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ANALYSIS OF THE PROCESS OF DEHYDRATION OF PRODUCTS UNDER THE INFLUENCE OF ULTRASONIC WAVES

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Annotation. Dehydration is a widely used process in the food industry for the preservation and processing of various products. It involves the removal of water content from the product, thereby increasing its shelf life and reducing its susceptibility to microbial growth. Traditionally, dehydration has been accomplished through methods such as sun drying, hot air drying, and freeze-drying. However, in recent years, there has been an increasing interest in exploring alternative technologies to improve the efficiency and quality of the dehydration process. One such technology is the use of ultrasonic waves, which has shown promising results in enhancing dehydration processes. This article aims to provide an in-depth analysis of the process of dehydration of products under the influence of ultrasonic waves.

Key words:flavonoid, Complementary, Ultrasonic,

Introduction. Ultrasonic waves refer to sound waves with a frequency greater than the upper limit of human hearing, typically above 20 kHz. These waves are produced by an ultrasonic generator and can propagate through different media, including solids, liquids, and gases. When these waves interact with a medium, they create a phenomenon called cavitation, which is the formation, growth, and implosion of tiny bubbles. This cavitation phenomenon can generate heat and mechanical effects, which can be exploited for various industrial applications, including dehydration. The application of ultrasonic waves during the dehydration process offers several advantages. Firstly, the mechanical effects created by cavitation can enhance mass transfer by disrupting the boundary layer surrounding the product. This disruption leads to the removal of water molecules from the surface of the product, thereby accelerating the dehydration process. Additionally, the heat generated by the cavitation bubbles can contribute to the overall drying rate, influencing the quality of the final product. Several studies have investigated the effects of ultrasonic waves on different aspects of the dehydration process. One significant advantage of using ultrasonic waves is the reduced drying time compared to traditional methods. The mechanical agitation of the waves increases the evaporation rate, thus reducing the overall drying time. Furthermore, the use of ultrasonic waves can result in a more uniform distribution of drying between the product's surface and interior, resulting in improved product quality. In short, FIR drying can improve internal heat transfer of materials, and contact ultrasound technology can promote the internal mass transfer during drying process. Therefore, the application of ultrasound technology in FIR drying can theoretically promote the heat and mass transfer of materials synchronously, thereby significantly improving dehydration rate. However, there is no detailed research about the effect of contact ultrasound on the quality properties of FIR dried materials. Since ultrasonic power is the most important factor of contact ultrasound strengthening method for drying, the target of this research was to explore the effects of contact ultrasound power on FIR drying of potato which was a familiar and favorite food and was chosen as dried object. The effects of ultrasound power on drying process and D_{eff} values of potato slices were to be studied. The internal microstructure changes of dried potato slices with contact ultrasound treatment were to be analyzed by scanning electron microscopy (SEM). Moreover, several quality attributes including texture, color, total phenolic content (TPC) and total flavonoid content(TFC) of potato products dried under different ultrasonic powers were to be discussed. To achieve the desired dehydration results, it

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is crucial to determine the optimal parameters for the ultrasonic dehydration process. Factors such as frequency, power level, treatment time, and sample thickness can significantly impact the effectiveness of the dehydration process. By carefully controlling these parameters, it is possible to optimize the process to achieve the desired dehydration rate and product quality [1].

Although the use of ultrasonic waves in the dehydration process holds great potential, there are several challenges that need to be addressed. These include the development of efficient and cost-effective ultrasonic generators, optimization of process parameters for different products, and understanding the effects of ultrasonic waves on the product's nutritional content. Future research should focus on addressing these challenges to fully unlock the benefits of ultrasonic dehydration in the food industry.

