

DURUM WHEAT BREAD: FLOW DIAGRAM
AND QUALITY CHARACTERISTICS
OF TRADITIONAL ALGERIAN BREAD *KHOBZ EDDAR**

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Abstract. The purpose of this work was to evaluate the cellular structure and the physical and sensory properties of traditional Algerian bread named *Khobz Eddar* after establishing the flow diagram of its manufacturing by a household survey. The household survey involving 50 Algerian housewives was realised in the town of Constantine (Algeria). A majority of the women reported that *Khobz Eddar* bread is made using durum wheat semolina, salt, yeast, water, oil and eggs, and also nigella and sesame seeds on bread surface. Subsequently, *Khobz Eddar* bread was produced under controlled conditions, in a laboratory, according to the results of the household survey, and it was tested for its quality. The results showed that the traditional bread had a specific volume of $3.64 \text{ cm}^3 \text{ g}^{-1}$, a low hardness and chewiness (13.15 and 3.70 N), and a high springiness of 0.867. Colour measurements showed crumb lightness with L^* value of 72.66 and brown crust of bread with L^* value of 57.78. Cellular analysis of bread crumb images indicated a number of cells of 628.5 per 778.63 mm^2 total cell area with small holes (1.14 mm^2). Produced bread was found acceptable and desirable with respect to its volume, colour, texture and crumb structure. Sensory analysis indicated also that *Khobz Eddar* is an appreciated bread.

Key words: durum wheat; flow diagram; household survey; *Khobz Eddar* bread; quality of bread

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INTRODUCTION

Durum wheat is known for its high endosperm hardness, protein content, intense yellow colour, good taste, pleasant aroma and excellent cooking qualities (Kneipp 2008, Torbica *et al.* 2011). Durum wheat is particularly popular for bread making at home in the Mediterranean regions and its popularity is spreading also to other countries. Bread made with durum wheat has a characteristic taste and smell, is rich in carotenoids with pro-vitamin A activity and has a more prolonged shelf life. Many of these breads are not produced industrially, so their production is still traditional (Pasqualone *et al.* 2007, Sissons 2008, Chiavaro *et al.* 2008).

Bread is produced in most countries of the world, and is very popular especially where it constitutes a major source of dietary proteins and calories. Several kinds of durum wheat bread are made mostly by traditional methods in Turkey, Middle East, Northern African countries and Southern Italy (Gocmen Inkaya and Aydin 2009, Mir *et al.* 2014). About 24% of the world's population uses durum wheat semolina for making bread. In western Asia and northern Africa, 50% of durum wheat semolina is used for making flat bread (Guzmán *et al.* 2016).

In Algeria, *Khobz Eddar* is a traditional leavened home-made bread characterised by a crispy crust and a soft crumb, which is made of durum wheat semolina (Kezih *et al.* 2014, Bourekoua *et al.* 2016). It is a very nutritious bread, due to the high content of protein in semolina and, above all, to the inclusion of eggs in its formulation.

In most countries around the world, some traditional foods are at risk of disappearing because of modified lifestyles, and for that reason it is important to study them to maintain these important elements. Therefore, the traditional Algerian bread can be popularised around the world.

In the absence of studies about traditional Algerian bread *Khobz Eddar*, it seemed interesting to carry out a household survey to establish the flow diagram of the productive process of *Khobz Eddar* bread, in order to identify the different ingredients used in its baking and to determine its quality by evaluation of the major physical, structural and sensory characteristics of this bread.

MATERIALS AND METHODS

Material

Durum wheat semolina (particle size between 200 and 500 μm) had 14.20% moisture, 0.83% ash, 0.67% lipid and 13.93% protein. All materials included instant dry yeast (saf-instant, France), salt, commercial sunflower oil, fresh eggs, nigella and sesame seeds purchased from Algerian local market.

Household survey about Algerian bread *Khobz Eddar*. Collection of data

To study the traditional Algerian bread *Khobz Eddar*, a household survey was carried out in the town of Constantine (Algeria). The choice of this town was based on the need of rendering the survey nationally representative. This town is the most popular town in terms of production of this bread.

Constantine city is located in eastern Algeria. It is composed of 10 sectors in the official newspaper of the Algerian republic N° 69 (JORA 1991). According to ONS (2008), the population of Constantine town was estimated at 448.374 inhabitants with 225.621 women and 222.753 men.

