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Published online on: 09 Jun 2021

How to cite: Coline Martin, Marie-Hélène Morel, Bernard Cuq. 09 Jun 2021, Pasta: Durum Wheat Proteins – a Key Macronutrient for Pasta Qualities from: Handbook of Molecular Gastronomy, Scientific Foundations, Educational Practices, and Culinary Applications CRC Press

Accessed on: 11 Oct 2023
Pasta: Durum Wheat Proteins – a Key Macronutrient for Pasta Qualities

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Pasta Quality Is Driven By Both Raw Material and Process

Durum wheat (Triticum durum) pasta is a staple food in the diet of many countries. Its colour and firmness, its smooth texture, and its convenient use make it really popular. Pasta is made from a blend of only durum wheat semolina and water. Pasta quality in each step of the pasta-making process is mainly driven by the control of structuration mechanisms and drying temperature, which strongly impact protein transformations and the visco-elastic texture of the cooked pasta. Durum wheat proteins (10–14%) are strongly modified during the pasta-making process and are involved in the texture and visual aspects of pasta. After giving an overview of durum wheat composition and the pasta-making process, this chapter aims to explain the contribution of durum wheat proteins to pasta quality.

Durum Wheat Components

Durum wheat semolina is obtained by milling durum wheat grain for the purpose of recovering semolina particles (200 to 300 µm in size) free from outer grain layers. Semolina derives from the central part of the grain and includes starch (80%), proteins (10–14%) and smaller quantities of lipids, non-starch polysaccharides and minerals. Starch occurs as semi-crystalline granules composed of assemblies of linear and branched polymers of glucose, referred to as amylose and amylopectin, respectively. Most of the semolina protein (85%) coincides with grain storage proteins, also called gluten. The gluten proteins are insoluble in water and, once hydrated, form a cohesive and viscoelastic mass stabilized by numerous weak interactions (hydrogen bonds, hydrophobic and van der Waals interactions). Gluten includes two types of proteins: gliadins and glutenins. Gliadins are a group of more than 20 different polypeptides ranging from 20,000 to 75,000 g/mol, sharing the same solubility in ethanol/water solvent (70%, v/v) and having no free thiol groups. Glutenins are in the form of disulfide-linked polypeptides ranging from 100,000 to millions of grams per mole. While gliadin contributes to gluten viscosity, glutenins provide mechanical resistance and elasticity. The texture of cooked pasta relies on the viscoelastic properties of gluten.

Pasta-Making Process

The pasta-making process can be described in four major steps (Figure 65.1).

(i) The first step consists in hydrating and mixing semolina with a sufficient amount of water (32% w/w) to ensure protein hydration, but not enough to allow dough development. Low-speed mixing is used to seamlessly distribute water on semolina particles and are involved in the texture and visual aspects of pasta. After giving an overview of durum wheat composition and the pasta-making process, this chapter aims to explain the contribution of durum wheat proteins to pasta quality.

(ii) Hydrated semolina is shaped into a malleable pasta through extrusion, which requires a high input of mechanical energy. Structuration mechanisms are induced by mechanical stresses (shearing and compression) applied to the dough conveyed between the sheath and the extrusion screw. At the end of the screw, the structured dough is forced through a die to give it the final shape. Curved (e.g., short macaroni) or spiral (e.g., torti or fusilli) pasta shapes are generated by a differential flow speed of the dough in the die. Pasta is cut to the desired length by a knife blade scraping the die’s external surface.

(iii) Extruded pasta is dried under a hot air flow in a temperature- and humidity-controlled atmosphere until it reaches a target water content of 12%. Drying decreases water activity to 0.5 and ensures the microbiological and physico-chemical stability of pasta throughout its shelf-life. Drying also leads to a large
decrease in pasta weight. High temperatures (>70 °C) speed up the drying step and reinforce the gluten protein network by promoting disulfide bonding between gliadin and glutenin polymers, thus improving the texture qualities of cooked pasta (Figure 65.2).

(iv) Dry pasta is cooked before intake by immersion in a large volume of salted boiling water for a necessary and sufficient time span (5 to 12 min depending on pasta shape). As simple as it seems, cooking is a critical step, which determines pasta's organoleptic and nutritional qualities. Cooking leads to an increase in water content (200–250% wet basis) at the optimal cooking time. Starch gelatinization occurring during cooking increases its digestibility and leads to the specific firm and smooth texture of pasta.

### Pasta Qualities

**Colour** – The act of purchase is substantially driven by dry pasta colour. Dry pasta has a light amber-yellow colour, which turns to a characteristic light yellow after cooking. Pasta colour can be described using three indices in the CIE Lab frame of reference: lightness L* (55–65); yellowness b* (20–30); redness a* (4–7).