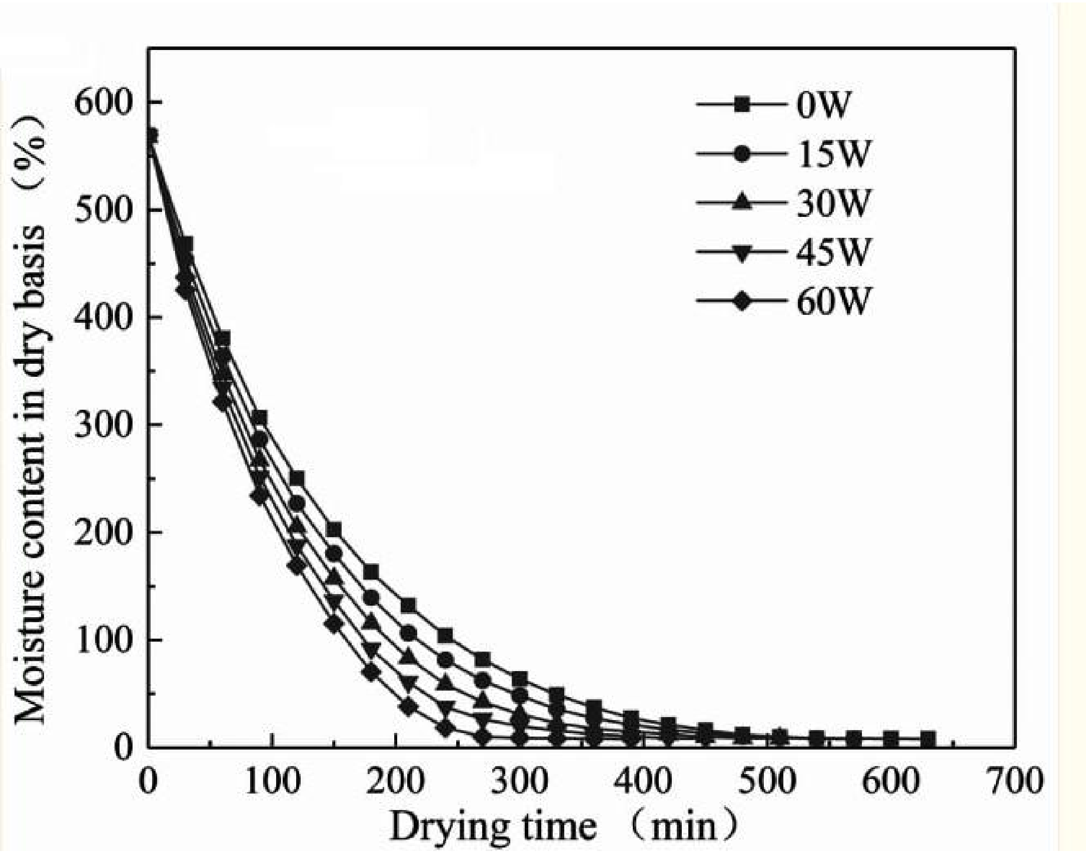

Figure 1. The corresponding drying curves and drying rate curves

It can be seen from the figure that contact ultrasound application could significantly reduce drying time and promote drying rate [2]. The drying time without ultrasound application was 630 min, while the drying times decreased as 570, 510, 450 and 390 min at ultrasound powers of 15, 30, 45 and 60 W, with the declination ratios of 9.5%, 19.0%, 28.6% and 38.1%, respectively. Compared with the average drying rate of 0.89%/min at ultrasonic power of 0 W, the average drying rates rose to 0.98, 1.10, 1.25 and 1.44%/min when ultrasound powers were 15, 30, 45 and 60 W, with the rising ratios of 10.1%, 23.6%, 40.4% and 61.8%, respectively. An explanation for this fact may be that the ultrasound energy radiated from the ultrasound board could penetrate directly inside the samples when the potato slices were put on the ultrasound board during drying process. Because of the rapid compression and expansion of the internal structure caused by the high-frequency vibration of ultrasound, a large number of micro-bubbles are generated, and strong kinetic energy and compression energy are produced when the bubbles burst instantaneously [3]. In the initial stage of

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drying, the average drying rates increased by 25.9% and 43.4% at ultrasonic powers of 30 and 60 W, respectively, compared with single FIR drying. When the moisture content of the material was dropped by half, the corresponding average drying rates increased by 23.4% and 39.1% at 30 and 60 W, respectively, compared with single FIR drying. When the moisture content of the material dropped to about one-fourth of the initial value, the corresponding average drying rates increased by 20.3% and 35.8% at 30 and 60 W, respectively, compared with the FIR drying without ultrasound application. When the moisture content was below 35%, all drying rate curves tended to coincide.

