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PASTA and COUSCOUS: basic foods of MEDITERRANEAN tradition

Key words: durum wheat, pasta, couscous, quality traits

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ABSTRACT

A brief overview of the main durum wheat final-products, pasta and couscous, is here presented. Data about production and consumption of these two products are reported. The influence of raw material characteristics and processing conditions on quality are also discussed as well as the present research trends.

INTRODUCTION

Durum wheat is a crop of primary importance for many Mediterranean countries where its derived products represent staple foods. According to the International Grains Council, the world production of durum wheat was 37.7 million tons in 2008; in particular, Canada and Italy were the main producers in the world. In the same period, at the EU level, durum wheat production reached 9.3 million tons (about 24.7% of world production). Italy by itself produced 4.3 million tons: these figures, together with the French, Spanish, and Greek production, cover about the 96% of the European total.

Durum wheat is mainly used for pasta production in Western Countries (**fig. 1**) 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, as pointed out by Guezlane (1994).

A brief overview of the main durum wheat end-products, pasta, and couscous, follows.

PASTA

Pasta is a basic product of the Italian tradition. Italy is the first producer in the world (**table 1**) with more than 3 million tons per year (corresponding to about 28% of world production), of which approximately 50% is exported. In Italy, pasta industry is currently represented by about 130 industrial factories (with an average capacity of 1,000 tons per day) and is a key sector of the national economy (Un.i.pi., 2008).

Italy also has the leadership of the pasta consumption (**table 2**) with 27 kg per

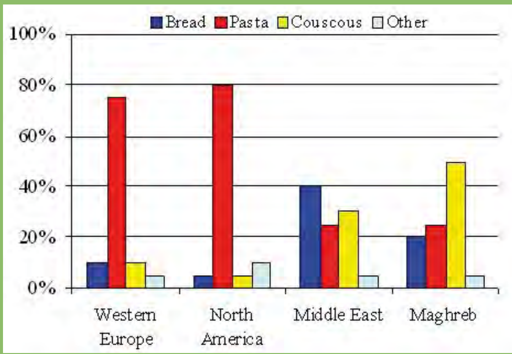

Fig. 1 - Consumption of main durum wheat food-products in the world (adapted from Guezlane, 1994).

Table 2 - Pasta consumption in the world (source: Un.i.p.i. 2008).

Countries	kg/year per capita	Countries	kg/year per capita
Italy	27.0	Canada	6.5
Venezuela	12.9	Turkey	6.0
Tunisia	11.7	Russia	6.0
Greece	10.3	Austria	5.6
Switzerland	9.5	Belgium-Lux.	5.4
USA	9.0	Estonia	5.3
Sweden	9.0	Spain	5.1
Chile	8.1	Slovak Rep.	5.0
Peru	7.5	Bolivia	4.8
France	7.5	Netherlands	4.4
Argentina	7.2	Lithuania	4.4
Hungary	7.0	Letvia	4.1
Germany	7.0	Dominican Rep.	4.0
Portugal	6.7	Australia	4.0
Brazil	6.7	Israel	4.0
Czech Rep.	6.5		

Table 1 - Pasta production in the world (source: Un.i.p.i. 2008).

Countries	tons	Countries	tons
Italy	3,228,000	Portugal	74,000
USA	2,000,000	Hungary	67,000
Brazil	1,500,000	Dominican Rep,	65,000
Russia	858,400	Romania	52,600
Turkey	600,400	Czech Republic	48,755
Egypt	400,000	Switzerland	48,215
Venezuela	350,333	Bolivia	43,000
Germany	297,000	Guatemala	38,000
Argentina	291,300	Austria	37,803
Mexico	285,000	United Kingdom	35,000
France	244,959	Ecuador	32,000
Peru	231,493	Slovak Republic	22,000
Spain	229,000	Sweden	20,200
Canada	170,000	Jordan	20,000
Poland	150,000	Costa Rica	20,000
Greece	150,000	El Salvador	13,000
Japan	144,500	Syria	9,005
Chile	139,410	Lithuania	5,976
Colombia	131,270	Panama	4,364
Tunisia	110,000	Latvia	1,845
India	100,000	Estonia	1,400

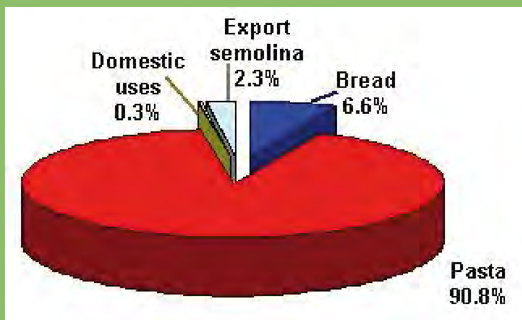

Fig. 2 - Main uses of durum wheat in Italy (source: Italmopa).