Only women aged above 18 years were involved in the household survey, accounting for a total number of 50, coming from the 10 sectors of the town of Constantine representative of the total population. This choice was based on the fact that only household women usually manufacture bread *Khobz Eddar*. The survey was conducted using the method of quota sampling to obtain the information with a maximum of detail and to insure the representativeness of the household survey.

The collection of data was performed using a questionnaire. It contained a part of identification, where women were asked for personal information. The second part of the questionnaire included data about bread: type of durum wheat used, ingredients and their proportions for the manufacture of bread. Finally, the questionnaire ended with the manufacturing steps of *Khobz Eddar* and the flow diagram.

Flow diagram according to household surveys

The women investigated were aged between 25 and 64 years. The average age was 43.6 years. Of all the women surveyed, 96% make *Khobz Eddar* at home with 4% who buy it.

The results of the household survey showed that 98% of women make *Khobz Eddar* bread with durum wheat semolina against 2% who make it using soft wheat flour. Apart from water, yeast and salt, the totality of women added additional ingredients, namely vegetable oil (mostly sunflower oil) and fresh whole eggs. Water was used at warm temperature (40°C), and was added in two steps, during manual mixing and during kneading. The process of bread making included a resting step of 10 minutes after manual mixing and before kneading. Eggs were added during kneading. At the end, sesame and nigella seeds were added on bread surface.

The flow diagram type that resulted from the household survey of traditional *Khobz Eddar* bread is shown in Figure 1.

Preparation of bread

The recipe for the bread, according to the results of household surveys, included durum wheat semolina (100 g), salt (2 g), oil (20 ml) and water (40 ml). Water added in bread making was determined by preliminary experiments according to the results of household survey, and accounted for 55 ml for 100 g of semolina,; a part of the amount of water (45 ml) was added in the mixing step and the rest (15 ml) was added during kneading (according to the results of household survey presented in Figure 1).

The dry ingredients were mixed, and yeast (2 g) was added to the remaining mixture with warm water. After mixing, the dough was rested for 10 min at room temperature, then the dough was kneaded for 15 min. During the kneading step, 10 g of beaten whole eggs and the rest of water (15 ml) were added gradually until the dough became soft. After kneading, the dough was rounded and placed in a mould and fermented in a climatic chamber (Sadkiewicz Instruments, Bydgoszcz, Poland) for 45 minutes at 37°C; the surface of dough was spread with egg yolk, sesame and nigella seeds after the fermentation step. The bread loaves were baked in an electric oven (Sadkiewicz Instruments, Bydgoszcz, Poland) at 230°C for 20 minutes.

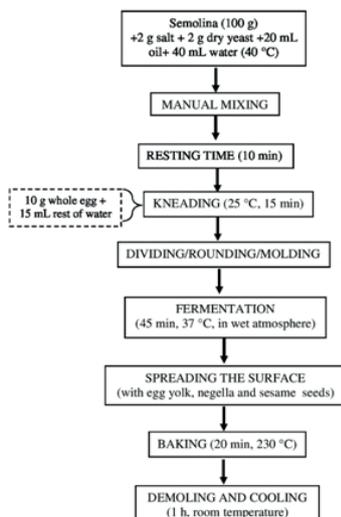


Fig. 1. Established diagram type of traditional Algerian *Khobz Eddar* bread

Bread quality evaluation

Bread analyses, carried out one hour after baking (Fig. 2), consisted in the determination of specific volume, TPA analysis, bread moisture and colour of crumb and crust. For each analysis, four loaves of bread were used.



Fig. 2. Appearance of traditional Algerian *Khobz Eddar* bread

Physical properties

Bread volume was measured by rapeseed displacement according to the AACC Approved Method 10.05 (AACC 2000). Breads were weighed and their specific volume ($\text{cm}^3 \text{g}^{-1}$) was calculated by dividing volume by weight. Moisture content was calculated based on ICC 110/1 method (ICC 1996).

Texture profile analysis (TPA) was performed on the breadcrumb using a texture analyser (ZWICK Z020/TN2S strength tester), the samples (30 x 30 x 20 mm) of bread crumb were compressed twice using a capital equipped with a 30 mm lug until 50% depth at a crosshead speed of 1 mm/s was achieved (Różyło *et al.* 2014, 2015a, 2015b). The parameters recorded were hardness, cohesiveness, springiness and chewiness, obtained from two-bite TPA curves (1 and 2-curves): hardness (peak force 1), springiness (length of the base of area 2/length of the base of the area 1), chewiness (hardness \times cohesiveness \times springiness) (Gámbaro *et al.* 2006). The texture tests were performed in four replicates for each loaf.

