur grains:

Various Physical Properties of Burghul grains were determined, and the results obtained are presented in Table (1).

Table 1. Physical Properties of Burghul seeds

Physical Parameters	Values
	M+ SD
Weight of 1000 seeds (g)	4.10 \pm 0.10
Volume Of 1000 seeds (ml)	20.00 \pm 0.00
Density (gm/ml)	0.21 \pm 0.07
Diameter (m/m)	1.47 \pm 0.11

M+ SD: Mean \pm Standard Deviation.

The mean weight and volume of the 1000 burghul were 4.10 \pm 0.10(gm) and 20.00 \pm 0.00(ml) respectively. Different dimensional properties like density and diameter were measured and found to be 0.21 \pm 0.07 (g/ml), 1.47 \pm 0.11 (mm) respectively. Table: (1).

The color of Burghul is the most important parameter for the acceptability of the final product for wheat Burghul (Bayram, 1997).The color values of Burghul grains and powder Burghul was estimated using lovibond tintometer, and the results in Table (2) indicated that Burghul powder had a higher blue value and lower red value comparing with those of Burghul grains also, it was found that yellowness values were the highest for both of the tested samples. (Eratas, 2017), stated that, durum wheat cultivars are possessing high yellow pigmentation.

Dominant wave length (hue value) , lightness and purity values were calculated using CIE system, the hue value for each of Burghul grains and Burghul powder indicated a yellowish orange color with highest yellowness value for the Burghul. On the other hand both of Burghul grains and powder samples had almost the same lightness value, being 46, 45 respectively, the purity value was higher (0.60) in Burghul powder than that of Burghul grains. Generally processing steps like tempering, dehulling and milling affect the color values of Burghul.

Proximate Chemical Composition

Moisture:

Moisture contents of products are very important criteria for the product quality and process ability. Moisture content is controlled at each step along bulgur processing lines.

Results given in the table (3) indicated that the moisture content was 10.09%. Similar results were observed by (Caba, *et al.*, 2013), they found that the total amount of moisture of Burghul grains ranged from 10.4 to 11.6%). Drying process of Burgul can be done naturally or in towers to lower Burghul moisture content to ~12% (Bayram, 2007). Moreover, (Tacer, 2008) reported that the total moisture contents of the Burghul were determined in the range of 11.1 to 13.4%, and the average moisture content of the Burgul was 12.4%.

Crude Protein:

Protein is the second most common constituent of cereals grain, following starch. Depending of cereal species, variety, and agronomic conditions, the protein

content in cereals can range from 5 to 20%. The type and amount of protein in cereal grain are important in terms of nutritional values as well as the impacts on functional properties of food or feed containing the protein (Shewery, 2007). From the results of the Table (3) it could be observed that the protein was 8.55(% ,W.B.) and 9.51(% , D.B.). (Koksel, *et al.*,1999) showed that protein contents of Burghul ranged from 9.5% to 11.4%. This results agree with the work of (Caba, *et al.*, 2013), they showed that the average protein contents of Burghul samples ranging between (8.2 to 9.9 % , D.B.).

Crude Ether Extract:

It is clear from Table (3) that the crude ether extract content of Burghul grains was 4.77 (% , W.B.) and 5.31(% , D.B.). (Al- Baraznji, and Al-Abdullah, 2016), reported that, the crude ether extract content in Burghul grains was (2.01 % - 2.62%).

Ash, Crude Fiber and Carbohydrates:

The results in Table (3) show that the total ash content was 1.15 (% , W.B.) and 1.27 (% D.B.), respectively. However, (Singh, *et al.*, 2007) and (Tacer, 2008), they showed that the average ash contents found in Burghul were within the range of 0.86 to 1.80%. Also, (Caba, *et al.*, 2013) reported that the average ash contents of Burghul samples was in the range of 0.71- 1.06 (% , D.B.). The ash content of Burghul is related to bran content, which is generally affected by the debranning, milling, and polishing operations. . According to Table (3) the average of crude fibers of Burghul were 1.01 (% , W.B.) and 1.12 (% , D.B.). (Al- Baraznji, and Al-Abdullah, 2016), they founed that the crude fibers of Burghul samples was in the range of 3.82 – 4.22%. Data of Table (3) also, indicated that the digested carbohydrate of Burghul was 74.44 (% , W.B.) and 82.79 (% , D.B.). (Abd-El-Aziz, 2018), reported that the carbohydrates in Burghul flour was 82.65±0.01(% , D.B.). Table (4) illustrated that the starch content in Burghul grains was 71.94 (% , W.B.), and 80.02 (% , D.B.). On the other hand, (Caba, *et al.*, 2013), reported that the average amount of starch content was in the range of 66.9- 71.6 (% , D.B.).

