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Research Article

Development of Coconut Chips Air Fryer

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ABSTRACT

The growing demand for coconut chip delicacies has prompted local producers in Palawan, Philippines, to scale up production. However, the lack of suitable air frying equipment remains a challenge. Currently, household-scale air fryers with a 300–350 g capacity are used, leading to high energy and labor costs, as multiple units are needed to meet production demands. This method is also labor-intensive due to the need for manual stirring every five minutes to ensure uniform chip cooking. To address these issues, an innovative air fryer was developed. The air fryer was evaluated based on its temperature profile, optimal capacity, and the uniformity of the cooked chips. Results of the evaluation showed that the air fryer obtained an optimum capacity of 6–8 kg of coconut chips per batch. The device is equipped with adjustable temperature settings that reach up to 250°C. It features a rotating cylindrical perforated bin, reinforced with metal strips, ensuring efficient agitation and uniform cooking. A mechanical exhaust system aids in moisture removal and even heat distribution. This air fryer not only enhances production efficiency but also holds the potential for dehydrating and roasting other agricultural products at a larger scale with consistent results.

Keywords: Air Fryer; Coconut Chip; Air Frying Capacity; Air Frying Temperature; Air Fryer Agitator; Uniform Heat Distribution.

INTRODUCTION

Coconut (*Cocos nucifera L.*) is known as the “tree of life”, a continuous fruiting perennial tropical fruit and oil crop commonly found in the humid and sub-humid coastal tropics. The various parts of this palm hold significant utility and economic value, making them suitable for applications such as handicrafts, lumber, and others. Additionally, the palm boasts a productive lifespan of six to seven decades (Subramanian et al., 2024). It is a source of livelihood for many fulfilling economic and practical needs (Yang et al., 2018, Hebbar et al., 2020, Beegum et al., 2019, Manikantan et al., 2018). Coconut is cultivated in over 97 countries worldwide, with an annual production of 63.76 million tonnes. In 2019, the top coconut-producing nations were Indonesia (16.65 million tonnes), the Philippines (14.15 million tonnes), India (10.34 million tonnes), Brazil (2.46 million tonnes), and Sri Lanka (2.09 million tonnes) (FAO, 2019).

The Philippine Coconut Authority (PCA) under the Department of Agriculture, reported that the Philippines has 3.6 million hectares of land planted with coconut with an annual production of 14.7 metric tons (Philippine Coconut Authority, 2024). This is one of the major commodities in tropical areas utilized as food and also provides opportunities for business and employment to millions (Manikantan et al., 2016). However, the coconut industry of the Philippines has faced many challenges that have caused its price to fluctuate continually and generally low. The affecting factors include the eminent competition of substitute products like palm oils, which have lower production costs (Karandeep et al., 2019) and the high production costs of local labor, far distance from farm to market road, pests, and diseases, difficulty in nut collection, and high transportation cost (Gürbüz, 2019). As such, there is a need to explore and make innovative products of coconut apart from oil such as coconut chips. Coconut chip products are now getting known and creating demand in both local and international markets thus making companies and organized cooperatives start to venture into commercial-scale production such as the Reals’ Food Products Company in Palawan, Philippines, Dang Foods Company and in the United States of America, CocoBites (Nature’s Charm) Company in Thailand, and other companies in Sri Lanka, Indonesia, Malaysia, and Vietnam.

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Coconut chips are gaining popularity as innovative products that offer a delicious taste, nutritional benefits, and functional advantages, including being an excellent source of fiber (Kamsiati, 2010). Ojobor et al. (2018) and Solangi and Iqbal (2011) stated that coconut is a good source of oil, carbohydrate, dietary fiber, and protein. A high level of crude fats was found at around 56% and carbohydrates at 31%. Furthermore, coconut has a considerable amount of crude protein and fiber around 7% and 2%, respectively. Processing coconut flesh into coconut chips also helps maintain the quality and shelf life of coconuts, which have high moisture content (Divekar et al., 2010).