The colour measurements of bread crumb and crust samples were performed using a 4Wave CR30-16 colorimeter (Planeta, Tychy, Poland) under the following conditions: light: D65; space: *Lab*; diam: 16 mm; style: 8/d. Colour was recorded using CIE-*Lab* uniform colour space, where L^* indicates lightness. Redness+/greenness- and yellowness+/blueness- were denoted by the a^* and b^* values, respectively. Data from three slices per sample were averaged.

Crumb image analysis

Cellular analysis of bread crumb was performed using Image J software (version 1.43, National Institutes of Health, USA) according to Gonzales-Barron and Butler (2006). Images of the centre of a bread slice (1 cm thickness) were scanned using a flatbed scanner (Epson scan Cx4300). Images were scanned in the presence of scale at 300 dots per inch.

Original scanned images (RGB) were converted to 8 bit format (greyscale) where each pixel in an image has a grayscale intensity in a scale ranging from 0 (black) to 255 (white). Images were adjusted and transformed to binary images in which cells are presented as black holes (Fig. 3).

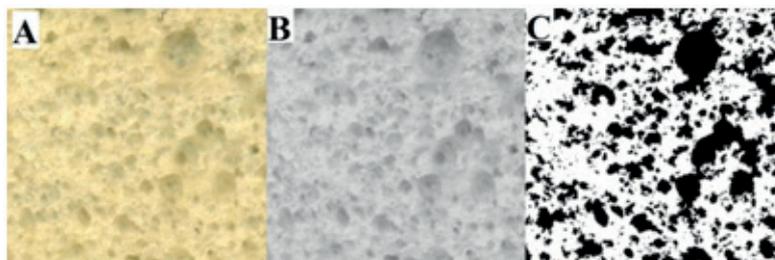


Fig. 3. Crumb structure of *Khobz Eddar* bread showing the different steps of image analysis (image J. 1.43). A: Original image; B: Grey level image; C: Binary image thresholded

Analysis of the binary images allowed to determine the cellular structure of crumb bread. Number of cells and average size were calculated. As reported by Scheuer *et al.* (2015), small cells present an area of $< 4 \text{ mm}^2$, medium ($4\text{-}8 \text{ mm}^2$), and large cells are those with an area $> 8 \text{ mm}^2$.

Sensory analysis

For sensory evaluation, the samples were sliced mechanically (1 cm thick) and divided into eight parts (Matos and Rosell 2012). The panel for sensory evaluation consisted of 52 untrained consumers (23-48 years old, 28 females and 24 males) who were habitual consumers of bread. According to a nine-point hedonic scale (1: dislike extremely, 5: neither like nor dislike, 9: like extremely), the taste, aroma, texture and the overall acceptability of breads were evaluated (Lim *et al.* 2011).

Statistical analysis

In this study, means and standard deviations (SD) were calculated using MINITAB (version 13.31, USA) statistical software. Epi Info software version 7 (CDC, USA) was used to analyse the results of the household survey. All of the filled questionnaires were seized. The data were analysed descriptively and analytically. For quantitative variables, the average values and standard deviations were calculated.

RESULTS AND DISCUSSION

Physical characteristics of bread

Bread with good quality is characterised by having sufficient volume, an attractive appearance and well developed crumb. The consumers' acceptance of this product is limited when volume is low, texture is coarse, and staling is fast (Boz and Karaoglu 2013, Dapcevic Hadnadev *et al.* 2014).

Data for the characteristics of obtained breads and breadcrumb are presented in Tables 1 and 2 with standard deviations of the measurement values.

Volume of bread

Loaf volume is the most important criterion used for the determination and assessment of bread quality (Różyło and Laskowski 2011, Dogan *et al.* 2012).

Laboratory produced *Khobz Eddar* bread samples, prepared according to the survey results, presented high specific volume (3.64 ± 0.105) $\text{cm}^3 \text{g}^{-1}$ (Table 1).

