International Journal of Agricultural Technology 2025 Vol. 21(4):1369-1378
DOI: https://doi.org/10.63369/ijat.2025.21.4.1369-1378
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Design, fabrication and evaluation of Jackfruit (*Artocarpus heterophyllus*, Lam.) seed sheller

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Ngoho, R. A., Bellen, J. A. and Cerna, J. B. (2025). Design, fabrication and evaluation of jackfruit (*Artocarpus heterophyllus*, Lam.) seed sheller. International Journal of Agricultural Technology 21(4):1369-1378.

Abstract Jackfruit seed endosperm has been used to create several food products. However, raw jackfruit seeds are covered with hard covering making it difficult to remove the shell manually. Manual seeding is uneconomical because of the sheer volume of jackfruit seeds produced during the production of vacuum-fried jackfruit. The jackfruit shelling machine performance was rated according to shelling capacity, shelling efficiency, percentage seed injury, and percentage separator loss. The fabricated jackfruit seed sheller has a smooth feeding performance, no unpleasant mechanical vibration, and tolerable level of blower noise. Shelling efficiency was highly correlated with drying time for both raw and frozen seeds. Shelling efficiency of the machine feed with dried raw seeds using single pass shelling is best at 57%, while 59% for frozen seeds, when both were dried for 15 hours. Shelling capacity of the machine using frozen seeds increases with longer drying period unlike raw seeds that is more or less constant. The average capacity of the sheller is around 390 – 420 kg-hr-1 of raw seeds and 251 kg-hr-1 to 532 kg-hr-1 of shelled seeds for frozen seeds. Seeds that were frozen prior to drying attained the highest shelling capacity when dried for 9.0 hours at 528 kg-hr-1 and is 20% higher than dried raw seeds at 420 kg-hr-1. In addition, losses and injuries were only recorded for seeds dried for not more than 3 hours (frozen) and 6 hours (raw) at 2.75% and 5.96%, respectively.

Keywords: Drying, Freezing, Jackfruit seeds, Sheller

Introduction

Jackfruit (*Artocarpus heterophyllus*, Lam.) is considered the banner crop in Eastern Visayas, Philippines (DA-BAR, 2022; Galvez and Dizon, 2017). Jackfruit seed is made up mainly of three components. The white or plain seed and two covering layers: the outer thick layer coating which is popularly termed as the seed coat and a very thin brown skin. The seed coat is made up of protein, which is hard in nature. That is why one of the identified problems in the

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utilization of jackfruit seeds for product development is the removal of the seed coat (Lauzon *et al*., 2013). Jackfruit seeds are a good source of starch (22%) and dietary fiber (3.19%) (Basalo and Lina, 2020; Hettiaratchi *et al*., 2011). The flavor of boiled jackfruit seeds is similar to chestnuts and is a delicious and healthy snack for people of all palates. They can be roasted, boiled, or cooked and then preserved in syrup, much like chestnuts (Swami *et al*., 2012).

Products developed from jackfruit, aside from fresh pulp, ranged from processed pulp in a form of jams, compotes, frozen fruit pulps, juices, vacuum fried pulp, dehydrated pulp and soft drinks to co-products like seeds in brine, seeds in syrup, jackfruit pith patty, vacuum fried seeds, jackfruit rags as macaroons, and many more (Braga *et al.,* 2019; Lauzon *et al*., 2013).

