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Baking: Laminated Bakery Products

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Classic pastry, such as shortcrust, choux or filo pastry, is obtained from a homogeneous dough consisting of flour, water and fat, sometimes supplemented with sugar, salt or eggs. Laminated doughs, however, form a distinct category of pastry comprising an alternation of up to hundreds of dough and fat layers. This particular structure is obtained by successive sheeting and folding operations, referred to as the “lamination process”. During baking, the layered dough transforms into a generously lifted, aerated and flaky product, with a characteristic crispiness and mouthfeel. Laminated bakery products include puff pastries, such as vol-au-vent cases, and also fermented products like Danish pastries and croissants.

From Basic Ingredients to a Sophisticated Pastry

The preparation of puff pastry starts with elaboration of a simple dough, usually called the pre-dough, traditionally made of wheat flour, cold water (about 50–60%), in-dough fat (about 0–15%) and salt (0–1%, flour based) (Corke et al., 2008; Ooms et al., 2016). A large proportion of lamination fat, also called roll-in fat, is then added to the pre-dough in an appropriate manner. Based on flour weight, 50%, 75% or 100% of roll-in fat is used to prepare half, three-quarter and full puff pastries, respectively. In order to obtain the desired puffing effect, alternating layers of intact pre-dough and roll-in fat should be created and maintained during the whole pastry preparation.

Ingredient dosage influences pastry development and provides each laminated product with its own specificities. Therefore, while a puff pastry is typically very crispy, a croissant is crispy on the outside but tender on the inside as a consequence of its lower (in-dough and roll-in) fat content and the action of the yeast. A Danish pastry is also softer than a puff pastry but richer and softer than a croissant due to the addition of eggs and higher levels of fat and sugar (Corke et al., 2008; Ooms et al., 2016). Nonetheless, different types of laminated goods share a similar preparation procedure.

Pre-dough ingredients are first mixed to get a homogeneous paste. Roll-in fat (stored at appropriate temperature beforehand) and pre-dough are then separately sheeted to about 7 mm height before being combined. Two different main methods are dedicated to the inclusion of the roll-in fat inside the pre-dough: the French and English methods (Figure 5.1a and b). The main dough obtained is then folded according to one or a combination of folding procedures, the most widely used being the half turn (three-fold) and the book turn (fourfold) methods (Figure 5.1c and d). Sheeting and folding operations followed by resting periods are repeated a certain number of times in order to get the desired amount of layers. Before baking, Danish pastry and croissant doughs are proved in appropriate temperature and humidity conditions to favour fermentation and allow the dough to rise.

In the oven, high temperatures (above 200 °C) cause the water present in the dough to evaporate. The characteristic lifting of puff pastry is generally attributed to the entrapment of steam inside the pastry due to the mechanical barrier created by fat layers (Cauvain and Young, 2001; Deligny and Lucas, 2015; Wickramarachchi et al., 2015). Nevertheless, while water vapour is the essential leavening agent in puff pastries, the growth of large gas bubbles obtained by fermentation is mainly responsible for the lifting of croissants and Danish pastries (Ooms et al., 2018a; Deligny and Lucas, 2015). Pastry height is further influenced by the amount and type of roll-in fat incorporated, as well as the number of layers created (Cauvain and Young, 2001).

Ingredient Functionality for Pastry Lift

The development of a gorgeous evenly lifted crispy pastry results from the interplay between the different constitutive ingredients of laminated products, each possessing essential physicochemical properties. A typical structure made of well-separated and homogeneous alternating pre-dough and roll-in fat layers able to entrap gasses from water evaporation and fermentation has been shown to be the key for a suitable pastry lift. Furthermore, most probably, obtaining such a high-quality layered system essentially relies on roll-in fat and pre-dough rheology (Renzetti et al., 2016; Ooms et al., 2017).