Currently, the Reals Food Products Company, one of the producers of coconut chip products in the Philippines, is still using the air fryers that are commonly available in the market. These air fryers are designed with a capacity for home use and not really for commercial purposes. Using this kind of air fryer is tedious and costly for commercial use.

Coconut meat has a high moisture content of around 48% (Estal, 2014) and the thickness of coconut chips is at most 0.5 mm, which tends to stick together and form lumps, making air frying a difficult process, especially in attaining uniformity of cooked chips. With this, manual stirring every five minutes interval is used which makes the process tedious. In addition, the capacity is small wherein a single air fryer can carry only around 350g per cooking and be cooked for almost 45 minutes. The current process is also costly in terms of labor and energy because of the number of air fryers being used due to their small capacity, to cope with their production target. One labor personnel can only operate a few air fryers simultaneously, because of the manual stirring of the coconut chips to be made several times to ensure uniform cooking. In addition, the subsequent interruption and removal of the air frying pan for agitation of the chips, while the air fryer is in operation mode, is energy inefficient.

Several patented models of air fryers can be found but are not yet readily available in the market. Furthermore, the main application of these air fryers is not specifically for commercial-scale coconut chip production, in terms of size and design configuration particularly in the cooking bin (Backus and Ron, 2010; Yun, 2019, Shikong et al., 2010; Mcnerney et al., 2017; Sun et al., 2019; Hunt, 2020). Thus, this study will explore designing and developing an innovative air fryer suitable for coconut chips and applicable to commercial applications. Product specifications and processes of the local industry partner, particularly the Reals Food Products Company, were also considered in the development.

OBJECTIVE

Generally, this study is aimed to develop a commercial-scale air fryer primarily for coconut chip production. Specifically, it is aimed to design, fabricate, and evaluate an air fryer in terms of temperature profile, optimum capacity, and uniformity of cooked chips.

METHODOLOGY

Design of the Air Fryer

The designed air fryer (Figure 1) essentially has major components similar to the existing air fryers: the heat source, cooking bin, insulated wall, cooking pan or bin, and others. The innovations are focused on enhancing the size or capacity, configuration of air fryer components to ensure the even cooking of the coconut chips, and performance efficiency in terms of energy and ease of operation.

The thickness of the coconut chip products varies depending on producers' preferred product quality and specifications. The unique property and characteristics of coconut chips requires a suitable design, especially its thickness and high moisture content. Thin coconut chips around 0.5 mm, which is the desired thickness of the industry partner, with high moisture content usually stick and form lumps making it difficult to cook evenly. The capacity is designed for commercial application and is essentially larger than common air fryers available on the market. It has the following dimensions: length – 1.77m; width – 0.63m; and height – 0.80m.

The identified factors that directly affect the uniformity of cooking based on the characteristics of the coconut chip are the cooking bin and the equal distribution of heat inside the air fryer. The cooking bin is cylindrical and made of a perforated stainless metal plate. It has angled metal strips placed inside along the cylinder to enhance the stirring

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of the coconut chips when the bin rotates slowly. In addition, the bin has an opening with a lock mechanism for easy loading and unloading of coconut chips. The entire cooking bin is also detachable to facilitate cleaning activity and give way for other air fryer applications and accessories such as roasting and dehydrating other agricultural products.

The mechanical exhaust system was designed to cope with the high moisture content of the coconut chips. Moisture must be removed and regulated properly to avoid condensation and delayed cooking time which may affect the quality of the chips. In addition, due to the large volume of the air fryer, the method and design of moisture removal have a critical effect on the heat distribution inside. With these, the suction inlets of the exhaust fan were spread along the cooking bin to remove the moisture evenly, because the air fryer is quite long and profiling of moisture concentration is most likely to happen if the inlet chute of the exhaust fan is placed only at one side.