Table 3 - Technological requirements of durum wheat for pasta production.

Physical parameters
Impurities (foreign materials, other cereals)
Black specks, bran particles
Ash content
Vitreousness
Test weight, 1,000 seed weight
Protein content, gluten quality, colour

capita per year; for reasons related to history, culture, and quality, pasta is strictly connected with durum wheat, universally considered the best raw material. Even for specific legal reasons (durum wheat semolina is the only raw material allowed for dry pasta products), the Italian pasta industry has always focused on the quality of durum wheat, knowing that the undisputed success of Italian pasta in the world is strictly related to using raw materials of high quality.

Quality parameters

In the agro-food domain, quality is a term frequently used, but not easily definable, as it is intended to describe a set of features: sanitary, technological, nutritional, and sensorial.
The sanitary quality in the pasta sector is a pre-requisite that must be guaranteed for consumer's health; the technological quality refers to the fitness of raw materials for a specific industrial process whereas the sensory quality relates to consumer acceptability. Lastly, 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. These compounds have to be present in the raw material and maintained during the technological process.

Technological quality
The technological quality of raw materials is of particular importance as it determines their industrial use. In Italy, about 90% of durum wheat production is used for the pasta-making process (**fig. 2**), so the quality of durum wheat is primarily seen in terms of suitability for pasta production.
In **table 3** the kernel parameters influencing the milling process and the quality of semolina and pasta products are summarized. In Italy, a voluntary durum wheat grading system was also defined by National Standard Body (U.N.I. Standard 10709, 1998). This standard is based on physical and technological parameters and fixes the maximum limits for factors suitable to adversely affect grain quality.
Protein content, gluten quality, and colour are the main requirements of raw material in order to obtain pasta of very acceptable quality. Therefore, the characteristics of final products are linked to the properties of raw materials, that reflect in turn the influence of genotype and cultivation environment (Mariani *et al*., 1995); in fact, the protein quality is highly dependent on the environment (locality, year, etc.), while the gluten quality and colour are mainly affected by genotype.
Besides the raw material parameters, pasta-product quality is influenced by the technological process and, hence, by milling and the

Table 4 - Textural characteristics of cooked pasta.

Primary parameters
firmness
consistency
elasticity
stickiness
Secondary parameters
chewiness
bulkiness

pasta-making process. Many improvements have been introduced in pasta processing and significant success was achieved in '70s by introducing high temperatures (HT) in the pasta drying phase. HT drying cycles have become universally accepted in pasta processing; HT conditions yield firmer, less sticky pasta than traditional low temperature (LT) drying cycles (Dexter *et al.*,1981 and 1983; D'Egidio and Nardi, 1991).

Raw material quality, particularly protein content and gluten quality, plays a different role when using HT or LT technology (D'Egidio *et al.*, 1990). These authors emphasized that the two parameters play an almost equivalent statistical role in the case of LT drying-cycles, whereas the protein content becomes prevalent compared to the gluten quality if HT drying-cycles are used. Therefore, the choice of suitable raw materials should take into account the technological conditions adopted during each phase of the process. Moreover, other parameters of semolina (as starch damage and α-amylase activity) are determinant for controlling the extent of the heat-damage induced by drying (Resmini *et al.*, 1996).

