Assessment of Kamut® wheat quality

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Abstract

Purpose – The purpose of this paper is to investigate the potential quality of Kamut® (triticum turgidum turanicum) as an ancient relative of modern durum wheat for food preparation and Egyptian consumption.

Design/methodology/approach – The methodology included in this paper is based on quality evaluation of Kamut wheat of the Dashure-Fayume geographical origin physically, chemically and technologically compared to Beni Suef 1, Beni Suef 3 and Suhag 3, the most dominant durum varieties in Egypt. After that, producing a specific end product (traditional couscous) regarded the critical quality aspects in Kamut wheat.

Findings – The results obtained showed that Kamut grains had higher physical properties indicating higher milling yield potential. Besides, Kamut flour was remarkable with higher protein and oil content. The use of a farinograph for assessing the rheological properties of Kamut dough has proven a useful quality for its measured characteristics compared to the Egyptian durum varieties. The good physical and rheological properties, coupled with high protein content, validated that Kamut is a valuable addition to the Egyptian diet and suited for the production of pasta and/or couscous. The sensory attributes of traditional couscous were significantly ($p < 0.05$) highly acceptable to the panelists.

Originality/value – These results lead to valuable addition and improvement of the Egyptian diet which consider The Sustainable Agricultural Development Strategy (SADS) towards 2030 in Egypt based on achieving higher rates of food security in strategic goods in regard to improve food quality and safety, especially Kamut wheat which produces high quality grains without artificial fertilizers and pesticides.

Keywords Kamut, Beni Suef 1, Beni Suef 3, Suhag 3, Durum wheat quality, Physical, Chemical, Rheological properties, Traditional couscous, Egypt, Wheat

Paper type Research paper

Introduction

Current trends toward low-impact and sustainable agriculture as well as an increase in the utilization of "biological" and "functional" products led to the development of new specialty foods based on grain blends. Components of such foods are often so-called "ancient wheats" which were never the subject of modern plant breeding programs (Grausgruber *et al.*, 2005; Brandolini *et al.*, 2008). "Ancient grains" or "primitive grains," have origins that date back to pre-historic times. These grains include einkorn, emmer (farro), spelt and Kamut® (Stallknecht *et al.*, 1996).

Kamut brand grain is an ancient relative of modern durum wheat Kamut is not the name of a grain it is a trademarked word used to market a grain which contains certain guaranteed attributes (The Kamut, 2008).

The real history of the Kamut brand grain has been as elusive as its taxonomic, most scientists believe it probably survived the years as an obscure grain kept alive by the diversity of crops common to small peasant farmers perhaps in Egypt, or Asia Minor. It is thought to have evolved contemporary with the free threshing tetraploid wheats. Scientists from the USA, Canada, Italy, Israel, and Russia have all examined the grain and have reached different conclusions regarding its identification. All agree that it is a *Triticum turgidum* (AABB), which also includes the closely related durum

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wheat. The correct subspecies is in dispute. It was originally identified as *polonicum*. Some now believe it is *turanicum*, while others claim it is durum. One Russian scientist believes it is a durum cultivar called "Egiptianka" or "the durum of Egypt." Still others believe it is may evolve from a mixture of many types which would be consistent with its supposed descent from an ancient landrace originally gathered by primitive farmers from the wild. The majority now identify the grain as *turanicum* commonly called Khorasan wheat. Although its true history and taxonomy may be disputed, what is not disputed is its great taste, texture, and nutritional qualities as well as its hypo-allergenic properties (Quinn, 1999).

The available information on kernel physical characteristics and chemical composition shows that Kamut kernels are twice the size of wheat kernels with 20-40 percent more protein, higher in lipids, amino acids, vitamins, and minerals and characterized by a hump shape, but it is best known for its distinctive nutty, buttery flavor. Thousand-kernel weight, in most cases >50 g and often even >60 g. The high thousand-kernel weight might be a valuable trait to transfer into durum wheat to improve grain yield. Moreover, the grain has an amber color and high vitreousness (Quinn, 1999; Grausgruber *et al.*, 2005; Singh, 2007). On the other hand, very little is known about its rheological and pasting performances although Kamut is making a foothold in the organic grain market (Brandolini *et al.*, 2008).

Accordingly, the present research aims to assess Kamut wheat quality physically, chemically, and technologically compared to the most dominant Egyptian durum varieties named Beni Suef 1, Beni Suef 3, and Suhag 3 to better understand its potential quality for food preparation and Egyptian consumption.