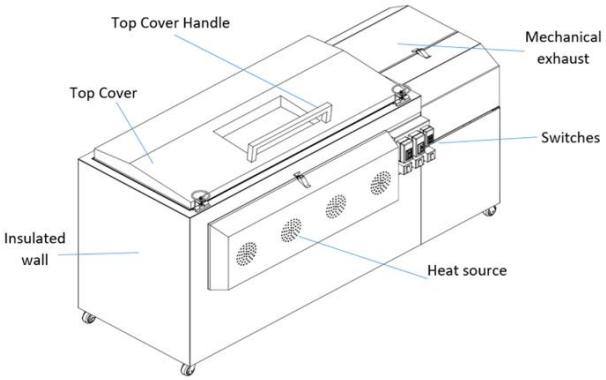

Figure 1. CAD drawing of the air fryer

The air fryer's cover is made of stainless metal and insulated with carbonized rice hull and ceramic fiber. The opening is placed at the top. It has a glass window for monitoring while in operation, a handle, and a lock system. The heat source is placed on one side of the air fryer to avoid possible wetting during the cooking process. Caster wheels with locking means are used to move the air fryer easily.

Fabrication

The air fryer was fabricated at the Technology Innovation Center of the College of Engineering and Technology at Western Philippines University.

Evaluation

Before the final evaluation, the air fryer was subjected to preliminary testing. Several modifications were made until the air fryer was functional. The parameters being assessed include the optimum capacity, trends of temperature at different settings, temperature distribution inside the air fryer, and the actual air frying performance. The optimum capacity was determined by measuring the optimum amount of coconut chips that can be carried by the cooking bin per cooking and per unit of time. The temperature trends were measured at selected settings because of the large volume of the developed air fryer relative to the common air fryers. In addition, the possible temperature variations at different points in the air fryer were also assessed. This was done by measuring the temperatures at various points simultaneously.

RESULTS AND KEY FINDINGS

The Developed Air Fryer

Figure 2 shows the prototype of the air fryer. It configures a right rectangular prism. The design of the cooking bin has shown better stirring of the coconut chips which contributes to uniform cooking of the chips. The possible formation of lumps of the chips due to their high moisture content and thin thickness was avoided. It can be observed that the coconut chips were essentially spread evenly inside the cooking bin. The angular speed of the cooking bin, around 17 rpm, effectively helped in the stirring process. The cooking bin can be replaced and removed to facilitate thorough cleaning and for other attachments for other applications.

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Figure 2. The developed air fryer

The combination of ceramic fiber and carbonized rice hull as heat-insulating materials has shown good performance. The mechanical exhaust system greatly helped remove the high amount of moisture inside the air fryer. Condensation of vapor on the walls has been eliminated during the cooking process. In addition, spreading the inlet chutes of the exhaust system has been effective in avoiding moisture profiling inside the air fryer. The prolonged presence of moisture should be avoided as it can affect the quality of the chips and also extend the cooking time. The glass window and lamp inside the air fryer have greatly helped for visual monitoring of the coconut chips.

The developed air fryer can also be a potential technology for roasting and drying other agricultural products. It can be done because the temperature can be adjusted and the bin can easily be replaced with other attachments suited for the product. Thus, the equipment is suggested for evaluation for different applications such as roasting cashew nuts and other cereals, roasting meat, drying medicinal herbs, fruits, vegetables, and others.

Temperature Profile

The temperature inside the air fryer was assessed to determine its possible changes over time. This was determined with the exhaust system in continuous operation. Temperature must be maintained as it will directly affect the quality, especially for sensitive products. The evaluation results showed that the temperature reaches its desired setting within ten to fifteen minutes (Figures 3 and 4). This can be attributed to the air fryer's volume, the insulator, and the constant rate of air removal through the exhaust system. Generally, the temperature inside the air fryer is maintained over time at the preferred magnitude. This result implied the effective performance of the automatic control switch of the heating system. This feature is vital, especially in processing products that have sensitive properties to heat changes. The temperature of the air fryer can be raised to 250 °C.