Pre-dough

Similarly to bread, rheological properties of the pre-dough such as strength and extensibility are extremely important for the quality
of laminated bakery products. These are mainly determined by
the protein content and composition of the flour, the amount
of water added, the temperature and the mixing procedure.
Medium to strong wheat flour containing between 8% and 15% of proteins is typically used for the preparation of puff pastry and
its fermented counterparts (Ooms et al., 2016). Gluten-forming
proteins, glutenins and gliadins, account for about 80% of total
wheat proteins and play a key role in the establishment of dough

FIGURE 5.1 Schematic roll-in fat incorporation methods: (a) the French method; (b) the English method. Schematic dough folding methods: (c) half turn; (d) book turn.
rheological properties (Hay, 1993; Cauvain, 2015). Glutenins are linear proteins that can form extremely large polymerized protein strands, while gliadins are globular proteins (Delcour et al., 2012).

It is thought that pastry dough development is closely related to what is observed for bread dough (Ooms et al., 2016). The mechanisms of dough formation have been extensively studied but are still not fully understood. Upon addition of water and energy to the flour (i.e., during pre-dough preparation), protein hydration allows the formation of a gluten matrix, comprising long and entangled glutenin molecules, including smaller globular gliadin molecules. With additional energy supply (i.e., with further mixing or, in the case of laminated doughs, during sheeting), glutenin strands are stretched. In addition, covalent bonds such as disulphide bonds and non-covalent bonds such as hydrogen bonds and hydrophobic interactions dissociate and reconnect to neighbouring protein molecules that are progressively being aligned in the sheeting direction. The role of dityrosine bonds in dough development is unclear (Tilley et al., 2001; Hanft and Koehler, 2005). The network therefore reorganizes during mixing and transforms into a visco-elastic continuous mass with improved strength and elasticity, a phenomenon called gluten development. The pre-dough possesses some elasticity and cohesiveness, imparted by glutenin molecules. On the other hand, gliadins present in the network act as plasticizers and are responsible for dough viscosity and extensibility (Delcour et al., 2012; Cauvain, 2015).

The dough is allowed to relax during the resting periods observed between the different sheeting steps of the lamination process. At rest, covalent and non-covalent bonds may reform, and dough elasticity and strength decrease. Furthermore, dough viscosity and extensibility increase due to the contribution of gliadins to the network (Delcour et al., 2012; Cauvain, 2015; Ooms et al., 2017). Pre-dough should be moderately elastic to prevent dough shrinkage, but extensible and strong to withstand the sheeting steps and not disturb the layering (no tearing or breaking). A good balance between glutenin and gliadin molecules (intrinsic flour properties), as well as sufficient energy input and resting, are therefore essential to get the appropriate consistency.

In addition to adequate integrity and separation of the layers, pre-dough rheological properties should also enable gas retention in fermented laminated products such as Danish pastries and croissants. The gluten network has to be sufficiently strong to retain gas bubbles that have been trapped in the dough during folding and allow them to grow without leakage during fermentation (Ooms et al., 2018a). As the layered structure may be disrupted due to bubbles rising inside the pre-dough during fermentation, fewer but thicker and therefore more robust layers are typically created for fermented laminated products (Cauvain and Young, 2001). As an example, puff pastry dough typically contains about 100 to 250 fat layers, while only 18 to 50 layers are usually present in fermented doughs (Cauvain and Young, 2001; Bent, 2007).

Starch granules represent the major flour constituents (65% flour, dry weight based) and participate in increasing pre-dough viscosity as they also absorb water (Cauvain, 2015). Whether starch and starch gelatinization during baking play a fundamental role in pastry structure and lifting is, however, not clear yet (Ooms et al., 2016; Ooms et al., 2018b).

Water is added to the pre-dough for several purposes. In addition to allowing the formation of the gluten network and acting as a leavening agent during baking, water is also used to control pre-dough temperature. Cold water is usually added in order to cool the dough and avoid melting of the roll-in fat during incorporation. Finally, a small proportion of fat can also be added to the pre-dough to provide lubricity and facilitate lamination (Bent, 2007; Cauvain, 2015).