Table 1. Physical characteristics of traditional Algerian *Khobz Eddar* bread

Parameters	<i>Khobz Eddar</i> bread
Specific volume ($\text{cm}^3 \text{g}^{-1}$)	3.64±0.030
Hardness (N)	13.15±0.953
Springiness	0.867±0.013
Chewiness (N)	3.700±0.606
Moisture content (%)	26.140±1.606
Colour of bread crumb	
L^*	72.66±4.134
a^*	0.43±0.026
b^*	28.66±0.726
Colour of bread crust	
L^*	57.78±0.779
a^*	15.03±0.336
b^*	40.33±0.446

Note: Values are means \pm standard deviation

Although durum semolina usually produces a lower loaf volume than bread wheat flours (Sissons 2008), the high specific volume of *Khobz Eddar* could be attributed to the composition of semolina and, above all, to the ingredients (oil and egg) added in *Khobz Eddar* recipe. Orth *et al.* (1988) indicated that semolina from durum wheat generally has a high protein content. Many studies have reported the relation between bread volume and protein content of wheat (Dexter *et al.* 1994, Liu *et al.* 1996, Dogan *et al.* 2012).

Fat increases loaf volume and improves the crumb grain, retention of freshness, and dough handling properties (Pyler 1988).

Eggs and their derivatives are important ingredients in the composition of several types of bread products. In addition to an exceptional nutrient power, they have the ability to retain air, thus forming foams and other soft structures. This ingredient is capable of improving the coherence between starch granules, increasing the stability of the dough. In fact, egg albumins are reported to form a relatively stable aerated foam structure, potentially suitable for stabilising other dough ingredients, including lipids (Pasqualone *et al.* 2010).

Textural parameters of traditional *Khobz Eddar* bread

Texture profile analysis (TPA) measurements allow to consistently and objectively check the quality of bread (Paciulli *et al.* 2016). Different textural parameters of traditional Algerian *Khobz Eddar* bread are shown in Table 1.

Data indicated the lowest values of hardness as 13.15 N, chewiness – 3.70 N, while the bread presented the highest value of springiness of 0.867.

Hardness of bread crumb is considered as an important criterion of texture to describe the quality of bread, with consumers desiring soft and flexible crumbs and low hardness (Hager and Arendt 2013). The lowest hardness and chewiness of traditional Algerian bread were probably due to the addition of egg and oil in the recipes and to the highest specific volume of bread.

Springiness is associated with fresh, aerated and elastic product, thus high springiness values are recommended (Matos and Rosell 2012). Values obtained for traditional Algerian bread indicated that this bread presented an acceptable springiness.

Moisture content

Moisture content is not a wheat-grade determinant but it is important for providing information when storing or processing wheat; bread quality is also affected by moisture content (Sanina *et al.* 1996, Maghirang *et al.* 2006). As can be seen in Table 1, *Khobz Eddar* had an average moisture content of 26.14%. This value of moisture content may be related to the moderate amount of water added for manufacturing in making the bread (55 ml).

Colour of *Khobz Eddar* bread

Colour of bread is one of the most important indicators of bread quality and it is related to consumer preferences. Maillard reaction and caramelisation are responsible for the appearance of colour when bread is heated (Artan *et al.* 2010). The colour (L^* , a^* , b^*) characteristics of crumb and crust of traditional Algerian bread samples made from semolina are given in Table 1. According to Yi *et al.* (2009), the most desirable crust and crumb colours of bread should be golden brown and creamy white, respectively.

Considering the colour of the crumb (Tab. 1), bread appears clear because the value of L^* parameters is high – 72.66; the lower L^* values in the crust of bread – 57.78 – were expected due to Maillard browning and caramelisation. Lightness of ingredients plays an important role in bakery products with regard to consumer preferences (Metzger, 2003).

Regarding a^* values of crumb colour, the value of 0.43 indicated that the samples had a slight tendency for the red colour, while for crust the samples had a positive high value of 15.03.

The parameter b^* highlighted yellow crumb, showing a high value of 40.33 in the bread crust and 28.66 in the crumb, which may attributed to the addition of egg in the recipes of the bread.

Crumb cellular properties

To produce bread with desirable characteristics such as as high loaf volume and uniform crumb, it is important to reach an optimal number and distribution of cells present in the crumb. These cells originate from gas entrained during mixing and their number and size depend on the ability of the dough to retain this gas over long periods, especially during fermentation and oven rising (Wrigley and Bietz 1988, Trinh 2013). The characteristics of crumb structure of bread *Khobz Eddar* are shown in Table 2.

Table 2. Crumb cellular structure of traditional Algerian *Khobz Eddar* bread

Parameter	<i>Khobz Eddar</i> bread
Number of cells	628.5±4.550
Average size (mm ²)	1.14±0.020
Total cell area (mm ²)	778.63±1.152

Note: Values are means ± standard deviation.

