Chapter 2
Effect of Blanching on Food Physical, Chemical, and Sensory Quality

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Abstract Besides the well-known positive impact of blanching on color, the benefits of blanching can reach texture and even flavor. These effects are usually related to the activation or inactivation of key enzymes. Furthermore, reports on the positive effect of blanching on physicochemical parameters of foods are numerous. This chapter aims at reporting the effect of blanching on the physical, chemical, and sensory quality of foods. Given the importance of potatoes for mankind and the numerous studies on the blanching of potatoes, the first section of the chapter is devoted to this topic. Subsequently, blanching of miscellaneous foods is dealt with. The results of these studies are usually presented together with hypotheses that try to explain the observed behavior of foods as affected by blanching. Several equations used for modeling changes in color, texture, and enzymatic activity during blanching are presented. This chapter is very helpful for understanding the impact of blanching on food quality from a general perspective.

Keywords Blanching · Color · Texture · Peroxidase · Polyphenol oxidase

Impact of Blanching on the Quality of Potatoes and Related Products

The focus of this section is to provide information on the effect of blanching on the physical, chemical, and sensory quality of potatoes. Works on the reduction of undesirable compounds, such as acrylamide and pesticides, along with the reduction of microbes in potatoes will be presented in Chaps. 4 and 5. Additionally, works on the influence of blanching on the drying kinetics of potatoes will be shown in Chap. 6.

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Potatoes are processed in many ways by the food industry. In the potato processing plants, a blanching step is almost mandatory. In order to provide useful information for the potato processing industry, studies on the blanching of potatoes have been extensively conducted over the years. The most ancient report on this issue available in Scopus database is the study of Wallerstein et al. (1947). They report the inhibition of color changes in macerated potatoes by blanching. This effect was probably due to the inactivation of the polyphenol oxidase (PPO) enzyme in the tissue.

There are numerous other studies dealing with aspects such as color and texture in potatoes during blanching. The changes in such parameters were sometimes fitted to kinetic models, helping to explain how texture and color change during blanching and consequently helping to design blanching processes. In addition, studies on the positive impact of blanching on other quality aspects of the final product, like decrease in oil absorption and reduction in water activity of potato chips, are available.

Texture change during blanching is an important phenomenon to be understood and it has been under investigation for a long time. One of these studies showed that two-step blanching leads to higher peak force in potatoes when compared to one-step blanching. The former consisted of immersion in water at 70 °C for 10 min followed by immersion in water at 97 °C for 2 min, and the latter consisted only of immersion in water at 97 °C for 2 min (Agblor and Scanlon 1998).

Texture and color of French fries as affected by blanching, drying, and frying were assessed by Agblor and Scanlon (2000). Their results confirmed their previous study in which a two-step blanching consisting of immersion in water at 70 °C for 10 min followed by immersion in water at 97 °C for 2 min improved the color (higher lightness-L^*-value) and the texture (higher peak force and peak deformation) of potatoes. Nevertheless, one-step blanching at 97 °C for 2 min was suggested by them for processors aiming at promoting softening of firmer tubers (e.g., those with high dry matter content) and maintaining good color quality.

Verlinden et al. (2000) found that hot water blanching of potatoes at 55–75 °C affected their texture parameters, as per reducing the maximum force and the rupture force of the samples, and increasing the deformation at maximum force and the rupture deformation. They attributed this behavior the loss of turgor pressure in the tissue during heating. Additionally, they found that blanching/cooling before cooking had a strengthening effect on potatoes, especially when blanching treatments were longer.

Varnalis et al. (2001a) observed that blanching in boiling water for 2 min before drying of potato cubes led to puffing of the product. Their results show that blanching lead to lower penetration force, lower Young's modulus, and higher volume, which were typical characteristics of puffed cubes. They affirmed that blanching may affect not only the surface of the product, but also the rigidity of the structure allowing the vapor inside the cubes to press the walls of the cubes from inside out, thus promoting puffing. A second study on this issue (Varnalis et al. 2001b) showed that blanching reduces the permeability of a partially dried layer probably due to gelatinization of starch thus allowing puffing. Lewicki and Pawlak