Hygienic and sanitary quality

At present, hygienic and sanitary quality is receiving much attention, thus benefitting consumer safety. Fusarium head blight is a fungal disease of small-grain cereals with a strong impact on food safety because of the presence of trichothecene mycotoxins in infected kernels. The most prevalent trichothecene in *Fusarium*-infected wheat is deoxynivalenol (DON). Trichothecenes are thermally stable, but, during milling, they distribute among the mill fractions in various proportions. Nowicki *et al.* (1988) found that retention of DON in semolina obtained from severely infected durum wheat was about 80% lower than the concentration in clean wheat; DON concentration was further reduced to 50% during pasta cooking, due to leaching into the cooking water. Visconti *et al.* (2004) reported that DON retention (on a dirty wheat basis) for durum wheat artificially inoculated with *F. graminearum* and *F. culmorum* averaged 77% in cleaned wheat, 37% in semolina, 33% in spaghetti and 20% in cooked spaghetti. The debranning process of durum wheat before milling (Dexter and Wood, 1996; Bottega *et al.*, 2009) might allow a significant reduction of DON concentration in durum wheat kernels, being the mycotoxins accumulated mainly on the kernel external layers.

The environmental conditions (temperature, rainfall, etc.) during the grain filling period are among the factors responsible for mycotoxin contamination. In Italy, the agroclimatic characteristics of areas traditionally dedicated to durum wheat cultivation, such as the Southern regions, are generally characterized by drought and low levels of rainfall, conditions which are naturally conducive to yielding safe crops. Particular attention to fungal contamination in the early phases of grain filling and the choice of specific and cautious agro-technical practices could help to contain fungal diffusion and mycotoxin contamination.

Sensorial quality

The sensorial quality is the aspect closest to consumer concerns. It is strongly linked to eating habits and traditions. For the Italian consumers, pasta quality is based on cooking performance and resistance that are mainly represented by textural characteristics (**table 4**), generally evaluated according to sticki-

ness, firmness, and bulkiness (D'Egidio and Nardi, 1996).

Nutritional quality

The nutritional quality of pasta is strictly related to the composition of the raw material as pasta formulation is merely constituted by semolina and water. Durum wheat, like all cereals, is rich in starch, has a moderate protein content and low fat level; its mineral and fibre content is related to milling process conditions. From a nutritional point of view, pasta can be assessed as a very natural food, conforming to present dietary/nutritional guidelines, which suggest the daily consumption of foods containing high percentages (at least a share of 45% carbohydrates) of slowly digestible carbohydrates, such as starch.

In addition, different bioactive compounds can be found in durum wheat grains. Among those molecules, two main classes have received much attention: fibre and antioxidants. As for fibre, besides the natural amounts of FOS, arabinoxylans, resistant starch and β-glucans present in durum wheat kernels, it is more and more frequent to find works about the possibility to increase their level by adding other cereal meals (e.g., from barley or oat, sources richer in β-glucans). A similar approach can be adopted for antioxidant compounds: durum wheat is naturally rich in phenolic compounds (phenolic acids, alchilresorcinol, etc.), carotenoids, vitamins but their amount is drastically reduced after milling. Therefore, it is important to maintain their native level by adopting specific technological conditions or adding other cereals. Other classes of compounds, such as lignans characterised by estrogenic activity, are also considered of interest (Durazzo *et al.*, 2009).

COUSCOUS

Couscous, one the most famous Arabian dishes, is the food-staple made from durum wheat, which is second only to pasta in world popularity and consumption. It's mainly produced in North Africa. According to Habib Burguiba, ex-leader of Tunisia, the border of Maghreb, the oriental region of North Africa, is marked by an "imaginary line", corresponding not to a geographic but to a cultural boundary: east of that line the staple-food is rice; west, the staple-food is couscous (www.saudiaramcoworld.com).

In North Africa couscous plays the role that semolina pasta has in Italy. Algeria is the leader of couscous production (about 1 million tons/year), above all consisting of home-made or artisanal production; in this Country couscous consumption reaches 50 kg per capita/year, while in Tunisia it is about 20 kg per capita/year. Even if the figures are much lower, couscous is becoming more and more present in some European Countries, particularly in the Mediterranean area: this trend is surely related to the growing interest towards the so-called "ethnic foods" and the increase in the population of Arabian-origin people living in Europe.

Although durum wheat semolina is considered the best raw material for couscous preparation, other cereals, such as sorghum, millet, maize or fonio are used, especially in West and sub-Saharan Africa (Galiba *et al.*, 1987; Aboubacar and Hamaker, 1999).