**Roll-in Fat**

Historically, butter was mainly used as the lamination fat, but it is now largely replaced by manufactured fat products such as margarine and shortening, specifically designed for this application (Ooms et al., 2016). Margarine is a structured water-in-oil emulsion consisting of water droplets stabilized by a fat network of solid fat crystals and liquid oil (Danthine, 2014). The term “shortening” generally refers to any fat product made of (usually modified) vegetable and/or animal oils and fats, which may in some cases contain water, designed to meet a wide diversity of applications. Both shortenings and margarines may also include emulsifiers and other additives such as antioxidants, colourings and flavours (O’Brien, 2004). While it is certain that water vapour from pre-dough is critical for puff pastry lifting, there is currently no scientific evidence on the role of water originating from the lamination fat in the leavening phenomenon (Ooms et al., 2016). Also, it has been shown that anhydrous shortenings provide similar results and appropriate pastry development as compared with shortenings containing water (Kriz and Oszlanyi, 1976).

It is generally accepted that the primary role of roll-in fat in puff pastry is to act as an impermeable barrier that prevents water vapour created during baking from escaping from the dough, which allows the latter to swell. Although the exact fundamental origins of the lifting process are unknown, it is thought to result from a combination of several mechanisms. Firstly, water vapour created inside the pre-dough layers is trapped and expands in the gluten network (Podmore, 2002). In addition, a portion of steam from the pre-dough layers may migrate into the molten fat layers, joining water liberated from the roll-in fat, if it contains any. Water vapour can therefore also expand between the pre-dough layers as growing gas bubbles surrounded by a thin film of molten fat (Ooms et al., 2016). For Danish pastries and croissants, similar mechanisms probably occur, with carbon dioxide as the main leavening gas (Deligny et al., 2017; Lucas et al., 2018) (Figure 5.2).

The rheology of the fat layers is of upmost importance for the integrity of the layered structure. The roll-in fat has to be strong and plastic enough to stay intact during the sheeting and folding steps. A brittle fat could break in the dough, while an excessively hard fat could damage the pre-dough layers due to the shear and pressure forces applied during the lamination process (Cavillot et al., 2009; Wickramarachchi et al., 2015). Similarly, a too soft and molten fat may become incorporated in the pre-dough layers and interrupt the layering. Therefore, in
order to achieve its mission, lamination fat must possess appropriate firmness, plasticity and melting properties (Cavillot et al., 2009; Wickramarachchi et al., 2015; Ooms et al., 2016). Those macroscopic characteristics result from the interaction between several physicochemical properties of the crystal network: the organization of the network at different levels of structure (e.g., size and arrangement of the crystals and crystal aggregates), polymorphism (three-dimensional crystalline structure) and the amount of solid fat present (Cavillot et al., 2009; Ooms et al., 2016). These properties themselves depend on the nature of the triglyceride molecules and the processing conditions (Miskandar et al., 2005; Wickramarachchi et al., 2015).

High consistency is usually achieved for a roll-in margarine by incorporation of a high amount of saturated fatty acids (high melting temperature), which often represent at least 50% of the fat formulation (Wickramarachchi et al., 2015). In order to obtain the desired plasticity and melting properties, these need to be carefully selected and processing conditions adapted to the fat composition.

In addition to their important role in the formation of robust independent impervious fat layers, it has been shown that roll-in fat consistency and behaviour also influence the elasticity and strength of the whole dough (Simovic et al., 2009; Renzetti et al., 2016).

Although they should stay firm and unmelted during pastry preparation, the thin fat layers should also melt rapidly once in the mouth in order to avoid the “waxy taste” resulting from an excessive amount of solid fat at body temperature (O’Brien, 2004). Besides, the fat melting in the mouth requires energy taken as heat, which provides a feeling of freshness, typical of the sensory experience associated with puff pastries.

**Conclusion**

As a result of their particular structure made of alternating pre-dough and roll-in fat layers, laminated doughs transform into a highly aerated pastry in the oven, illustrative of the so-called “puffing effect”. The integrity and appropriate consistency of the pre-dough and lamination fat layers are essential for adequate pastry lift. In addition to the importance of the physicochemical properties of the constituents, the laborious preparation procedure needs to be carried out with care. Nevertheless, obtaining the resulting delightful and sophisticated puffed product provides a feeling of satisfaction that encourages anyone who took up the challenge to do it again.

**REFERENCES**