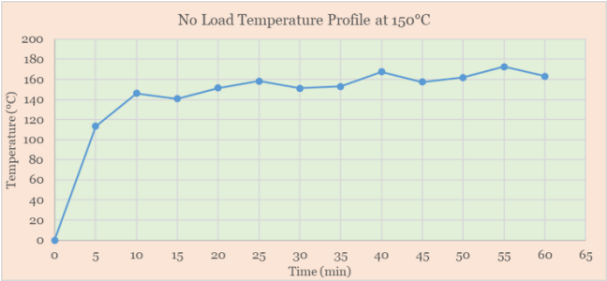

Figure 3. Temperature profile at 150 °C

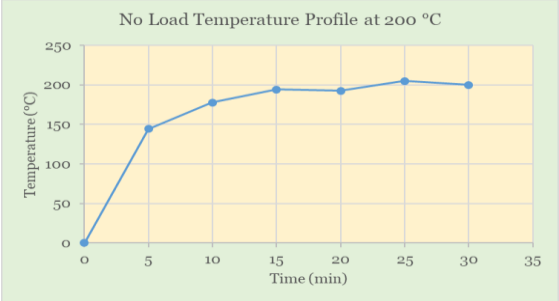

Figure 4. Temperature profile at 200 °C

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Air Frying Performance

Generally, the ultimate focus of the innovation was to make a larger capacity air fryer that cooks the coconut chips uniformly. The optimum capacity of the cooking bin was determined gradually. Several tests were made to find out the safe capacity of the cooking bin wherein it does not affect the physical quality of the chips, such as breakage, and can still be cooked uniformly. The effect of intermittent application of the exhaust system was also tested to shorten the time to get the required amount of heat at the initial stage, because of the bigger size of the air fryer which requires additional time in heating the air and walls before the desired temperature is attained. Doing such, resulted in a formation of condensed moisture that appeared on the walls and implies the unsuitability of the method. The time of air frying is highly dependent on the magnitude of the temperature which also depends on the product requirement.

Figure 5 shows the raw coconut chips inside the cooking bin. It can be observed that the chips were scattered along the bin uniformly during the air frying process. This result implied the effectiveness of the stirring mechanism being used. Figure 6 shows the air-fried coconut chips. It can be observed that the chips have the same color which implies uniform cooking. Six kilograms of coconut chips were used in the test. The chips were not given any treatment or flavoring. It is recommended that the air fryer be tested at a higher capacity and different levels of angular speed of the cooking bin.

Figure 5. Fresh coconut chips inside the cooking bin

Figure 6. Photo of air-fried coconut chips

CONCLUSION

Generally, the developed coconut chips air fryer is a potential technology to support the emerging coconut chips industry in the locality, primarily in the Province of Palawan, and other places in the Philippines. The innovation addresses the problem of tedious manual stirring, the low capacity of available air fryers in the market, and the uneven cooking of chips. Consequently, this technology has the potential to enhance productivity, reduction of production costs, ease the air frying process, and ensure product quality.

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REFERENCES

[1] Abdul Hameed Solangi and M. Zafar Iqbal. (2011). Chemical Composition of Meat (Kernel) and Nut Water of Major Coconut (Cocos Nucifera L.) Cultivars at Coastal Area of Pakistan. Pakistan Journal of Botany, 43(1): 357-363.

[2] Backus, A. L. and Ron P. (2010). Enclosed Rotisserie with Detachable Electronic Components. Ronco Acquisition Corporation, Patent No. US20100071565.

[3] Beegum et al., P.P.S. Beegum, M.R. Manikantan, M. Sharma, R. Pandiselvam, R.K. Gupta, K.B. Hebbar. (2019). Optimization of processing variables for the development of virgin coconut oil cake based extruded snacks. Journal of Food Process Engineering, 42 (4), Article e13048, 10.1111/jfpe.13048.

[4] Divekar, S. P., Thokar., N. J., Sawant., A. A., Thombare, J. J.., & Raut, H. N. (2010). Study of Effect of Different Packaging Material on Quality of Coconut Chips. International Journal of Agricultural Engineering, 3(1), 14-16. https://doi.org./10.1080/10942910903580884.

[5] Estal, B.R. (2014). Pricing Movements of Copra in the Philippines. Proceedings Book of ICETSR, Malaysia Handbook on the Emerging Trends in Scientific Research ISBN: 978-969-9347-16-0.