Couscous is traditionally prepared by a lengthy, hand mixing of semolina and salted water in a large wooden dish (**fig. 3**) until granule formation is attained. The agglomerates are firstly sieved to obtain a uniform size (generally three types are produced:

coarse, medium, and fine size), eventually steamed, then sun-dried and stored, as summarized in the flow-sheet of **fig. 4**. The drying step is strictly related to the climatic conditions that account for the production of home-made couscous during the sunny summer months (Kaup and Walker, 1986). The final cooking of this product is carried out by steaming the couscous agglomerates inside a particular device, the *couscousière*, formed by two superimposed pots (**fig. 5**): the granules, placed on the perforated bottom of the top pot, are steamed for 30-40 minutes at least. The main disadvantages of the home-made product consist of not only its long final cooking procedure but also the development of rancidity during storage (Pagani *et al.*, 2009).

The industrial production of couscous started in '70s (Debbouz and Donnelly, 1996). The main steps of the current process, summarized in **fig. 6** and carried out in fully automated lines assuring a production up to 2,000-3,000 kg/hour (**fig. 7**), are the same as the artisan ones. After the mixing of semolina and water, the formation of aggregates is completed in special rotary sieves (*rouleur*) which, at the same time, allow the granules to be separated according to size and remove the non-hydrated semolina fraction. The couscous granules are then placed on a belt and cooked by steaming. This operation plays an important role in determining couscous quality. In fact, the effects on physical properties and cooking characteristics are strictly related to the steam temperature, the treatment time and the diffusion of steam inside the mass: in this regard, some lines use steam injectors to spray steam over and under the product, assuring a more homogeneous cooking of the product layer (www.fava.it). In any case, the pre-cooking assures a dramatic reduction in cooking time (only a few minutes). Drying (generally performed in dryers for short pasta), cooling, and final sieving complete the steps of this industrial process (Quaglia, 1988).

As quoted above, the product is typically sold in three different sizes: small couscous, recommended for cake preparation, principally formed by aggregates with diameters lower than 1.5 mm; medium couscous, 1.7-2 mm diameter, the most appreciated for traditional dishes; coarse couscous, with particle size up to 2.5 mm (Kaup and Walker, 1986). In any case, the native semolina particles are easily recognizable in the agglomerates (**fig. 8**).

Quality parameters

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 colour and no unusual flavour can be used to describe the quality of the dry aggregates (Debbouz *et al.*, 1994; Debbouz and Donnelly, 1996; Ounane *et al.*, 2006). The cooking behaviour considers rehydration and cooking times, sauce absorption capacity (Debbouz and Donnelly, 1996; Ounane *et al.*, 2006) without aggregation of granules (Guezlane and Abecassis, 1991) and sensory indices related to texture, as stickiness and mouthfeel (firmness and smootheness) (Debbouz *et al.*, 1994; Kaup and Walker, 1986). Few studies suggest to complete and/or replace the sensory judgement with an instrumental approach (Guezlane and Abecassis, 1991; Yettou *et al.*, 1997).

Fig. 3 - Home-made production of cous-cous.

Fig. 5 - Example of typical pot for couscous cooking (left) and home cooking of couscous (right).

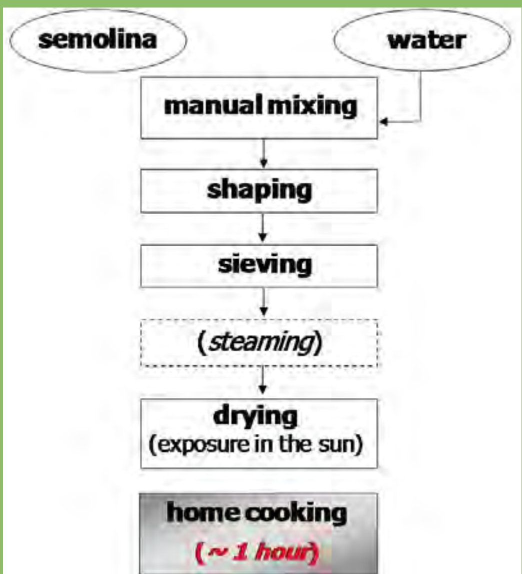

Fig. 4 - Flow-sheet of artisan production of couscous.

