

Durum wheat requirements for pasta and related products.

J. Abecassis, P. Feillet, T. Laignelet and J.C. Autran.

Unité Technologie des Céréales, INRA, 2 Place Viala, 34060
Montpellier Cedex 1, France.

Durum wheat is unique with regard to its tetraploid nature, hardness of its kernel, its gluten quality and carotenoid content. It is most suitable for use in the manufacture of pasta products and couscous but, in some countries, it is appreciated for bread making. The semolina requirements for the best pasta processing value are well documented: protein content, gliadin and glutenin composition, carotenoid pigments, polyphenoloxidase activities. However, the recent trend of using high drying temperatures leads to redefine what is accepted as major quality attributes. For instance, a greater emphasis should be put on protein content and enzyme activities. The behaviour of kernels during milling and the physical characteristics of semolina are also important parameters of pasta processing and quality. Beside their physicochemical properties, size and shape of semolina particles could be of special importance to determine the properties of couscous. On the other hand, recent studies have outlined the relationship between type γ -42/ γ -45 of gliadin composition and bread volume of durum wheats.

Durum wheat requirements for pasta and related products ¹

J. Abecassis, P. Feillet, T. Laignelet and J.C. Autran.

Unité Technologie des Céréales, INRA, 2 Place Viala,
34060 Montpellier Cedex 1, France.

I am most honoured to be with you this morning and to discuss some problems about durum wheat and semolina requirements for pasta and related products (Slide 1).

First of all, I'd like to express my gratitude to the organisers for having invited me to contribute ~~to~~ ⁱⁿ this one-day conference.

- In the first part of my talk (Slide 2), I will draw your attention to the main differences between durum wheat and common wheat grains and I'll discuss some statistical data on durum wheat production, trade and utilisation in the world.

- In a second part, I will focus on the present ways of processing durum wheat semolina into final products such as pasta, bread or couscous and on durum wheat or semolina quality requirements for the different steps of the processes.

- The third part will be devoted to the physicochemical basis of quality for pasta-making, couscous manufacture and breadmaking from durum wheat.

Before talking about production and utilisation of durum wheat, I'd like to briefly review (next slide, S3) the main differences between durum and common wheat grains, although this is certainly very familiar to most of you. There are genetic, chemical and physical differences.

Durum and common wheat are different species with a different number of chromosomes and genomes. Durum wheat lacks genome D and has only 28 chromosomes while common wheat has 42. Durum wheat is a tetraploid wheat and common wheat is an hexaploid one. As a consequence, durum wheats are significantly different from common wheats by their amber yellow color, very hard endosperm

¹ Presented at the Workshop on "Recent Trends in Durum Wheat Processing: Biochemical and Technological Aspects", 26 September 1994, Rome, Italy.

Presented at the Workshop on "Recent Trends in Durum Wheat Processing: Biochemical and Technological Aspects", 26 September 1994, Rome, Italy.

texture, high protein and pigment content and high tenacity of gluten. Because of their hard endosperm texture, they yield semolina during milling rather than flour. Because of their protein composition and their pigment content they are highly suitable for the pasta and couscous industries. I will come back later on these different points.

On the next slide (S4), I have summarised some data from the International Wheat Council on durum wheat production in the world. You will notice that the data in 1970, 1980 and 1990 are the average values for three years as 69, 70 and 71 for 1970. During the last twenty years, durum wheat was and is still grown in four main regions: Europe, North America and Middle East with an increase of cultivated areas; and North Africa which lost almost two millions hectares. Simultaneously the yield per hectare increased significantly in Europe and in North Africa, where the level is nevertheless still very low; and decreased slowly in North America, South America and Middle East.

From these data, as shown on the next slide (S5), it's easy to calculate the amount of durum wheat production as expressed in millions of metric tons. The world production is about twenty eight millions of metric tons. When looking at these data, it's very clear that Europe is presently the leading region in the world for durum wheat production, slightly ahead of North America. Furthermore, and probably because of the instability of the region, the production of durum wheat in the Middle East has sharply decreased during the last ten years and is now at the level of the seventies. South America which was in the past an important producing region, as Argentina which was an exporting country, has now become an importing region as shown in the next slide (S6).

By comparing the export and the import tendencies it's clear that Canada, the USA and the EU supply North Africa and the East European countries in durum wheat. The needs in North Africa, mainly Algeria, in durum wheat ~~is~~ very impressive. Please, keep this information in mind, because Algeria mainly consumes durum wheat as couscous and that means that the quality requirements in durum wheat have to satisfy not only the pasta industry but also the couscous home making or industrial manufacturing.