Materials and methods

Source of wheat grains

Wheat grains (*Triticum durum* L.) varieties Beni Suef 1, Beni Suef 3, Suhag 3, and Kamut wheat (*Triticum turgidum turanicum*) were obtained from Field Crops Research Institute, Agricultural Research Center (ARC), Giza, Egypt. During field experiments in Dashure-Fayume area, researchers of Field Crops Research Institute obtained Kamut grain from a small peasant farmer and they started to make pilot experiments on it. The farmer used to plant a small area in his farm and known that Kamut produce high-quality grains without artificial fertilizers and pesticides and had a valuable addition to his household diet.

Physical properties of wheat grains

Wheat grains were subjected to test the physical properties; hectoliter mass (kg/hl) was determined according to American Association of Cereal Chemists (AACC) 55-10 (AACC, 2000). Thousand-kernel weight was measured on cleaned grain sample as the weight (g) of 1,000 seeds. Kernels were sliced with a farinator and vitreous kernels counted. Semolina extraction rate (percent) were obtained after cleaning and conditioning to 15 percent moisture content for four hours wheat grains were milled according to The AACC 26-21A (AACC, 2000) on a laboratory mill, model Brabender® Duisburg, type 279002, Made in western Germany. The extracted semolina granules (size range 150-540 μm) were kept in air tight container at 3-5°C till used.

Chemical analysis of wheat flours

Moisture, crude protein, crude fiber, total lipids, and ash contents were determined in wheat semolina according to the methods outlined Association of Official Agriculture

Chemists (AOAC, 2000). Total carbohydrates were determined according to the method described by Montgomry (1961).

Rheological properties of wheat doughs

Farinograph curves were generated according to AACC Method 54-21 (AACC, 2000). The 50 g mixing bowl was used, in conjunction with the standard operating speed of 63 rpm. The curves were read manually and several studied parameters (water absorption (percent), arrival time (min), dough development time (min), dough stability (min) and degree of softening (BU)) were recorded using a Brabender® OHG Duisburg. Wet gluten content was determined following AACC Standard Method 38-12 (AACC, 2000) and dry gluten content was determined using AACC Standard Method 38-12A (AACC, 2000).

Traditional couscous preparation

Two kinds of couscous were prepared from Kamut semolina flour and commercial one according to the method described by Debbouz and Donnelly (1996). Approximately 100 ml of water with 2 percent salt was added to 250 g of flour in a large aluminum pan and thoroughly mixed and rolled by hand until agglomeration of semolina particles resulted in couscous granule formation. The couscous was sieved through a set of two sieves (1,400 and 1,900 μm mesh openings). The well-shaped and uniformly sized couscous granules were steamed in a couscous maker (couscousière) for 30-40 min. The steamed couscous was laid out on a cloth sheet and dried at room temperature for 48 hr after drying; couscous was sieved through a standard testing sieve (1,700 μm mesh opening) to remove any large agglomerates formed during the steaming process.

Sensory evaluation of couscous

A ten-member panel was selected among staff of Crops Technology Department, Food Technology Research Institute to conduct the sensory evaluation of the two kinds of couscous. Couscous were cooked with small amount of water then dressed with butter. Samples were evaluated for their cooked sensory attributes (color, taste, odor mouthfeel – granulation appearance and overall acceptability) according to the method of Debbouz and Donnelly (1996).

Statistical analysis

The data obtained from sensory evaluation of traditional couscous were statistically analyzed using the Statistical Analysis System (SAS Institute Inc., 1999). Analysis of variance and Duncan's multiple range tests were used for mean comparisons. $p < 0.05$ was considered significant. All data are expressed as mean $\pm$ SD.

Results and discussions

Wheat quality can be broadly defined into physical quality, chemical quality, and rheological and processing characteristics. Physical grain quality traits include kernel hardness, vitreousness of the grain, kernel weight, hectoliter weight, kernel size, and shape, all of which can influence rheological and/or processing characteristic (Bandla, 2008). Table I exhibits the physical properties of Kamut and Egyptian durum grains.

Data revealed that Kamut wheat had the highest properties of hectoliter (88.1 kg/hl), thousand-kernel weights (55.2 g), vitreousness (93.75 percent), and semolina extraction (77.1 percent) followed by Beni Suef 1 and Suhag 3.

Hectoliter (also referred to as test weight), is a measure of grain density, and is widely utilized as a wheat grading factor to predict milling potential, but there is no consensus on its true value as a milling yield predictor (Hook, 1984). However, different wheat classes and different varieties within a wheat class exhibit different relationships between test weight and milling yield (Dexter and Edwards, 1999). With lower test weights (below 80 kg), the milling yield usually falls rapidly (Bandla, 2008).