**Surface roughness** – A smooth and shiny surface after cooking relates to a firm non-sticky pasta, while a rough and degraded surface corresponds to a soft and sticky pasta.

**Stickiness** – Cooked pasta stickiness correlates well with its surface aspect. A smooth and shiny surface attests that pasta is not too sticky. Cooked pasta stickiness correlates with a weak gluten network, which is distorted by starch granule swelling and leads to high quantities of soluble amylose in the cooking water.

**Texture** – When eating pasta, consumers are looking for a specific firm and melt in the mouth texture. Cooked pasta texture qualities can be described using sensory or instrumental methods.

**Pasta nutritional value** – Durum wheat pasta is rich in easily digestible energy coming from the high proportion of gelatinized starch. Pasta also provides significant amounts of proteins, minerals (iron) and some vitamins (thiamine, riboflavin and nicotinic acid). Nevertheless, as pasta is especially poor in lysine, its consumption alone will not provide all the essential amino acids.

### Gluten Proteins Control Pasta Qualities

**Protein Contribution to Quality throughout Pasta-Making Process**

(i) Semolina particle wetting is critical for reaching an ideal rubbery state of gluten. Hydration lowers the...
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(iii) Cooking pasta in boiling water (100 °C) continues gluten cross-linking mechanisms, and this phenomenon is competitive with starch granule gelatinization. The gluten protein network in high-temperature-dried pasta is almost completely cross-linked after drying stage, but some new disulfide bonds can still be created. Starch granule swelling is therefore restrained by the strong gluten network. As the gluten network is acting as an elastic net around starch granules, it limits amylase chain diffusion and thereby pasta stickiness. In contrast, the gluten network from low-temperature-dried pasta is less reticulated and more deformable. Starch granules are free to absorb water, swell and gelatinize, which leads to strong amylase chains leaking out of starch granules and to sticky pasta (Shewry and Tatham, 1997).

Protein and Pasta Qualities

Colour and enzymes – Pasta colour can be altered by enzymatic activity of some durum wheat semolina proteins (peroxidases, polyphenol oxidases and lipoxygenases). Being able to control the pasta-making process can minimize the adverse impacts of enzymatic reactions on pasta lightness ($L^*$) and yellowness ($b^*$). The semolina hydration step is enough to increase water activity and to activate enzymes. These enzymes remain efficient as long as water activity and temperature conditions are favourable. Two technological tools might be used to minimize the impact of enzymatic reactions and preserve pasta yellowness and lightness. Firstly, mixing can be conducted under vacuum to remove oxygen, which would otherwise be involved in oxidation reactions. Secondly, increasing the temperature above 70 °C at the beginning of the drying step leads to enzyme activation (Icard-Vernière and Feillet, 1999).

Surface aspect, texture and gluten network – The control of cooked pasta stickiness and texture depends on several parameters. The quality and quantity of semolina gluten proteins play a critical role through their ability to embed starch granules into a continuous viscoelastic network. The continuous gluten network is developed during extrusion and cross-linked during the drying step. During cooking, protein network cross-linking continues, constraining starch granules from swelling during gelatinization and restricting amylase chain leakage. Cooking is the final step contributing to pasta surface quality (Del Nobile et al., 2005).

Gluten network and glycaemic index – The slow digestion rate of starch is associated with the low glycaemic index of pasta. The compact texture of pasta and the water insolubility of gluten are key factors in reducing starch digestion rates. The low glycaemic index of pasta can be attributed to the strong, reticulated gluten network (Fardet et al., 1998). The continuous gluten network causes an encapsulation of starch granules that limits their swelling during cooking. The compact and dense structure of pasta limits the surface area over which digestive enzymes are able to gain access to available starch, thereby limiting rates of digestion.

Protein digestibility – High drying temperatures increase the occurrence of Maillard-type reactions, resulting in higher protein cross-linking and decreasing lysine availability, which affects both protein digestibility and antigenicity (Colonna et al., 1990).

Conclusion

Gluten proteins act as a key macronutrient for the control of durum wheat pasta quality. In recent decades, a varietal selection has been made in favour of durum wheat varieties containing high levels of qualitative gluten proteins. Throughout the pasta-making process, gluten proteins are activated during semolina hydration and structured in a continuous network during
extrusion. High-temperature treatment during drying and cooking strengthens the gluten network through the coupling of gliadin to glutenin through disulfide bonds. A good knowledge of starch and protein reactivity towards hydration, mechanical or thermal stresses allows the pasta-making process to be designed to achieve the optimal visual aspects and textural quality.

REFERENCES