In Leyte, Philippines, the Department of Food Science and Technology at Visayas State University has developed vacuum-fried and dehydrated jackfruit from ripe jackfruit pulp of the EVIARC sweet variety. The product has high market demand, and the processing technique is currently adopted and commercialized by local food processors from Mahaplag, Baybay City, and Ormoc City, Leyte, Philippines. With the commercialization of the jackfruit pulp, a large bulk of co-products were produced with every processing operation. EVIARC sweet jackfruit has 30-35% pulp, leaving the 65-70% as co-products, which include peel, pith, rags, seeds, and seed coat. While studies are available for developing zero waste processing options for jackfruit co-products (Lauzon *et al*., 2019; Lauzon *et al*., 2013). Seeds, as one of the co-products, which are about 11% (or more in terms of dry-weight ratio) of the total weight of the fruit, possess great processing potential. Many of the products developed from jackfruit seeds include seeds in brine, seeds in light syrup, sauce, noodles, baked products from seed flour, vacuum-fried seed, and jackfruit seed coffee-like powder (Lauzon *et al*., 2019). However, in a community group in Baybay City, which processes jackfruit seeds, the most common method of shelling jackfruit seeds was done by manually separating the seed coat from seed flesh using fingernails and knives which causes scratching and breakage of flesh, resulting in a poor appearance of the seeds. In addition to physical damage, seed flesh manual shelling is very tedious and takes a long time to peel the seeds; hence, it makes the process costly. The marketability of their products is restricted by the ineffective, tiresome, and time-consuming nature of the conventional, traditional, or manual method of shelling jackfruit (Lim *et al*., 2015; Sobowale *et al.,* 2016). Because of this problem, it is necessary to develop a shelling machine to facilitate the immediate processing of jackfruit seeds, especially during peak season when bulk quantities of these co-products are usually left behind. Shelling involves removing the outermost part (husk) from the jackfruit seed endosperm.

This study was conducted to design, fabricate, and evaluate the jackfruit seed sheller to easily separate the seed coat from the jackfruit seed. The processing of jackfruit seeds is imperative to further diversify its use.

Materials and methods

The design of the jackfruit seed sheller is loosely based on the existing designs of seed shellers like melon seed sheller (Stephen and Lukham, 2015); jathropa seed shelling machine (Amoah and Bobobee, 2018; Aremu *et al*., 2015; Kheiralla *et al*., 2012; Ting *et al*., 2012); moringa seed dehuller (Ikubanni *et al*., 2017); and peanut/groundnut sheller (Orias, 1980; Orge, 1982). Modification was done on the clearance, roller speed and material. The conceptual design and engineering drawing of the jackfruit seed sheller were drawn and rendered using AutoCAD 2017 as shown in Figure 1.

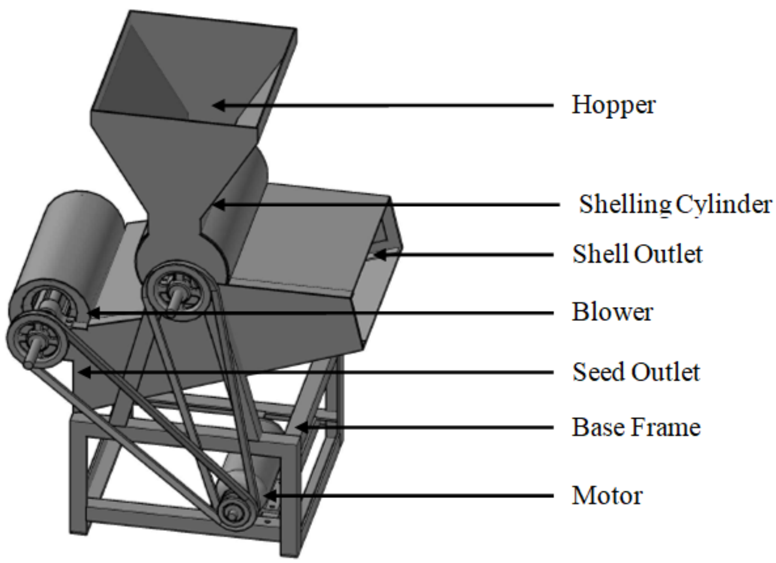

Figure 1. Jackfruit seed sheller conceptual design and parts

Performance evaluation of the machine was done using seeds of EVIARC Sweet varieties 1 and 2 of jackfruit sourced from the Baybay Women's Association Jackfruit Processing Plant, Sta. Cruz, Baybay City, Leyte, Philippines. Sheller properties like shelling efficiency, shelling capacity, seed injury and losses were observed. Machine performance, like noise and vibration, was also observed.