Thousand-kernel weight is a measure of average kernel size. Matsuo and Dexter (1980) reported a high correlation between milling yield and grain size in durum wheat. With large kernels a greater milling yield is generally expected due to a greater ratio of endosperm to bran.

Kernel vitreousness is another aspect for evaluation of durum wheat quality it describes endosperm structure (refers to the optical states of the endosperm), whether it appears glassy or mealy, which is strongly influenced by the environment (Haddad *et al.*, 1999). The high vitreous wheat generally mills to higher amount of semolina and lower amount of flour compared to less vitreous wheat (Breen *et al.*, 1977). Generally, durum wheat have higher percentage from vitreous kernels (El-Rassas *et al.*, 1989).

The quality for the miller is mainly represented by high extraction rate (i.e. the proportion of the wheat kernel that is milled into semolina). During milling, hard samples show higher starch damage, flour extraction rate and energy consumption (Troccoli *et al.*, 2000; Brandolini *et al.*, 2008).

The high test weight (more than 65 kg/hl) and vitreousness (more than 70 percent) values grade wheats at the heavy hard amber durum wheat US grade No. 1, as described by the United States Department of Agriculture (USDA, 2001).

Accordingly, it could be abstracted that Kamut wheat had highest physical properties indicating highest milling yield potential and graded it at the heavy hard amber durum wheat US grade No. 1.

The nutritional quality is linked to the chemical composition and the presence of specific elements and/or bioactive compounds suitable to satisfy the nutritional needs of consumers and contribute to their welfare and health (D'Egidio and Pagani, 2010). Table II exhibits the chemical composition of Kamut and Egyptian durum semolina.

Wheat samples	Hectoliter (kg/hl)	1,000-kernel weight (g)	Vitreousness (%)	Semolina extraction (%)
Kamut®	88.10	55.20	93.75	77.10
Beni Suef 1	85.00	50.20	89.50	71.20
Beni Suef 3	82.00	43.50	87.50	64.70
Suhag 3	82.80	51.60	68.50	73.30

Table I. Physical properties of Kamut® and Egyptian durum grains

Wheat samples	Crude protein (%)	Ash (%)	Crude fiber (%)	Total lipids (%)	Total carbohydrates (%)
Kamut®	18.64	1.90	1.80	3.41	75.25
Beni Suef 1	14.80	1.70	3.10	1.97	76.43
Beni Suef 3	13.80	1.80	3.20	1.98	79.22
Suhag 3	13.20	1.60	2.80	2.15	80.25

Table II. Chemical composition of Kamut® and Egyptian durum semolina (results based on 15% water content)

Data revealed that Kamut flour recorded the highest chemical composition except for crude fiber. The most striking superiority was its protein potential compared to the other durum varieties which exhibited chemical composition ranged from 13.20 to 14.80, 1.60 to 1.80, 2.80 to 3.20, 1.97 to 2.15, and 78.43 to 80.25 percent for crude protein, ash, crude fiber, total lipids, and total carbohydrates, respectively.

Our present findings are in line with Analytical Report No. 88011589 (1988) done by Medallion Laboratories who did a complete nutritional analysis of Kamut compared with common wheats (hard, soft, and durum). Because Kamut brand wheat is made up of such a large seed (about two to three times the size of a normal wheat kernel), the ratio of the seed coat to the seed volume is less than other studied wheats explains little percent of fiber. Also, the complete nutritional analysis of Kamut brand grain boasts more lipids and fatty acids substantiates than other wheats. The most striking superiority of Kamut brand wheat is found in its protein level up to 40 percent higher than the national average for wheat, e.g. Canadian durum wheats protein varied from 10.6 to 12.7 percent (Matsuo and Irvine, 1970) and Egyptian durum wheats protein varied from 12.66 to 14.40 percent (Nadia *et al.*, 2009). Because of its higher percentage of lipids, which produce more energy than carbohydrates, Kamut brand can be described as a "high energy grain." Athletes, people with busy lives and anyone looking for quality nutrition will find Kamut brand products a valuable addition to their diet (Quinn, 1999).

The important chemical component that related to the physical properties is considered to be the protein content. From physical properties Kamut wheat distinguished by high vitreousness. El-Rassas *et al.* (1989) found a significant positive correlation between protein and vitreousness degree in durum wheat Stork's variety.