Table2. Color values of seed Burghul and powder Burghul

Color	BurghulGrain	Burghul Powder
Blue	1.10 ±0.00	2.17 ±0.06
Yellow	10.20 ±0.00	10.13 ±0.06
Red	3.40±0.06	2.37 ±0.06
Hue(λ)	575	567
Lightness	46	45
Purity	0.36	0.60

Table 3. Proximate Analysis of Burghul grains

Moisture %	Crude Protein %		Crude Ether Extract %		Total Ahs %		Crude Fiber %		Digested Carbohydrates*** %	
	(%)*	(%)**	(%)*	(%)**	(%)*	(%)**	(%)*	(%)**	(%)*	(%)**
10.09 ±0.04	8.55 ±0.06	9.51 ±0.07	4.77 ±0.06	5.31 ±0.07	1.15 ±0.05	1.27 ±0.05	1.01 ±0.06	1.12 ±0.06	74.44 ±0.11	82.79 ±0.09

*On wet weight basis (W.B)

**On dry weight basis (D.W)

Calculated by diffe

Starch:**Table 4. Starch Content of Burghul**

Starch % (On wet weight basis)	Starch % (On dry weight basis)
71.94±0.16	80.02±0.22

Dietary fiber:

Dietary fiber which is very important from the nutritional point of view are classified into water insoluble (cellulose, lignin, some of hemicellulose) which represent NDF, ADF and ADL, and water soluble (mainly pectin and gums). (Thebaudin, *et al.*, 1997) (Grigelmo, *et al.*, 1999).

Table (5) show that the Burghul grains contained high values of the following types of dietary fibers, natural detergent fiber (NDF), 33.07 (% , W.B.), and 36.78 (% , D.B), while, acid detergent fiber (ADF) 1.99 (% , W.B.) and 2.21 (% , D.B.) Also, acid detergent lignin (ADL) 0.43 (% , W.B.), and 0.48 (% , D.B.) , hemicellulose 30.93(% ,W.B.) and 34.40 (% , D.B.), cellulose content was 1,54 (% W.B) and 1.71 (% , D.B). These types of fibers are important elements in the human diet. They represent the unhydrolyzed plant storage and cell wall polysaccharides by human digestive enzymes. (Bethesda, 1986) Our results are in accordance with the results of (Yang, *et al.* , 2014) and (Abd-El-Aziz, 2018).

Minerals Composition of Burghul:

Results given in Table (6) indicated that Burghul grains are high in calcium 1067 (mg/kg, W.B.) and 1186.38 (mg/kg, D.W.). Also, in magnesium content 676.50 (mg/kg, W.B.) and in 752.45 (mg/kg,D.B.), respectively. On the other hand. The content of essential micro nutrient content of Burghul grains was studied. The copper content (3.75 mg/kg, W.B. and 4.17 mg/kg, D.B.), iron (44.46 mg/kg, W.B. and 49.45 mg/kg, D.B.), while manganese content was (11.58 mg/kg, W.B. and 12.88 mg/kg, D.B.). Also, zinc content was (13.97 mg/kg, W.B. and 15.53 mg/kg, D.B). (Ozkaya, *et al.*, 1993), they reported that the homemade Burghul samples contain 612 ppm calcium and 1084 ppm magnesium , 24.8 ppm iron and 17.6 ppm zinc, and also Burghul samples produced at laboratory condition contain 604 ppm calcium and 1100 ppm magnesium , 24.6 ppm iron and 18.4 ppm zinc . The content of copper of industrially produced and laboratory scale Burghul, expressed as mg/kg with values of around 4.08, 5.08 and 5.37 mg.kg, respectively. It is clear from Table (6) that Burghul grains had zero content of cadmium. While, the nickle and cobalt contents were non detected. The cadmium content of Burghul of industrially produced, homemade and laboratory scale ranged between 0.01 and 0.09 mg/kg, 0.02 and 0.08 mg/kg and 0.08 mg/kg, respectively. Whereas (JECFA, 2016), the permit levels is up to 0.1 mg/kg, the recommended limit for cadmium in cereal grains including in wheat and rice, bran and germ.