Jackfruit seeds from the local jackfruit processor were either stored raw or frozen. Seed coats are strong and flexible when wet; therefore, drying is necessary to reduce the moisture of the coating, making it brittle. Thus, machine performance and evaluation were taken from both raw seeds and those that underwent the freezing and thawing process and were dried for different durations using a mechanical dryer, as shown in Figure 2. Using two seed conditions (raw and frozen) and five drying schedules, the study formulated ten experimental runs (Table 1) from a 2x5 factorial in a completely randomized design (CRD). Each experimental runs were done in triplicate with 10 kg of jackfruit seeds used in each trial. Analysis of Variance (ANOVA) was used to test whether the performance of the sheller varies with each experimental run. Post-hoc analysis was employed using Tukey's HSD to characterize each experimental run from each other. In addition, each machine performance property for both raw and frozen seeds was subjected to linear regression analysis to quantify the effect of drying time on those properties.

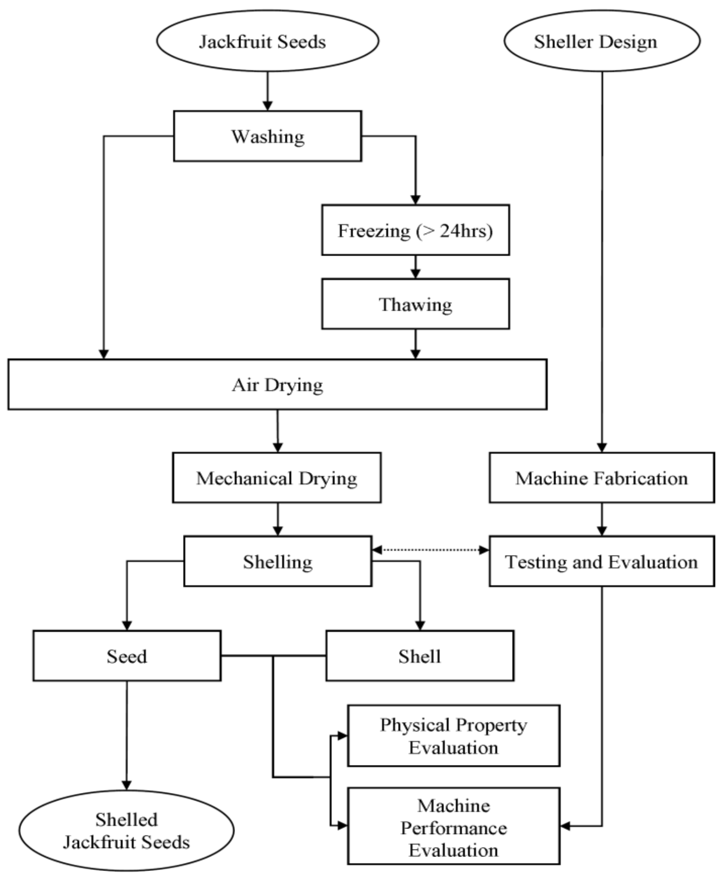

Figure 2. Process flow of the overall design, fabrication, and evaluation of the jackfruit seed sheller

Shelling properties include a) shelling efficiency (eq 1), shelling capacity (eq 2), shelling injury (eq 3), and separator loss (eq 4).

$$E_s = (W_c/W_F)\times 100 \quad (1)$$

$$C_m = w/t \quad (2)$$

$$\%I = (W_i/W_C)\times 100 \quad (3)$$

$$\%SL = (W_S/W_C)\times 100 \quad (4)$$

Where WF is the weight of feed seeds (kg), Wc is the weight of clean shelled seed (kg), w is the weight (kg) of cleaned seeds, t is the time (hours) of operation. This will include the time spent in removing raw seeds that will be mixed with cleaned seeds, Wi is the weight of injured seeds (kg), and Ws is the weight (kg) of seeds mixed with the shells at the shell outlet.