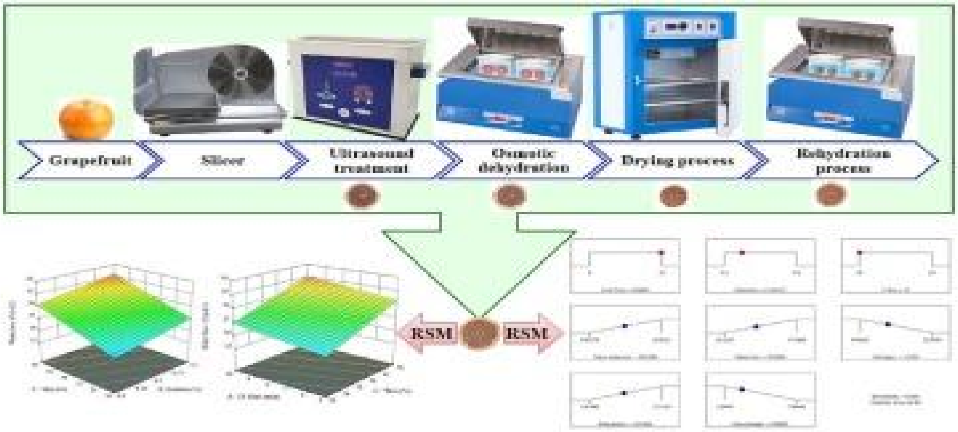

Figure 2. Schematic dehydration process of slices.

The above phenomena revealed that the enhancement effect of ultrasound is closely related to moisture content, and decreases with moisture reduction. In the initial period of potato drying, the higher moisture content of the material represented more free water and faster ultrasound transmission. At this time, the attenuation coefficient of the ultrasound wave and the internal transmission resistance were small, which were beneficial for the ultrasound waves to penetrate into the material and produce strong strengthening effect. Dehydration can be regarded as one of the oldest methods of food preservation. For thousands of years humans have dried or smoked meat, fish, fruits and vegetables to sustain them during out of season periods. Today, the dehydration section of the food industry is large and extends to all countries in the world [4]. The reduction of water content of products contributes to the preservation of the raw matter by preventing the degradation during the storage and transportation. Drying facilities range from simple sun- or hot-air driers to high capacity, sophisticated spray- or freeze-drying units. Ultrasound has been used as a means to enhance the efficiency of mass transfer during the osmotic dehydration of fruits and vegetables. The responsible phenomenon is called the sponge effect [5].

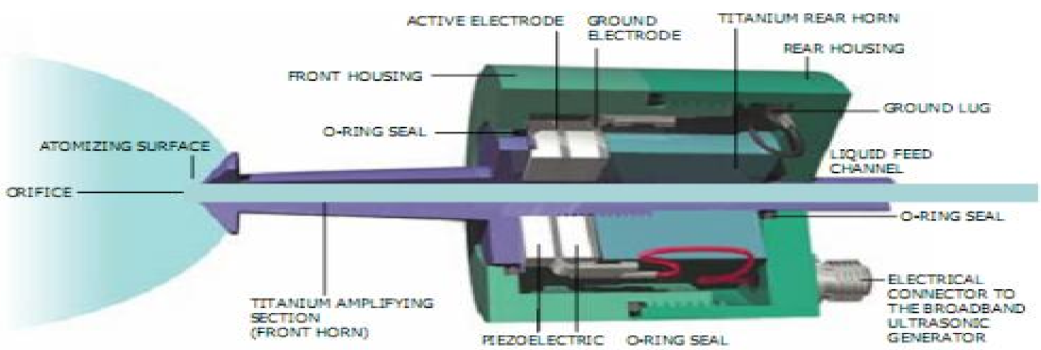

Figure 3. Schematic of an ultrasonic atomization system

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Ultrasonic waves can cause alternating compressions and expansions resulting in microscopic channels in the porous materials. Cavitation can also collapse explosively and generate localized pressure accelerating the degassing process resulting in higher diffusion rates in such processes as osmotic dehydration. An ultrasound-assisted hot-air drying system (in non-contact condition) which consists of a hot air generator, an ultrasonic transducer with the corresponding electronic generator and a flat plate parallel to the ultrasonic radiator acting as a reflector for the formation of a standing wave and also as sample holder. Complementary sets of equipment for measuring temperature, air flow velocity, and weight were used. Ultrasound technology has been directly or indirectly used as a pretreatment in many drying and/or dehydration applications [6]. Direct pretreatment improves the drying process by intensifying mass and heat transfer and the microstreaming phenomena in the structure of the material. Indirect pretreatment effects work in operations relevant to drying or dehydration operations. Ultrasonic pretreatment can be used before air-drying and osmotic dehydration of vegetables and fruits. Studies show that the effective water diffusivity increases after application of ultrasound causing a reduction of about 16% in the drying time.

Conclusion. The analysis of the process of dehydration of products under the influence of ultrasonic waves highlights its potential to improve the efficiency and quality of the drying process. The mechanical effects and heat generated by ultrasonic waves offer several advantages such as reduced drying time and increased product uniformity. However, further research is required to optimize process parameters and overcome existing challenges for its widespread adoption in the food industry. With continued advancements in ultrasonic technology, it is expected that this method will play an increasingly important role in the dehydration process in the years to come.

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