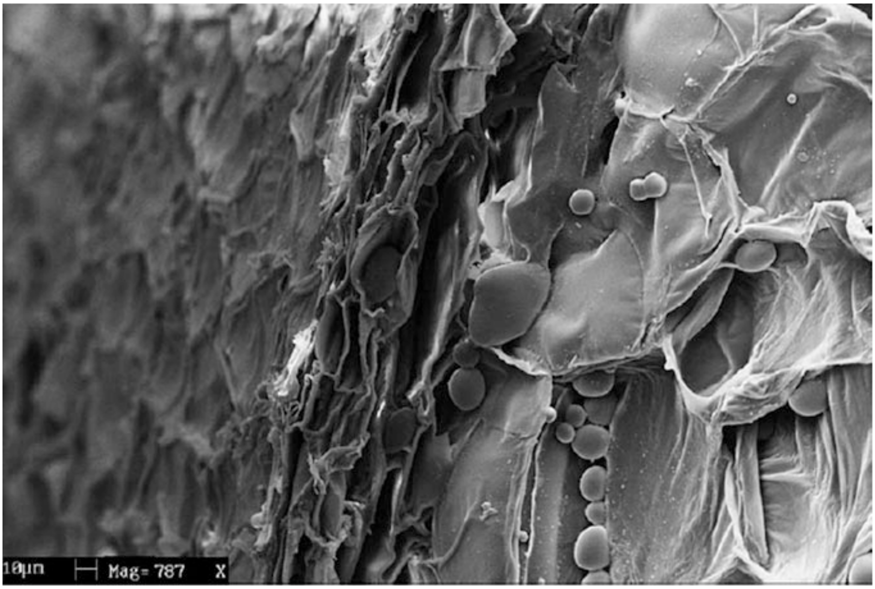

Fig. 2.1 Cross section of a potato tuber with a thin layer of skin and a group of flesh cells with starch granules (Lisińska and Gołubowska 2005)

(2003) confirmed using microscopy that blanching causes gelatinization of potato starch besides increasing the cells size and making their shape more regular.

Lisińska and Gołubowska (2005) studied the structural changes of potato tissue after technological processes used for French fries production, finding that blanching, pre-drying, and frying caused the most important changes in the tissue. When compared to fresh potato strips (Fig 2.1), blanched samples presented starch swelling in the outer layer along with a significant increase in volume (Fig. 2.2). In addition, blanching promoted an increase in non-starch polysaccharides and lignin content, which was related to water losses during the process.

Activation of pectin methyl esterase (PME) enzyme has been associated with better texture in potatoes and related products. For example, a hypothesis on this issue is provided in the study of Aguilar et al. (1997). They attributed firmness improvement in potatoes to demethoxylation caused by PME during blanching at 55–70 °C, which produces free carboxyl groups that can react with ions like calcium and magnesium to yield firmer structure. Aware of the importance and complexity of the impact of PME activity on firmness, Tijskens et al. (1997) modeled the activity of PME enzyme in potatoes as a function of blanching time and blanching temperature. They stated that PME denaturation is achieved in 10 min at 50 °C and in 1 min at 70 °C for potatoes of the cv. Bintje. González-Martínez et al. (2004) studied the temperature distribution in potatoes during blanching at 50–90 °C and its effect on PME activity, finding that heating-induced activation of the enzyme occurs when the

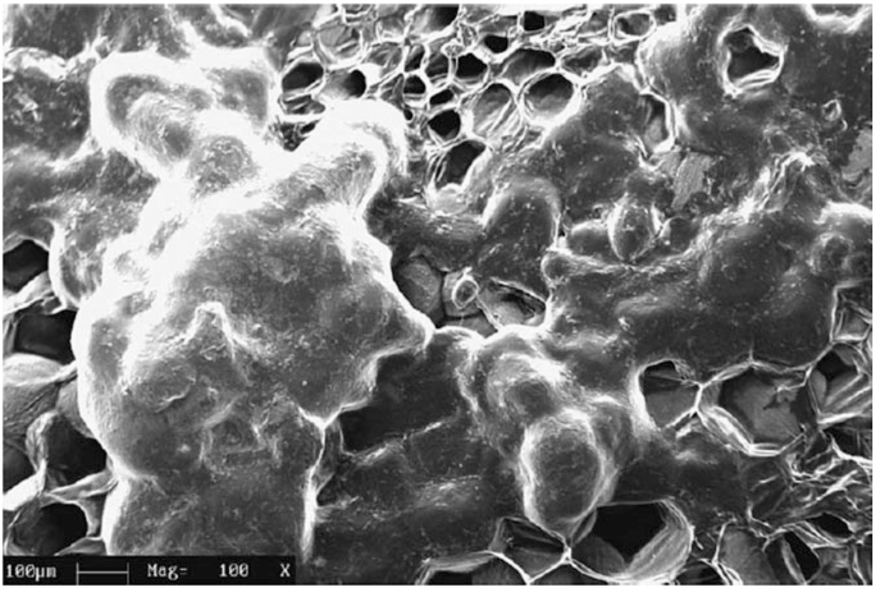

Fig. 2.2 The strips after blanching; starch swelling occurred in the outer layer of strips, along with enormous increase in their volume (Lisińska and Gołubowska 2005)