Rheological properties of wheat flour are measured while mixing and developing into dough. The farinograph test is one of the most commonly used flour quality tests in the world. It measures the energy required to mix dough as it progresses through water absorption, dough development, and dough breakdown. The obtained results are used as parameters in formulation to estimate the amount of water required to make a dough, to evaluate the effects of ingredients on mixing properties, to evaluate flour blending requirements, to check flour uniformity and for predicting finished product texture characteristics (Kansas State University, 2008; Wentzel, 2010). Table III exhibits the gluten content and rheological parameters of Kamut and Egyptian durum wheat doughs.

From Table III it could be noticed that Kamut dough recorded the highest value for wet and dry gluten, followed by Beni Suef 1 and Beni Suef 3. While, Suhag 3 recorded the lowest contents in wet and dry gluten.

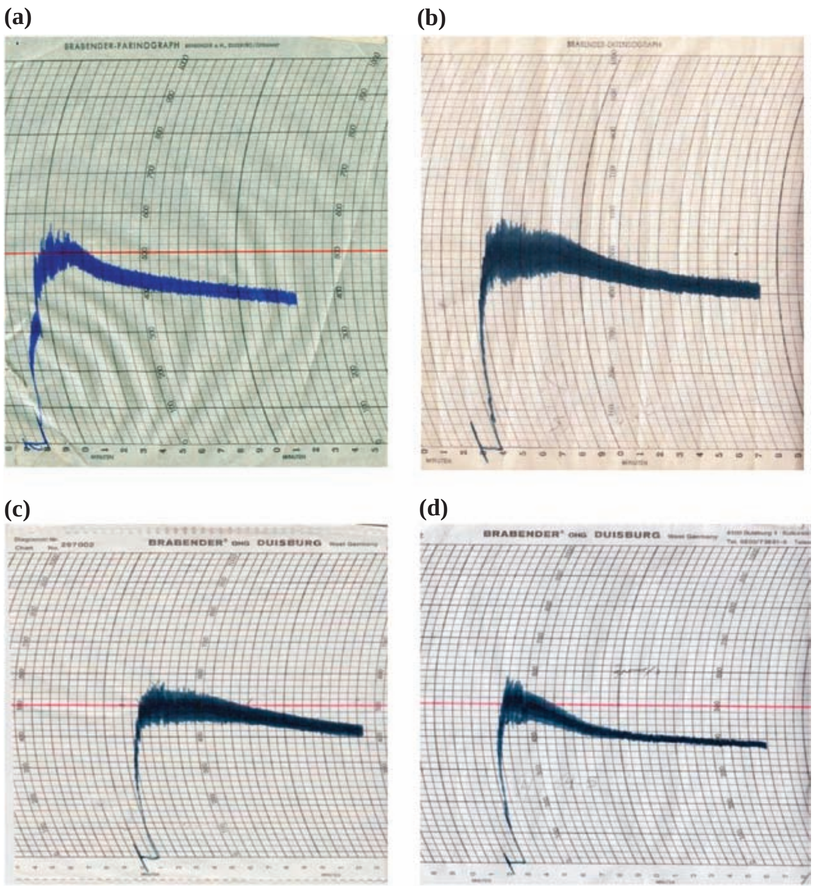
Table III. Gluten content and rheological parameters of Kamut® and Egyptian durum wheat doughs

Wheat sample	Gluten Wet (%)	Gluten Dry (%)	Water absorption (%)	Arrival time (min)	Dough development time (min)	Dough stability (min)	Degree of softening (BU)[a]
Kamut®	35.00	13.30	72.10	2.00	2.50	2.50	120.00
Beni Suef 1	33.00	12.30	70.80	1.50	2.00	5.50	80.00
Beni Suef 3	28.50	10.90	68.50	1.00	2.00	6.00	80.00
Suhag 3	25.00	8.90	64.50	1.00	1.50	3.00	110.00

Note: [a]BU, Barabender unit

The highest amount of wet and dry gluten in Kamut dough coupled with high protein content indicating strong gluten and good cooking quality. Our present findings are in agreement with Matsuo and Irvine (1975), Liu *et al.* (1996), Kansas State University (2008) and who stated that wet gluten reflects protein content and is a common flour specification required by end users in the food industry. There was a relation between wet and dry gluten content of wheat and its protein content. Wet gluten content 35 percent for high protein or strong gluten wheat and 23 percent for low protein or weak gluten wheat. Strong gluten is related to good cooking quality in durum wheat. Also with, Ames *et al.* (2003), Edward *et al.* (2003), and Mobark *et al.* (2009) who reported that protein and gluten content generally used to assess the quality of durum wheat. Increased protein is accompanied by increased gluten strength. Higher protein or very strong gluten results in better quality durum and plays a significant role in the end products.

