Valorization of peach peels with an optimized drying process based on ultrasounds pretreatment with ethanol

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Peach (*Prunus persica*) is a "stone fruit" originating from China, whose cultivation has shown a worldwide spread in many western countries, like USA, Italy, Spain, and Greece. Characterized by a significant amount and variety of phenolic compounds, carotenoids, vitamins and minerals, its nutritional value is deemed to be extremely high. Polyphenol-wise it is rich in catechin, epicatechin, procyanidin B1, quercetin, chlorogenic, and neochlorogenic acid, while the main carotenoids are lutein, zeaxanthin, β-cryptoxanthin, and β-carotenes. These bioactive compounds along with vitamin C (ascorbic acid) enrich the fruit with many health benefiting attributes, such as antioxidant and anti-inflammatory properties. Peaches are categorized, depending on whether the flesh sticks to the stone, as free-stone, mainly consumed fresh, or as clingstone, which has industrial applications. Many products can be processed from clingstone fruit, like juice, jam, jelly or canned, frozen, dried peaches. Preparation of raw material before processing involves removal of peel, which is later discarded as waste.

Peach peel is the major by-product of the peaches industry, resulting in disposal costs and waste environmental problems. However, it has been mentioned that peels, the epicarp, contain much higher concentrations of bioactive components as compared to the mesocarp. Chang *et al* (2000) mentioned that peach peel has as high as 2-2.5 times more phenolics and carotenoids than the flesh and this notion was later addressed by many researchers. It was also proposed that this phenomenon is observed in the outer layer because such substances can potentially protect the fruit from environmental stresses and microbial threats (Stojanovic *et al*, 2016). Consequently, peach peel has the potential to be a crude material of considerate nutritional value. It can be utilized, through extraction procedures aiming to isolate compounds of importance, or as a dry product supplementing functional foods or pharmaceutics (Şahin and Bilgin, 2021).

Drying is a procedure stemming from ancient times and is still one of the most prevalent methods of food preservation, deriving from water removal within the product until microbial stability inducing levels are achieved. In addition, due to lower water concentrations many of the moisture-mediated deteriorative reactions are inactivated, positively impacting shelf life (Deng *et al*, 2019). Hot air drying is the simplest and most frequently used method of drying, but comes with various setbacks. Extensive drying times and subsequently high energy costs are the major problems, increasing production costs and having an adverse effect on the quality of final product. Color and other organoleptic characteristics can be negatively impacted because of high inlet air temperature, while also risking the degradation of several thermosensitive phytochemical compounds (Calín-Sánchez *et al*, 2020). Case hardening is also prominent in air drying, inhibiting heat and mass transfer. As a result, novel drying techniques to provide faster drying rates and reduce the effect of the falling rate period, while retaining the quality characteristics of the product, need to be examined (İlter *et al*, 2018).

Pretreatments are procedures that aim to enhance the effects of the drying process. Ethanol and ultrasounds, as well as well their combined effect, are interesting, modern and green methods of amplifying the water removal rate. Ultrasounds induce the mechanical compression and expansion of the food material, which resembles a sponge that is squeezed and released repeatedly (sponge effect). Concurrently, pressure shifts in the liquid medium contributes to the formation of bubbles that expand, contract, and finally implode violently causing rapid and transient changes in pressure and temperature, intensely affecting surrounding tissues (cavitation effect). These two effects lead to alterations in surface tension and viscosity, cell wall disruption, and microscopic channel formation, changing the food matrix to assume a more porous structure (Wu *et al*, 2020). Ultrasonic pretreatment seems to improve drying rates, featuring higher water diffusivity through the newly formed canals, nutrient and color retention (Tao *et al*, 2016). Likewise, emersion in ethanol solutions is a promising way to positively affect the drying process. Ethanol acts on a structural level based on its ability to dissolve components of the cell wall, causing changes in the structure and increasing its permeability. Cells are observed to be more compact and thin-walled and due to vapor pressure changes intracellular air loss is also achieved. Furthermore, because of the concentration gradient between ethanol and the food moisture, the Marangoni effect occurs, which is the mass transfer along an interface between two fluids due to a gradient of the surface tension (Zhou *et al*, 2021). While results have shown impressive feedback regarding drying times, bioactive compound stability and color, share mixed results and need further studying to be determined (Llavata *et al*, 2020). Amanor-Atiemoh *et al* (2020) studied the combined effect of the two methods, yielding greater drying rate results, however few studies are only available as of now and the synergistic effect and possible interactions are not yet fully understood.

The complete valorization of peach fruit, while minimizing potential waste is at the best interest of the industry. Peach peel by-product can be of great importance, because of its high phenolic and carotenoid concentrations, as an additive to functional foods. Such nutrients of high biological activity are susceptible to intense heat over long periods of time, so ultrasound and ethanol pretreatment methods are going to be capitalized on to reduce the aforementioned time. The main focus of the study is to evaluate the effectiveness of each method in the drying process and water removal rates, using drying kinetics. Statistical analysis (RSM and ANOVA) was applied to determine the importance of each parameter and possible factorial interactions. Afterwards the collected data were used to optimize the procedure. Last but not least, various properties of dried peel including total phenolics content, total carotenoids content, ascorbic acid content, antioxidant activity, and color were examined.

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