



## Evaluation of Physical and Chemical Properties of Imported Durum Wheat and Their Produced Semolina in Libya

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### ABSTRACT

The Physical and chemical properties of durum wheat are important aspects in terms of its trading and processing. Accordingly, this research aimed to study the physical and chemical properties of two-imported durum (Mexican and Canadian) and their locally produced coarser and fine semolina, in addition to their contents of heavy metals. The results indicated that virtual properties, foreign matters and total impurities of the imported durum were in agreement with Libyan standardization for durum wheat. However, heat damaged grains, shrunken and broken grains in Mexican wheat were not in agreement with Libyan standardization for durum. Mexican wheat recorded less amount of moisture and protein compared to Canadian wheat. Cadmium and lead contents in durum and the produced semolina were with the requirements documented in Libyan standardization for wheat semolina. The results indicated that Canadian coarse and fine semolina significantly recorded higher contents of moisture, protein and ash compared to Mexican semolina. The results demonstrated that most of the measured physical and chemical properties of durum and semolina were in agreement with Libyan standardization for durum wheat.

### تقييم الخواص الفيزيائية والكيميائية للقمح الصلب المستورد والسميد المنتج منه في ليبيا

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### الكلمات المفتاحية:

الخواص الفيزيائية  
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القمح الصلب  
القمح الصلب الكندي  
القمح الصلب المكسيكي

### المخلص

تعتبر الخصائص الفيزيائية والكيميائية للقمح الصلب من الجوانب المهمة من حيث التداول والتصنيع. وبناءً عليه يهدف هذا البحث إلى دراسة الخصائص الفيزيائية والكيميائية للسميد الصلب المستورد من نوعين (مكسيكي وكندي) والسميد الخشن والناعم المنتج منهما محلياً، بالإضافة إلى محتوئهما من المعادن الثقيلة. أشارت النتائج إلى أن الخواص المتمثلة في القرنية، الأجسام الغريبة والشوائب الكلية للقمح الصلب المستورد تتفق مع المواصفة الليبية للقمح الصلب. هذا وقد وجد أن الحبوب التالفة بالحرارة، والحبوب المنكمشة والمكسورة في القمح المكسيكي لم تتوافق مع ما مع جاء في المواصفة الليبية للقمح الصلب. سجل القمح المكسيكي كمية أقل من الرطوبة والبروتين مقارنة بالقمح الكندي. كما أوضحت نتائج الدراسة أن كمية الكاديوم والرصاص في القمح الصلب والسميد المنتج منه متطابقة مع المتطلبات الموثقة في المواصفة القياسية الليبية لسميد القمح. وبينت النتائج أن السميد الكندي الخشن والناعم سجلا محتوى أعلى من الرطوبة والبروتين

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والرماد مقارنة بالسميد المكسيكي. بشكل عام أظهرت النتائج أن معظم الخواص الفيزيائية والكيميائية المقاسة للقمح الصلب والسميد كانت متوافقة مع المواصفات الليبية للقمح الصلب والسميد.

## Introduction

Durum wheat (*Triticum durum*) is one of the major food source in Mediterranean countries, where it mostly used to produce couscous and pasta, in addition to varieties of foods, such as, leavened and unleavened breads and other different traditional foodstuffs [1]. Durum wheat is more adapted to diverse environments compared to bread wheat, and it is grown very well in semiarid areas. The highest world production of durum takes place under rainfed environments in semiarid areas with moderately dry weather, warm days, and cool nights throughout crop growth. Moreover, these regions are also characterized by drought stress. Middle East, North Africa, southern Europe, India and North America are the common areas for growing durum wheat [2].

Durum wheat is distinguished by its hardness, high protein content, vitreousness and amber colour. There are many breeding attempts regarding increment of its yield, resistance to disease, increasing protein content, grain weight, vitreousness and semolina yield, additionally to strengthening its dough properties to improve pasta-making quality [2].

The technical and nutritional characteristics of durum wheat semolina are mainly influenced by type and amount of gluten, which affected by genetic properties and environmental conditions [1]. A study reported that the bran of durum wheat contains 61% of total dietary fiber and the insoluble fraction is the dominant. The same study found that the antioxidant ability of some durum wheat by-products, such as bran is almost equivalent to that of common fresh vegetables and fruits; it could be due to occurrence of fiber-bound phenol components [3]. Because of its high contents of fiber and antioxidants, durum wheat can be particularly utilized for cereal-based foods.