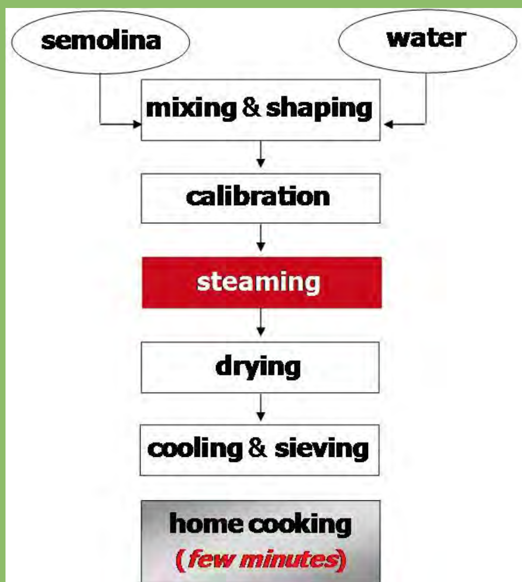

Fig. 6 - Flow-sheet of industrial production of couscous.

Influence of raw materials and process conditions on couscous characteristics

Home-made couscous is generally prepared by coarse semolina: this preference could be due to the higher product yield observed when this type of semolina is used, despite its lower water absorption during mixing (Debbouz *et al.*, 1994). 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).

The starch damage of semolina can play a role in controlling the water absorption index, both in cold and hot water (Debbouz *et al.*, 1994; Pagani *et al.*, 2009).

A recent work (Ounane *et al.*, 2006) established the importance of lipid fraction on couscous characteristics. In particular, polar free lipid content of semolina was positively related to product firmness, while free lipid and non-polar lipid content were negatively related to aggregate swelling. The lipid fraction can play another important role during couscous storage. In fact, phenomena of rancidity with the appearance of off-flavours can frequently be detected (Pagani *et al.*, 2009). This negative trait can be greatly reduced using a high temperature drying cycle (HT: 90°C for 1 hour) (**fig. 9**). This important result for the shelf-life of the product was in part related to the higher aggregate density and to a more effective lipase inactivation assured by HT cycles.

Other researchers (Debbouz and Donnelly, 1996) showed that the extrusion conditions (single or twin screw extruder) are also determinant for physical and cooking properties: the high-temperature short-time twin screw extruders assured an intense yellow colour and a high degree of starch gelatinization, a modification responsible for higher water absorption, shorter cooking times, better appearance and sensory evaluation. These results indicate that starch fraction has a determinant role in the properties of the product but many aspects have to be better clarified.

CONCLUSIONS

In conclusion, pasta and couscous are two staple, traditional foods of the Mediterranean regions with simple raw materials and recipes (semolina and water are the only raw materials), inexpensive processing and preparation, long shelf-life, and versatility of preparation. Moreover, the interest in pasta and couscous is well suited to contemporary lifestyles where consumers appreciate foods characterized by their functional properties, low amounts of fat and low glycemic index. In fact both foods fully satisfy the requirements of well-being and health, nature and tradition, taste and pleasure.

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Fig. 7 - Pilot plant for production of couscous (courtesy of Fava SpA, Ferrara, Italy).

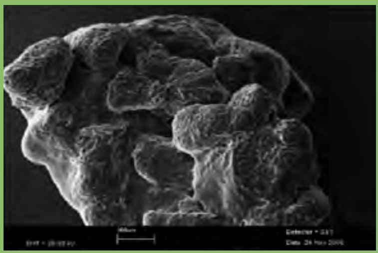

Fig. 8 - Couscous agglomerate (from Pagani *et al.*, 2009).

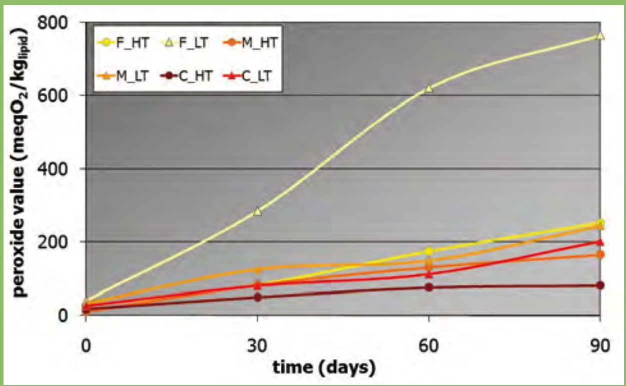

Fig. 9 - Peroxide variation of couscous during 3 months storage (from Pagani *et al.*, 2009).

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