Results

Motorized jackfruit seed sheller has been fabricated based on the design shown in Figure 3. The developed machine includes the following main components such as the hopper, the shelling chamber, the electric motor and the shaft, belt, pulley and frame. The fabricated machine was tested and showed smooth feeding performance, no unpleasant mechanical vibration, and a tolerable level of blower noise. The drum sheller was installed with bumps using spot welding to improve friction. The total cost of the machine was Php 14,957.61.

Shelling efficiency

The single-pass shelling performance of the sheller was based on the complete removal of the seed coat of jackfruit seeds. Partially removed seed coats were considered unshelled seed coats. Raw jackfruit seeds dried for 3 to 15 hours have shelling efficiencies of 26% and 57%, respectively (Figure 4). A linear increase of 1.5% of shelling efficiency is expected every hour extension of drying time (Table 2). On the other hand, frozen seeds can be shelled at 18% efficiency when dried for three hours. It was observed that a sharp increase of 3.56% hr-1 (Table 2) in shelling efficiency took place when the drying time was extended by another 6 hours, making the shelling efficiency reached 53-57% (Figure 4).

Figure 3. Actual image of the fabricated jackfruit seed sheller

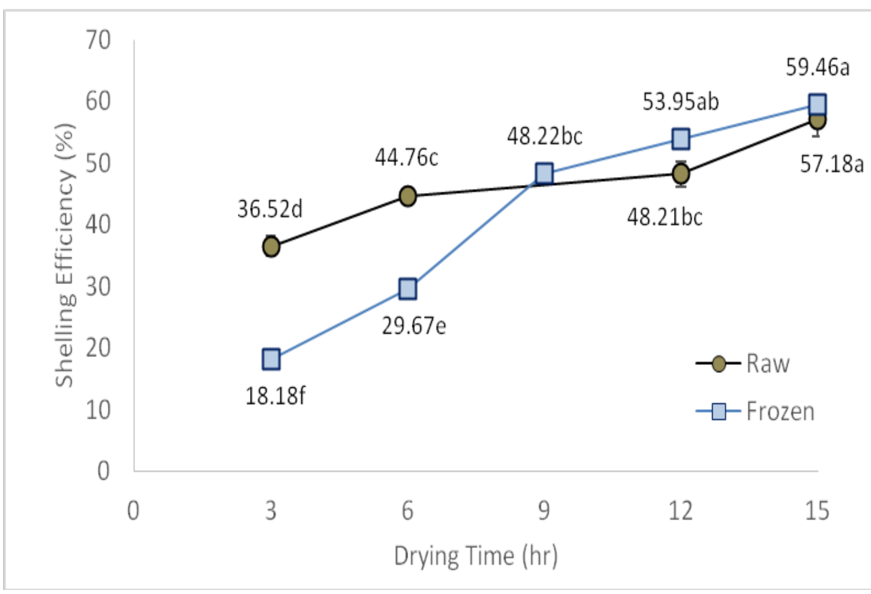

Figure 4. Plot of the shelling efficiency distribution as affected by the length of the drying process

Table 1. Summary of regression analysis of shelling efficiency as a function of drying time for both seed conditions prior to drying

Effects	df	Estimates of Effects	t-value	p-value
		Raw		
Intercept	2	33.234	10.039	0.002
Drying Time	2	1.493	4.587	0.019
R-sqr		0.913		
		Frozen		
Intercept	3	9.845	2.030	0.135
Drying Time	3	3.561	7.306	0.000
R-sqr		0.947		

Shelling capacity

The shelling capacity, ranged from 390 – 420 kg-hr-1, of raw seeds is not affected by the length of drying. On the other hand, frozen seeds had lower shelling capacity at 252 – 335 kg-hr-1 for the next 6 hours and then doubled after 9 hours of drying onwards at 527 – 534 kg-hr-1 (Figure 5).