Let's try to illustrate this point with the next slide (S7). Tentatively, we estimated the consumption of pasta, couscous, durum wheat bread and other products from durum wheats (mainly bulgur, snacks, cookies) in the world. In ~~our countries, I mean~~ occidental countries, it's usual to consider that the only use of durum wheat is for pasta processing. This is certainly not true at a world level. When looking at

North Africa and Middle East consumption, it's very clear that durum wheat bread and durum wheat couscous are two very important markets for the durum wheat growers. It means that we have to take into account the specific durum wheat quality requirements for bread making and couscous making if we aim at adapting the durum wheat composition to the needs of the world-wide market of to-morrow.

Next slide (S8) It's now time to move on the second part of the talk, dealing with the suitability of durum wheat semolina to be processed, as shown in the next slide (S9), into couscous, pasta, fresh pasta, oriental bread and occidental bread. I won't spend much time in describing the different processes, but I'll just try to outline the main specificities of these different flow sheets.

First, the level of added water is much lower for manufacturing couscous and pasta than processing semolina (or flour) into bread: 25 percent in the first case, 60 percent in the second. As a consequence, the dough development occurs in quite different conditions between the two processes and, therefore, the dough properties are very different. Nevertheless it's possible to identify in each process four main steps: hydration, dough development, shaping and heat treatment.

This is illustrated on the next slide (S10). As outlined before, dough development is the result of two operations - blending and extrusion - for pasta products and only one blending or mixing - for couscous and bread. Shaping is the result of the extrusion step followed by cutting of the extruded products for pasta processing; couscous is obtained by agglomeration of hydrated semolina particles followed by shaping while sheeting and moulding are the two steps of breadmaking that give the suitable shape to the loaves. Heat treatments, as baking, steaming or drying are very specific to each product.

Now, let's discuss about the semolina requirements. The question is to know which are the characteristics that we must find in a semolina to process it into pasta, couscous or bread in the best conditions? The three next slides will help us to answer this question.

In the next slide (S11), as far as water absorption is concerned, the expected tendency is to have the possibility to add less water during the pasta or couscous process, this in order to avoid the consumption of too much energy during the drying step. In contrast, we expect that the possibility of using more water for making a bread dough can be a request from the baker in order to improve the yield of semolina (or flour) processing into bread. Leaving you some time to look at this slide, I'd just like to comment on the protein content of semolina. It seems a

paradox that for all the three processes (pasta, couscous, bread), a high protein content is a favourable factor, whereas it's usually accepted that the higher the protein content, the higher the water absorption. But there is in fact no contradiction, because a pasta dough and a couscous dough are totally different from a bread dough.

The industrial requirements for pasta processing are to allow the transport of the dough into the extrusion barrel and to facilitate the dough extrusion through the die. For this purpose water acts as a lubricant agent but it's well known from the professionals that proteins have the same effect. Consequently, when protein content is high, less water is required to be able to extrude the semolina dough. For the same reasons starch damage is detrimental to the semolina quality because it brings an increase in water absorption.

During the dough development as shown ^{in the} next slide (S12), the main fault is the development of a sticky dough whatever the process is: pasta, couscous and bread making. In every cases, a low starch damage and a good balance between the elasticity and the viscosity of gluten proteins are required. As you know, a tremendous amount of work has been done in dough and gluten rheology, demonstrating that gluten viscoelastic properties are a quite important factor and relating it to protein composition. However, basic rheological measurements are still difficult to perform on a complex medium such as ~~a~~ dough or ~~a~~ gluten. Moreover, it's now more or less accepted that the soluble and insoluble pentosans, and their ratio, have to be taken into account, although further studies are still necessary to really understand their contribution to the dough development and to address any recommendation to the breeders.

The requirements for durum wheat and semolina quality (Slide 13) can also be analysed in terms of suitability to be submitted to different heat treatments: drying, steaming and drying, or baking. The main consequences of an unsuitable product during these treatments is the checking for ~~a~~ pasta, the disaggregation for ~~a~~ couscous and a low volume for ~~a~~ bread. Very little information is available to recommend the factors which are the most favourable from this point of view. From our experience, we would recommend to have a high protein content and a good gluten quality in semolina, a low or medium starch damage for all products as well as a high lipid content for processing semolina into pasta and couscous. But this information is tentatively given and I'm leaving this point to you for further discussion.