Regarding water absorption, arrival time, dough development time, dough stability, and degree of softening, Table III and Figure 1 illustrated that Kamut dough recorded



Notes: (a) Kamut farinograph curve; (b) Beni suef 1 farinograph curve; (c) Suhag 3 farinograph curve; (d) Beni suef 3 farinograph curve

Figure 1. Farinograph curves of Kamut® and durum wheat doughs

the highest values except for dough stability; it stabilized in a very short time compared to the other durum varieties and thus may be due to high semolina extraction. Liu *et al.* (1996) and Sissons (2008) stated that in farinograph tests, durum flours generally give higher water absorption values than bread wheat flours, due to higher levels of starch damage during milling, but they show shorter dough development time and a high mixing-tolerance index. As starch damaged during milling particles become finer, dough stability decreases.

In respect to the highest protein content of Kamut semolina, Kansas State University (2008) reported that higher protein content usually requires more water and a longer mixing time to achieve optimum dough consistency.

Quality can be described as how suitable a sample is for producing a specific end product and dough properties are regarded as critical quality aspects in wheat flour (Wrigley *et al.*, 2006). Durum wheat is mainly used for pasta production in western countries (according to the International Grains Council), the world production of durum wheat was 37.7 million tons in 2008, but couscous, another important product obtained from this crop, is very popular in the tradition of many countries of the Mediterranean area, together with bread: Egypt produces 400,000 tons pasta (Guezlane, 1994; Unipi., 2008). Accordingly, in the present study the authors directed Kamut semolina to produce couscous. To be more realistic and closely to the market and the consumer the authors compared Kamut couscous with the commercial one because in Egypt, about 90 percent of the annual production of macaroni/couscous are made using wheat flour 72 percent extraction and only 10 percent using semolina (Nadia *et al.*, 2009).

Although the consumption of couscous is increasing, few studies to date have investigated the role of raw materials and process parameters on its quality. Moreover, the definition of quality parameters is still not clear. Uniform size, pleasant color, and no unusual flavor can be used to describe the quality of the dry aggregates (Debbouz *et al.*, 1994; Debbouz and Donnelly, 1996; Ounane *et al.*, 2006; D'Egidio and Pagani, 2010). Table IV represents the sensory characteristics of traditional couscous made from Kamut semolina and commercial one.

In general, it could be noticed that there were no significant differences between Kamut couscous and commercial couscous in the studied characteristics. Although the statistical analysis showed no significant differences between the two kind of couscous, but some panelists like Kamut couscous a lot and stated that their were what a tasty, buttery, crunchy, and delicious flavor they feel at the end of taste and they like it a lot.

Our present findings are in line with Guezlane *et al.* (1986) that reported homemade or traditional couscous had a better shape and size uniformity and smoother surface than did commercial agglomerated couscous. Kaup and Walker (1986) found that

Characters	Color (10)	Taste (20)	Odor (20)	Mouthfeel (10)	Granulation (20)	Appearance (20)	Overall acceptability (100)
Commercial couscous	9.45 ± 0.68^a	18.81 ± 2.6^a	18.45 ± 2.01^a	9.0 ± 0.77^a	19.18 ± 1.05^a	19.45 ± 0.82^a	92.9 ± 7.8^a
Kamut® couscous	9.45 ± 0.82^a	19.09 ± 1.22^a	19.50 ± 0.68^a	9.27 ± 0.78^a	19.27 ± 0.90^a	19.64 ± 0.67^a	96.27 ± 3.49^a
LSD at 5%	0.673	1.850	1.340	0.694	0.874	0.667	4.970

Note: [a]Means with the same letter were not significant, but different letters appear the significance among the tested characteristics.

Table IV. Sensory characteristics of traditional couscous sensory panelists preferred the color of commercial couscous and the shape of the homemade product. Good-quality couscous requires good cooked flavor and mouthfeel. Good-quality couscous should not be sticky, but should absorb sauce well, have uniform particle size, and have individual particles that maintain their integrity during steaming and sauce application. All these factors affect the taste and mouthfeel of couscous. Stickiness and mouthfeel are the most important textural determinants of quality (North Dakota State University (NDSU)).

The important chemical components and rheological parameter that related to the couscous quality are considered to be the protein and the gluten contents. The role of protein quantity in determining couscous quality is controversial: some authors referred to a decrease in stickiness as protein content increased (Debbouz *et al.*, 1994) while others showed no significant relationship between couscous characteristics and semolina protein or gluten quantity and quality (Ounane *et al.*, 2006).

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