Table 5. Dietary Fiber Fractions (%) of Burghul

Neutral Detergent Fibers (NDF) %		Acid Detergent Fibers (ADF) %		Acid Detergent Lignin (ADL) %		Hemicellulose %		Cellulose %	
(%)*	(%)**	(%)*	(%)**	(%)*	(%)**	(%)*	(%)**	(%)*	(%)**
33.07 ±1.78	36.78 ±1.98	1.99 ±0.01	2.21 ±0.01	0.43 ±0.07	0.48 ±0.08	30.93 ±1.81	34.40 ±2.02	1.54 ±0.14	1.71 ±0.08

* On wet weight basis (W.B)

**On dry weight basis (D.W)

Table 6. Minerals Content of Burghul

Essential Macro Elements Content of Burghul									
On wet weight basis					On dry weight basis				
(mg/kg)					(mg/kg)				
Ca		Mg			Ca		Mg		
1067± 115.47		676.50 ± 11.03			1186.38± 127.90		752.45± 12.57		
Essential Micro Elements Content of Burghul									
On wet weight basis				On dry weight basis					
(mg/kg)				(mg/kg)					
Cu	Fe	Mn	Zn	Cu	Fe	Mn	Zn		
3.75 ± 0.12	44.46 ± 0.42	11.58 ± 0.02	13.97± 0.04	4.17 ± 0.13	49.45 ± 0.47	12.88 ± 0.03	15.53 ± 0.04		
Toxic Trace Elements Content of Burghul									
On wet weight basis					On dry weight basis				
(mg/kg)					(mg/kg)				
Cr	Cd	Ni	Pb	Co	Cr	Cd	Ni	Pb	Co
0.64 ± 0.01	0.00	N.D*	1.00 ± 0.04	N.D*	0.71 ± 0.01	0.00	N.D*	1.11 ± 0.05	N.D*

* N.D non detected

Table 7. Folic acid, Niacin and Pyridoxine contents in Burghul

On wet weight basis			On dry weight basis		
(mg/100gm)			(mg/100gm)		
Folic acid (B9)	Niacin (B3)	Pyridoxine (B6)	Folic acid (B9)	Niacin (B3)	Pyridoxine (B6)
12.93	6.65	0.13	14.38	7.40	0.14

Table 8. Amino Acids content of Burghul Grains

Amino Acids	Burghul Seeds	FAO/WHO	Amino Acids Score
(g /100 g protein)		(g A.A/100 g protein)	
Lysine	2.42	4.32	0.56
Histidine	2.61		
Arginine	4.88		
Asparatic Acid	4.10		
Threonine	2.54	2.88	0.88
Serine	4.44		
Glutamic Acid	32.90		
Proline	12.10		
Glycine	3.85		
Alanine	3.70		
Cystine	2.90		
Methionine	1.40	2.30	0.61
Valine	4.10	4.32	0.95
Isoleucine	3.10	4.32	0.72
Leucine	5.90	4.90	1.20
Tyrosine	1.40		
Phenylalanine	3.90	2.88	1.35
Tryptophane	0.75	0.90	0.83

Table (7) presented folic acid (B9), niacin(B3) and pyridoxine (B6) contents in Burghul grains. It is clear from this results that Burghul grains are high in folic acid 14 (mg/100gm, D.B.), niacin (7.40 (mg/100gm, D.B.), while, it is low in pyridoxine 0.14 (mg/100gm, D.B.). (Al- Baraznji, and Al-Abdullah, 2016), reported that the niacin (B3) ranged from 0.03 to 0.14 mg/100gm. This results do not agree with the work of (Clark, 2015), (Jnam, 2009). They reported that this differences due to the differences in the manufacture process during Burghul production.