Let us move now on the third and last part (Slide 14). I won't discuss any more the behaviour of ~~the~~ semolina or of ~~the~~ dough during

the process, and I'll focus on the relationship between physicochemical composition of semolina and quality of the end-product. With the next three slides I'll respectively consider pasta quality, couscous quality and bread quality.

Aspect and cooking quality, as shown on the next slide (S15), are the two main factors of pasta quality. A high carotenoid content, low lipoxygenase and polyphenoloxidase activities, a low percentage of damaged starch and small particle sizes are all favourable factors to a good aspect of the final product, that's to say high yellowness, low browning and absence of black specks. The cooking quality factors are also well documented, at least concerning viscoelasticity of the cooked pasta. It is now demonstrated that a high content in Low Molecular Weight subunits of glutenin is very favourable to a good viscoelasticity and that a high content in low-molecular-weight subunits content is genetically marked by the gliadin composition. In France, for example, all the new durum wheat lines and cultivars fall into the type γ -45 of the electrophoretic pattern of gliadins. However, the physicochemical basis of the surface conditions of the cooked pasta products, that's to say stickiness and disaggregation of the pasta strands during cooking, is still very poorly known.

The physicochemical bases of couscous quality, as shown on the next slide (S16), are not very different from those of pasta quality. In this slide, I'd just like to comment some recent results in our laboratory indicating that interactions between amylose and lipid result in a decrease of couscous stickiness during cooking. We feel that, from this point of view, a sufficient amount of lipids is a prerequisite to complex amylose and to avoid amylose leaching during cooking and consequently to prevent the stickiness of the cooked couscous in the plate.

The physicochemical bases of durum wheat bread quality have been the subject of relatively few studies. We tried, in the next slide (S17), to list the main quality factors of bread quality: crumb color, volume, crumb texture, taste and staling. Durum wheat bread is different from common wheat bread. In the countries where people use to eat durum wheat bread, they especially like the yellow crumb and the tightened texture. They also like the specific aroma that some people describe as a nut taste. As for pasta products, high carotenoid content and low lipoxygenase and polyphenoloxidase activities are favourable factors. From some papers published by the Italian groups and from preliminary studies in our laboratory, it seems that durum wheats with γ -45 gliadin type are favourable to get a better bread

volume. Moreover good storage properties, that means slow staling development, have been considered as a property of durum wheat bread but, in my knowledge, the physicochemical explanation of this behaviour has not been given.

I am now coming to my conclusion.

In the next slide (S18) I have summarized the main requirements for industrial and housewives uses of durum wheat, whatever the final end products are. Generally speaking, it can be recommended to breed, to grow, to purchase, to process durum wheat with the following properties:

- high carotenoid content and low enzymes activities to retain a nice yellow amber color
- high protein content and high gluten viscoelasticity to get the required rheological properties of the dough and a suitable texture of the final product
- and finally a low starch damage which depends mainly on the milling conditions and consequently on the kernel hardness. Because this last parameter is an important factor of quality, I'd like to stress the interest to look for durum wheats with different levels of hardness (by manipulating the 5Ds chromosome arm and the hardness gene), in order to meet the requirements of an increased number of end-uses.

This is the theory. In practice, as shown in the next and last slide (S19), things are somehow different. The present tendency in breeding for durum wheat quality in the main producing countries are summarized in this slide.

There are not much differences between these countries except that protein content, as far as we know, is higher in the USA than in other countries where gluten strength has been considered as the main factor. But, even in France or in Italy, with the change in the drying processes, which now involve higher temperatures, protein content has emerged as a factor may be as important as gluten strength.

We feel that much information is now available for pasta industry but further work is still needed to fully understand the relationship between physicochemical properties of durum wheat and quality of durum wheat bread and couscous. And because of the large amount of durum wheat processed into bread and couscous in the world, as we discussed previously, we recommend in conclusion to increase the research efforts in this direction.

The development of a pilot couscous production line has enabled the influence of raw material and the parameters of production on the quality of couscous to be studied. The following conclusions can be drawn:

The quality of semolina used determines the colour of the finished product, and influences the firmness of cooked product (also the case with pasta production). It affects production line control settings, due to differences in hydration properties and tendency to stick.

The production process mainly affects the cooking quality of couscous, the two important stages being agglomeration and pre-cooking. To obtain a high production yield, it is necessary to achieve a homogenous hydration of the particles to agglomerate. Towards this end a sufficiently high hydration rate and long kneading time are recommended.

The products obtained from the pilot production line present the best characteristics: good homogeneity - better cooking quality (low IPMT and IPMN).