Khobz Eddar bread contained an average of 628.5 cells per 778.63 mm² total cell area, with average size of 1.14 mm². These results indicate that *Khobz Eddar* is characterised by a high number of cells of small size. Svec and Hruskova (2004) reported that image analysis characteristics were related to specific volume, a higher total cell number is accompanied by a lower mean cell size.

Sensory evaluation

Sensory evaluation of traditional Algerian *Khobz Eddar* bread (Fig. 4) showed the highest values for all attributes, taste, aroma, appearance, texture and overall acceptability near to 9.

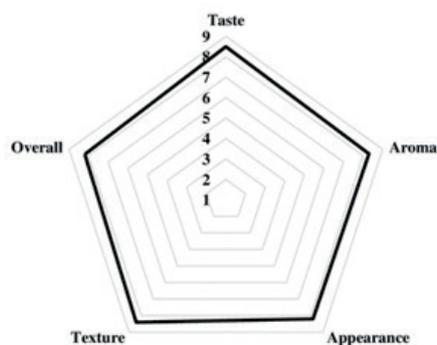


Fig. 4. Sensory profile of traditional Algerian *Khobz Eddar* bread

All consumers accepted this bread and they found it desirable. The particular recipe of *Khobz Eddar* bread with ingredients such as whole egg and oil probably make this bread to be appreciated by consumers. As reported by Gomez Pallares and Diez Val (2001), the taste of eggs helps to improve the sensory quality of the finished products, and also bread with a high volume is more appreciated by consumers.

CONCLUSIONS

This first study allowed us to perform a detailed diagram of traditional Algerian *Khobz Eddar* bread based on the results of a household survey conducted in the town of Constantine (Algeria), involving 50 women.

The results of the household survey showed that *Khobz Eddar* is a bread made by women in house, based in durum wheat semolina, oil and egg, and it is characterised by a high loaf specific volume, low hardness, chewiness but the highest springiness, yellow colour of crumb and brown colour of crust. The results of image analysis may be used to investigate and predict different properties of breads. Image analysis of crumb revealed that *Khobz Eddar* bread contained a high number of small holes, the breads exhibited an aerated and fine crumb structure. Sensory results proved that the bread produced was interesting, and these characteristics may suggest the suitability of durum wheat for making bread with the best quality.

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CHLEB Z PSZENICY DURUM: SCHEMAT WYTWARZANIA
ORAZ CHARAKTERYSTYKA JAKOŚCI TRADYCYJNEGO
ALGIERSKIEGO CHLEBA *Khobz Eddar*

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Streszczenie. Celem pracy było określenie właściwości fizycznych, struktury komórkowej oraz cech sensorycznych tradycyjnego algierskiego chleba o nazwie *Khobz Eddar*. Oznaczenia te wykonano po ustaleniu schematu jego produkcji na podstawie badań ankietowych przeprowadzonych w gospodarstwach domowych. W mieście Constantine (Algieria) zrealizowano ankietę obejmującą opinie na podstawie doświadczeń 50 gospodyń domowych. Większość kobiet zgłosiła, że chleb *Khobz Eddar* jest wytwarzany przy użyciu semoliny z pszenicy durum, soli, drożdży, wody, oleju i jaj, posypkę stanowią nasiona czarnuszki i sezamu. Opracowany schemat produkcji wykorzystano do wypieku chleba *Khobz Eddar* w kontrolowanych warunkach w laboratorium. Wyniki oceny jakości uzyskanego chleba wykazały, że miał on objętość na poziomie $3,64 \text{ cm}^3 \cdot \text{g}^{-1}$, miękisz charakteryzował się niską twardością i żuwalnością (13,15 i 3,70 N) oraz dużą sprężystością 0,867. Pomiary barwy wykazały jasną barwę miękiszu o wartości L^* wynoszącej 72,66, natomiast skórka chleba miała barwę brązową, dla której L^* wynosiła 57,78. Analiza obrazu w tym ocena porowatości miękiszu wykazała liczbę komórek 628,5 mieszczącą się na powierzchni $778,63 \text{ mm}^2$ z małymi porami ($1,14 \text{ mm}^2$). Wyprodukowany chleb biorąc pod uwagę jego objętość, kolor oraz strukturę miękiszu uznano za akceptowalny i pożądaný. Analiza sensoryczna wysoce doceniła walory trakcyjnego chleba *Khobz Eddar*.

Słowa kluczowe: pszenica durum, diagram wytwarzania, ankietowe badania gospodarcze, chleb *Khobz Eddar*, jakość chleba