The physical and chemical properties of durum wheat grain are the key factor regarding the suitability of the crop for its end-usage, and certainly are responsible for the pasta quality [4]. Factors that have been presented to impact durum wheat quality are genotype, environmental and the interface between them [5], [6]. These properties include test weight, vitreousness, hardness and protein, starch and ash contents. Hardness of the grain have been linked with the degree of kernels vitreousness and its protein and starch contents [7]. It is reported that starchy kernels have a discontinuous endosperm with numerous air spaces and seem white in colour [8]. The softer texture of the starchy grain could be due to its porosity caused by air spaces. Studies indicated that environmental conditions, for example light intensity and temperature during grain development are controlling the structure of the grain in terms of starchy or vitreous appearance [7].

Test weight is influenced by shape and size of the grain. It is generally used as a measurement in wheat grading, due to its globally acknowledged as an index of wheat consistency and wheat milling prospective. Test weight is reduced by grain weathering, occurred by rain during harvesting, and terminal drought cause grain Shrunken. Shrunken grains with high protein content produces a reduction in semolina milling performance. This might be due to the reason that small kernels consist a lower quantity of endosperm, where grains with higher starch content is economically valued [2]. Libya is one of the countries that grow durum wheat, but it is not enough for consumption, therefore we import durum from different countries including Mexico and Canada. It is largely used to produce semolina for production of pasta and couscous. The consumption of these products are very popular in Libya. Consequently, the objective of this study was to evaluate physical and chemical properties of two-imported durum (Mexican and Canadian) and their locally produced semolina, which used to make couscous and pasta, and compare their values with that documented in Libyan standardization for durum wheat and semolina.

## Materials and Methods

### Materials

Durum wheat and semolina samples, which were produced locally were collected from Ain Zara Mill. The study was conducted for 6

months from October 2012 to March 2013. The Mexican durum wheat and its fine and coarser semolina samples were collected during the first three months of the period of study. While, the last two months of the study period was Canadian durum wheat and its fine and coarser semolina. Wheat samples were monthly collected including three samples of Mexican wheat in October, November and December and two samples of Canadian wheat were collected in February and March. The collected samples were placed in polyethylene bags for further analysis. Regarding, fine and coarser semolina samples that were monthly taken during the production day at continual intervals (every two hours), followed by mixing these collected samples to form a representative sample for each month.

### Determination of physical properties

Physical properties, which included virtual tests (colour, smell and insect infection), impurities test (foreign material, weed seeds, broken and shrunken grains, damaged heat grains and other grains) and volumetric weight (kg/hl) were carried out according to the standard methods [9].

### Determination of proximate composition and heavy metals

The official methods of analysis [10] were used to determine moisture, total ash, protein and total dietary fiber contents in the collected samples. Also, lead and cadmium metals were determined in both durum wheat and semolina samples, using Atomic Absorption Spectrophotometric method [11].

### Determination of acidity

In this study the total acidity of the semolina samples was measured and estimated as sulfuric acid [12].

### Statistical analysis

Statistical analysis was performed using Complete Random Design. Duncan's test was used to find out the significant differences between the means at the 1% probability.

## Results and Discussion

### Physical properties of wheat samples

The virtual properties are an important issue for quality of durum wheat regarding its trade and processing. It was found that the results of virtual properties of the imported durum wheat were in agreement with Libyan standardization for durum wheat [13]. The insect infection grain (IIG) of Mexican and Canadian grains was 0.05%, as displayed in Table 1, which is the minimum required in Libyan standardization for semolina wheat.

The quantities of foreign matter (FM) in Mexican and Canadian durum were 0.10 and 0.02%, respectively, (Table 1). These values were within the minimum limits of Libyan standardization, with significant differences between the two samples ( $p < 0.01$ ). The results also showed that heat-damaged grains (HDG) in Mexican and Canadian wheat were 1.72 and 4.55% respectively, (Table 1) and therefore these results were above the upper limits (0.5%) mentioned in Libyan standardization for durum wheat.

The amount of broken and shrunken grains (BSG) in Mexican and Canadian wheat were 7.00 and 4.81%, respectively, as shown in Table 1. It is noted that the quantities of BSG in Mexican wheat did not agree with Libyan standardization for wheat due to its higher than the permissible upper limit (6%) [14]. On other hand, the amounts of BSD in the Canadian wheat samples were identical to Libyan standardization limits [14]. In fact, significant differences in the amounts of BSG were observed between the Mexican and Canadian wheat ( $p > 0.01$ ).

Total impurities (TI) in Mexican and Canadian wheat samples were 9.41% and 9.48%, respectively (Table 1). These results were correspond to the maximum limits for the TI found in Libyan standardization for semolina wheat. The results of total impurities, heat damaged grains, foreign matter and broken and shrunken grains of this study did not agree with the findings of a study conducted by [15]. The findings of hectoliter weight test (HW) of the samples were 83.96 kg/hl for Mexican wheat samples and 83.40 kg/hl for Canadian wheat samples, Table 1. Our HW results of Mexican and Canadian samples were higher than the values of HW values reported for two

types of Syrian durum (83.1 kg/hl and 85.9 kg/hl) [7]. Grain shape and size are the key features influence HW test. Furthermore, it is indicated that a thousand grain weight higher than 40 g and a test weight above 76 kg/hl are preferred for semolina wheat [2].