tissue reaches an average temperature of 52 °C. Another study showed that blanching at 65 °C led to higher firmness in new potatoes (partially grown potatoes) when compared to blanching at 75 °C, being the former the only temperature in which PME remained active even after 30 min of blanching (Abu-Ghannam and Crowley 2006). Therefore, it can be affirmed that PME was activated by blanching at 65 °C exerting a strengthening effect on new potatoes. Carbonell et al. (2006) found that a two-step blanching consisting of immersion in water containing 0.07 mg L^{-1} calcium chloride at 70 °C during 10 min followed by immersion in the same solution at 97 °C for 2 min was an effective pretreatment for preventing firmness loss and inactivating peroxidase (POD) in potatoes after freezing/thawing. This result was also attributed to the activation of the PME enzyme during the first blanching step. The use of blanching before cooking of mashed potatoes led to a desirable light-colored and thickened product, as expressed by higher lightness/yellowness (L^*/b^*) ratio, sensory, and instrumental texture measurements along with oscillatory measurements (Fernández et al. 2006). The thickening effect observed in the study was attributed to the activity of PME.

The mathematical modeling of textural changes in potatoes during blanching is important in order to design blanching processes. Liu and Scanlon (2007) investigated the influence of blanching time and blanching temperature on the texture of potato strips and built a model to serve as a guide to potato blanching operators (Eq. 2.1):

$$F_{\max} = F_0 \exp[kt(1/T - 1/T_{\mathrm{r}})] \quad (2.1)$$

where $F_{\max}$ is the maximum force attained in the force–deformation curve (N), F_0 is the initial texture of strips (N), k is a constant, t is the blanching time (min), T is the blanching temperature (°C), and T_{r} is a reference temperature at which no textural change with blanching time would be expected to occur (°C). Such model was validated experimentally suggesting that it can be used for estimating potato texture on the basis of blanching time and blanching temperature.

Moyano et al. (2007) used a model based on two irreversible serial chemical reactions for fitting the effect of blanching time on the texture of potato cubes. Equation 2.2 shows the two irreversible chemical reactions that are believed to occur during potato cubes blanching:

$$R(\text{raw tissue}) \xrightarrow{k_1} S(\text{soft tissue}) \xrightarrow{k_2} H(\text{hard tissue}) \quad (2.2)$$

where k_1 and k_2 represent the specific disappearance rate of the raw tissue and the specific disappearance rate of the soft tissue, respectively. After assuming that the concentration of these three types of tissue will change during blanching according to first-order kinetics and performing some calculation steps, the following model relating texture to blanching time was proposed:

$$F^*_{\mathrm{MAX}} = \frac{F_{\mathrm{MAX}}}{F_{\mathrm{MAX0}}} = 1 - K[1 - \exp(-k_1 t)] \quad (2.3)$$

where F^*_{MAX} is the dimensionless maximum force; F_{MAX} is the same parameter defined as $F_{\max}$ in Eq. 2.1; t is the blanching time (s); F_{MAX0} is the maximum force at $t = 0$; K is a proportional constant linking potato texture with dimensionless concentration of soft tissue; and k_1 is the same k_1 as in Eq. 2.2. This model was superior to the traditional first-order kinetic model for explaining the changes in potato texture during blanching between 50 and 100 °C.

Color and oil uptake are key-quality parameters of fried potatoes. Studies dealing with the measurement of these parameters as affected by blanching are numerous. For instance, potato strips blanched at 97 °C for 2 min and subsequently fried presented impaired color, loss of textural quality, and increased oil absorption as compared to unblanched ones (Alvarez et al. 2000). On the other hand, blanching at 75 °C for 8 min followed by immersion in sucrose–NaCl aqueous solutions reduced oil uptake by 15% in potato strips during ulterior frying (Moyano and Berna 2002). They explained such effect by the fact that, during frying, solutes are concentrated on the surface, enhancing the formation of a crust that acts as barrier to oil uptake. In another study, blanching in 0.5% $CaCl_2$ solution at 85 °C for 6 min followed by immersion in 1% aqueous solution of carboxymethyl cellulose type hydrocolloids reduced oil uptake in fried potato strips in 54% (Rimac-Brnčić et al. 2004). This effect was attributed to the formation of a fine net structure by hydrocolloids and calcium chloride which prevents oil absorption by the potato

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