[6] FAO. (2019). Available: http://www.fao.org/faostat/en/#data/QC/visualize.

[7] Gürbüz İ. B., Manaros M. (2019). Impact of Coconut Production on the Environment and the Problems Faced by Coconut Producers in Lanao Del Norte Province, Philippines. Scientific Papers - Series Management Economic Engineering in Agriculture and Rural Development, vol.19, no.3, pp.235-246, (ESCI).

[8] Hebbar, K. B., Arivalagan, M., Pavithra, K. C., Roy, T. K., Gopal, M., Shivashankara, K. S., & Chowdappa, P. (2020). Nutritional profiling of coconut (Cocos nucifera L.) inflorescence sap collected using novel coco-sap chiller method and its value added products. Journal of Food Measurement and Characterization, 14(5), 2703–2712. https://doi.org/10.1007/s11694-020-00516-y.

[9] Hunt R. (2020). Multi-function Cooking Oven Having Horizontally and Vertically Oriented Cooking Elements and Multi-Position Horizontal and Vertical Rotation Devices. Ronco Holdings Inc. Publication Number 20200029731.

[10] Kamsiati, E. (2010). Opportunities for the Development of Fruit Chip Processing Technology Using Vacuum Frying. Jurnal Litbang Pertanian, 29(2), 73-77. https://doi.org/10.21082/jp3.v29n2.2010.p%p.

[11] Karandeep, K.; Navnidhi, C.; Poorva, S.; Garg, M.; Anil, P. (2019). Coconut meal: Nutraceutical importance and food industry application. Foods Raw Mater. 7, 419–427.

[12] M.R. Manikantan, A.C. Mathew, K. Madhavan, T. Arumuganathan, M. Arivalagan, P.P. Shameena Beegum, K.B. Hebbar. (2016). “Coconut Chips” - Entrepreneurship Driven ICAR-CPCRI Technology for HealthyAlternative Non-Fried Snack Food. ICAR – Central Plantation Crops Research Institute & AICRP on PHET Kasaragod – 671 124, KERALA, Centenary Publication, Technical Bulletin 107.

[13] Manikantan et al., M.R. Manikantan, R. Pandiselvam, S. Beegum, A.C. Mathew. (2018). Harvest and postharvest technology. The coconut palm (Cocos nucifera L.)-Research and Development perspectives, Springer, Singapore, pp. 635-722.

[14] Mcnerney, G. J., Klock C. A., Sampath B. S., Jacob D., Barron, W. K. (2017). Air Frying Systems and Methods. Spectrum Brands Inc. Patent No. US2017045118.

[15] Ojobor CC, Anosike CA, Ezeanyika LUS. (2018). Evaluation of Phytochemical, Proximate and Nutritive Potentials of Cocos nucifera (Coconut) Seeds. Journal of Experimental Research, Vol 6 No 2.

[16] Pan Yun. Air Fryer. (2019). X J Electrics Hubei Co. Ltd. Patent No. CN209984073U.

[17] Philippine Coconut Authority, (2024). https://pca.gov.ph/index.php/resources/coconut-statistics.

[18] Subramanian P., Gupta A., Gopal M. et al. (2024). Coconut (Cocos Nucifera L.), Soil Health Management for Plantation Crops: Recent Advances and New Paradigms, Springer, 37–109.

[19] Sun Shikong, Zhang Shenglin, Yang Jinfeng, and Zhao Qiwen. (2010). Air Fryer with Uniform Heating Function. Ningbo Borine Electric Appliance Co. Ltd.

[20] Sun Y., Hu J., and Sun, W. (2019). Air Fryer with Rotary Container. Ningbo Manhua Electric Appliance C. Ltd. Patent No. CN209574438U.

[21] Yang Y., Iqbal A., and Qadri R. (2018). Breeding of Coconut (Cocos Nucifera L.): The Tree of Life, Advances in Plant Breeding Strategies: Fruits. 3, 673–725, https://doi.org/10.1007/978-3-319-91944-7_17, 2-s2.0-85063503258.