**Table 1: Virtual properties and hectoliter weight of Mexican and Canadian durum wheat**

Property	Mexican	Canadian	LNCSM (2005)
HW (kg/hl)	83.96±0.08 <sup>a</sup>	83.40±0.04 <sup>a</sup>	78 – 83
IIG (%)	0.05±0.004 <sup>a</sup>	0.05±0.003 <sup>a</sup>	0.5 - 2.5
FM (%)	0.1±0.05 <sup>a</sup>	0.02±0.002 <sup>b</sup>	0.2 - 2.0
HDG (%)	1.72±0.03 <sup>b</sup>	4.55±0.15 <sup>a</sup>	0.02 - 0.5
BSG (%)	7.00±0.24 <sup>a</sup>	4.81±0.05 <sup>b</sup>	2.0 – 6.0
OG (%)	0.00±0.00 <sup>b</sup>	0.02±0.03 <sup>a</sup>	0.3 - 3.0
WS (%)	0.54±0.04 <sup>a</sup>	0.03±0.003 <sup>b</sup>	0.1 - 0.5
TI (%)	9.41±0.28 <sup>a</sup>	9.48±0.20 <sup>a</sup>	3.0 - 12.5

The values are the means ± Standard deviations. Values with the same subscriber in a row are not significantly different ( $p > 0.01$ ). LNCSM, Libyan National Centre for Standardization and Metrology. HW, Hectoliter weight. IIG, Insect infection grains. FM, Foreign material. HDG, Heat damaged grains. BSG, Broken and shrunken grains. OG, Other grains. WS, Weed seeds. TI, Total impurities

#### Proximate composition of wheat samples

Mexican wheat recorded less amount of moisture and protein contents (8.93% and 11.75%, respectively) in comparison to Canadian wheat (10.98% and 15.86%, respectively) (Table 2). The low moisture content could reflect the desert environment of the grain growth. The protein content of Mexican wheat was lower than the permissible limit (12%) as stated in Libyan standardization for semolina wheat. Another study pointed to significant differences amongst Syrian durum genotypes in protein content and ranged between 10.7% to 14.1%. The reduction in protein content of the studied samples could be due to low nitrogen contents of the soils where these samples were grown or to genotypes. Quantity of protein in the durum grain is a significant quality parameter that would be over 13% to confirm a 12% protein content in the semolina and pasta to attain a desirable texture [2].

It is important to note that adverse aspects of high protein content include reduction of HW, semolina yield and produce dark pasta. On the other hand, very low protein levels leads to breakable spaghetti with low firmness. The desirable properties of spaghetti, such as swelling during cooking, reduced cooking loss, retaining firmness with overcooking and less stickiness are associated with high protein content of durum [2].

#### Heavy metals in wheat samples

Contamination of soil by heavy metals are hazardous for human health, they might be certainly enter the food chain through plant foods and animals [16]. In this study, the toxic metals including cadmium and lead were measured in the collected wheat samples. As shown in Table 2, the contents of lead and cadmium were less than 0.012 mg/kg and 0.0003 mg/kg, respectively. These results comply with the requirements found in Libyan standardization for semolina wheat. It also falls within the limits of a study conducted by [14]. Different investigation reported that the average Cd concentration in twelve commercial varieties of durum wheat grains were 0.61 µg/g [16]. The observed roles of heavy metals in metabolism of plant are their involvement in reduction/oxidation processes [17]. For example, cadmium toxicity is associated with reduced metabolism process, enzyme activities and then growth of the plant [18]. Cereal is one of the plants that can store up to 40% of Cd straight in the grains, which directly could affect animal and human health [19].

**Table 2: Moisture, protein, heavy metals contents of Mexican and Canadian durum wheat**

Component	Mexican	Canadian	LNCSM	
Moisture (%)	8.93±0.02 <sup>b</sup>	10.98±0.03 <sup>a</sup>	Max (13.0%)	level
Protein (%)	11.75±0.01 <sup>b</sup>	15.86±0.01 <sup>a</sup>	Min (12.0%)	level
Cadmium (mg/kg)	Less than 0.012		Max level (0.2 mg/kg)	
Lead (mg/kg)	Less than 0.0003		Max level (0.2 mg/kg)	

The values are the means ± Standard deviations. Values with the same subscriber are not significantly different ( $p > 0.01$ ). LNCSM, Libyan National Centre for Standardization and Metrology. Max: maximum, Min: minimum

#### Virtual properties of semolina

Virtual of coarse and fine semolina produced from durum wheat samples (Mexican and Canadian) were identical to Libyan standardization [13]. Moreover, these results were in agreement with that published by [20] and [21].