Amino Acids composition:

The results of quantitative determination of the various amino acids of Burghul grains are given in Table (8). Being expressed as g amino acid /100g protein. It can be observed that the protein of Burghul grains contain 18 amino acids including all the essential amino acids (8 for adults and 9 for children. (Davidson, 1975). For the nonessential amino acids glutamic and proline were found in the highest amounts among all the amino acids pattern of Burghul grains being (32.90 g/100g protein) and (12.10 g/100g protein). As for the essential amino acids, leucine and valin were the highest in Burghul grains, 5.90 g/100g protein, 4.10 g/100g/protein) respectively, comparing with FAO /WHO pattern (2007). These results are agreed with (Litwink, *et al.*, 2013) for their study on durum wheat. At the same time it was found that lysine was the lowest in concentration among the essential amino acids being 2.42 g /100 protein. Table (8). These results are in accordance with (Juvera, *et al.*, 2013) and (Litwink, *et al.*, 2013) in their study on wheat flour. On the other hand, the criterion of the biological value of protein assessing is not only the content of amino acids, but also the indicator of limiting essential amino acid as chemical score (FAO /WHO, 1985). Therefore the chemical score for the essential amino acids in Burghul grains was calculated in Table (8). It was found that lysine is the first limiting amino acid (0.56) which is typical for cereals. These results agreed with (kowieskane, *et al.*, 2011) and (Juvera, *et al.*, 2013). Moreover, methionine was found to be the second limiting amino acids in Burghul grains while (Litwink, *et al.*, 2013), they found that threonine is the second limiting amino acids in wheat durum flour.

CONCLUSION

Burghul is a traditional food in Arab Countries, in spite of that we noticed that there is lack in the researchs. The results of this study enhances our knowledge about nutritional components of Burghul grains.

Burghul grains had amounts of minerals especially calcium and magnesium and iron. Moreover the essential amino acids of its protein indicated that it had high amount of leucine and valine comparing with FAP/WHO pattern. Also, Burghul grains had higher amounts of folic acid and niacin. Combination of Burghul with other sources of protein would compensate the deficiency of certain amino acids such as lysine. Its consumption can considerably contribute to the improvement of the health state of the population.

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الملخص العربي

التقييم الكيميائي والتغذوي لحبوب البرغل

(*Triticum durum L.*)

غزة محفوظ علي أحمد

كما وجد أن حبوب البرغل تحتوي على نسبة مرتفعة من حامض الفوليك (٤,٣٨مجم/١٠٠جم) والنياسين (٧,٤٠مجم/١٠٠جم) بينما كان محتوى البيريدوكسين منخفض (٠,١٤مجم/١٠٠جم). كما وجد أن بروتين حبوب البرغل يحتوي على كل الأحماض الأمينية الأساسية وغير الأساسية (١٨حامض أميني) ولوحظ أن حامض الجلوتاميك (٣٢,٩٠مجم/١٠٠ جم بروتين) والبرولين (١٢,١٠مجم/١٠٠ جم بروتين) هما الأعلى بالنسبة لجميع الأحماض الأمينية. كما بينت دراسة الأحماض الأمينية الأساسية أن محتوى الليوسين (٥,٩٠مجم/١٠٠ جم بروتين) والفالين (٤,١٠مجم/١٠٠ جم بروتين) أعلى من النمط المقترح من منظمة الأغذية والزراعة / منظمة الصحة العالمية (٢٠٠٧). وقد وجد أن الليسين هو الحامض الأميني الحدي (٠,٥٦) لبروتين حبوب البرغل كما في باقي الحبوب.

تهدف هذه الدراسة إلى التقييم الكيميائي والتغذوي لحبوب البرغل كغذاء وظيفي ولذا تم دراسة التركيب الكيميائي للبرغل كالاتي: التركيب الكيميائي التقريبي والنشا ، المعادن ، الألياف الغذائية والفيتامينات والأحماض الأمينية. وفي الوقت نفسه تم حساب الحامض الأميني الحدي للبروتين (CS). أظهرت النتائج أن محتوى البروتين الخام كانت ٩,٥١% ومستخلص الإيثر ٥,٣١% والرماد الكلي ١,٢٧% والألياف الخام ١,٢١% ، ومحتوى الكربوهيدرات المهضومة كانت ٨٢,٧٩% والنشا ٨٠,٠٢% ، في حين كانت محتوى الألياف الغذائية ٣٦,٧٨% (NDF) ٢٠,٢١% (ADF) على التوالي (على أساس الوزن الجاف).

كما أظهرت النتائج أن محتوى الكالسيوم في البرغل كان مرتفعاً (١١٨٦,٣٨مجم/كجم) يليه المغنسيوم (٧٥٢,٤٥مجم/كجم) على التوالي (على أساس الوزن الجاف).