#### Proximate composition of semolina

The results indicated that Canadian coarse and fine semolina significantly recorded higher contents of moisture, protein and ash compared to Mexican semolina (Table 3). These results are identical to Libyan standardization [14] for semolina and they were in consistent with some published results [15]. It is stated that quality and quantity of protein in wheat semolina are important for couscous production, where protein gives it the desired yellow colour, holding water during processing and preventing it from sticking before evaporation stage and drying process [22].

Ash content is an important indicator of the extraction rate of semolina used in the manufacture of couscous and pasta, since, it affects their colours and the sensory qualities, if it exceeds the greater limits (0.9%) [23]. It is important to consider moisture, protein and ash contents of semolina, when used to manufacture its products such as couscous and macaroni [21], [24], [25], [26]. A durum wheat sample was milled to obtain coarse, medium and fine semolinas that were analysed for physical and chemical properties. The medium and fine semolina presented higher protein and ash contents compared to coarser semolina [27]. Purity is measured as an ash content and the amount of brown spots per unit area in the produced semolina. Semolina with ash content higher than 0.9% based on dry weight consider a product with high extraction rate, because of bran contamination, which negatively affect its brightness and yellowness. The results of the current study displayed that Mexican coarser semolina significantly had higher fiber content (0.97%) compared to canadian coarse semolina (0.92%) (Table 3). Although fiber content was not mentioned in Libyan standardization for semolina [22]. It was indicated that high fiber content reduces the quality of the semolina final product [28]. Practically milling of durum semolina is to produce flour particles that range between 300 and 500 µm. To obtain this rang of the particle size; the bran and germ fractions need to be eliminated from the flour; in addition, to the negative effects of fiber fraction on the final product sensory properties [20]. Although, bran and germ segments are rich in fiber, and other physicochemical components. A research was conducted to evaluate effects of bran incorporation into durum wheat semolina illustrated that the produced pasta had sticky, brittle texture and demonstrated high cooking loss. A high cooking loss lead to weakening of pasta structure, which negatively influence its sensory qualities [29].

#### Acidity of semolina

The Total acidity, estimated as sulfuric acid content of semolina samples, which were recorded in Table 3. The Acidity of Mexican fine and coarser semolina was 0.01%, while the total acidity of Canadian semolina was 0.006. The total acidity values of coarse and fine semolina samples were in agreement with Libyan standardization limits [21]. In fact, high acidity of semolina samples could cause clumps in the final product [28].

**Table 3: Proximate composition, total fiber content and acidity**

Component (%)	Mexican		Canadian		LNCSM (2009)	
	FS	CS	FS	CS	CS	FS
Moisture	12.4 <sup>a</sup>	13.33 <sup>b</sup>	13.5 <sup>b</sup>	13.62 <sup>b</sup>	14.5	14.5
Crud Protein	10.52 <sup>a</sup>	10.5 <sup>a</sup>	14.94 <sup>b</sup>	14.18 <sup>b</sup>	11	10.5
Total ash	0.86 <sup>a</sup>	0.82 <sup>a</sup>	0.97 <sup>b</sup>	0.98 <sup>b</sup>	1.0	0.90
Dietary fiber	0.91 <sup>a</sup>	0.97 <sup>b</sup>	0.93 <sup>c</sup>	0.92 <sup>a</sup>	-	-
Total acidity	0.01 <sup>a</sup>	0.01 <sup>a</sup>	0.006 <sup>b</sup>	0.006 <sup>b</sup>	0.1	0.1

The values are the means ± Standard deviations. Values with the same subscriber letter in a raw are not significantly different ( $p > 0.01$ ). LNCSM, Libyan National Centre for Standardization and Metrology. CS, coarser semolina. FS, Fine semolina.



### Heavy metals in semolina

Lead and cadmium contents were less than 0.012 mg/kg and less than 0.0003 mg/kg, respectively, in semolina samples. Our results were in accordance with the standard requirements of Libyan standardization for semolina [21], that stated the amount of lead and cadmium should not exceed 0.2 and 0.1 mg/kg in semolina, respectively.

### Conclusions

It can be concluded that most of the physical and chemical properties of the imported durum wheat and semolina produced from Mexican wheat were in consistent with Libyan standardization for semolina wheat. The measurements of these properties is a significant procedure, since these types of wheat are used to produce pasta and couscous that are widely consumed in Libya.

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