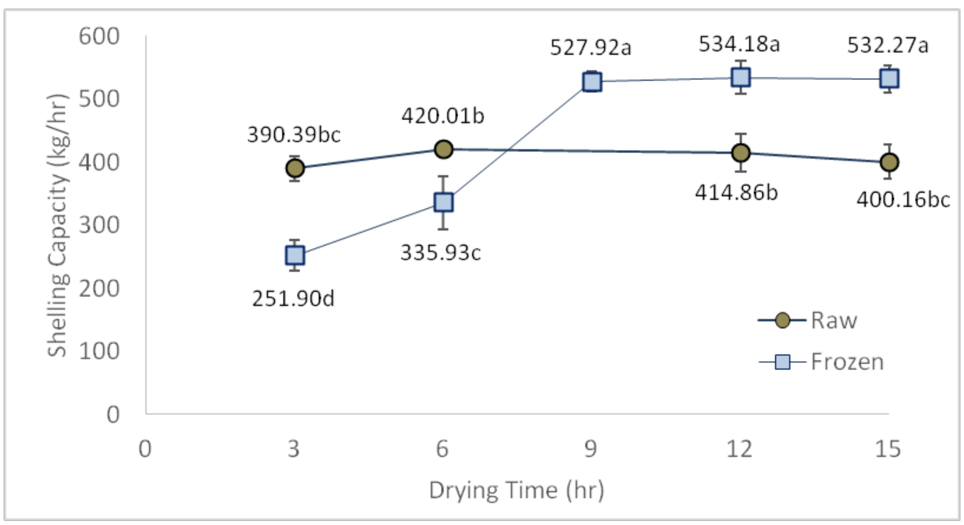

Figure 5. Plot of shelling capacity distribution as affected by the length of the drying process

Shelling injury and separator loss

Shelling is achieved due to the abrasive force of the rotating cylinder. The friction created by abrasion not only will remove the seed coat but could also damage the deshelled seeds. Dried raw seeds acquired more damage per unit weight of cleaned/shelled seeds than seeds initially frozen (Table 2).

Table 2. Summary of shelling injury (%) of the jackfruit seed sheller tested with raw and frozen seeds

Drying Time (hrs)	Seed Condition Before Drying	
	Raw	Frozen Seeds
3	14.37 ± 1.16	2.75 ± 2.47
6	5.96 ± 3.84	---
9	---	---
12	---	---
15	---	---

--- no injury was recorded

Discussion

The strong correlation of drying time and shelling efficiency, with R2 value of 0.913 and 0.947, is due to moisture content removal from the seed coat and the seeds. As drying time lengthens, the seed coat becomes drier and brittle, thus facilitated the efficient shelling effect. A study by Ameru *et al.* (2015) showed that a 3% difference in the moisture content of jatropha kernel leads to a 6% difference in shelling capacity. The initial slow shelling efficiency of frozen seed is due to the slow drying rate of frozen seeds as it first thaws the seed and seed coat before the drying process occurs. However, 9 hours of continuous drying rendered both raw and frozen seeds the same shelling efficiency. That is because, at that time, drying rates of the seed coat of both seeds were independent of the seeds themselves.

The constant shelling capacity of raw seeds dried for different durations, although shelling efficiency is increasing, is attributed to the mass reduction of seeds during the drying process. The volume of seeds cleaned may have increased as drying time increases, but the weight of seeds also gradually decreases. The behavior of frozen seeds was different. The doubling of shelling capacity after 9 hours of drying was attributed to the independent drying rates of the seed coat and the seed endosperm. The thin frozen coat can be easily thawed and dried as it detaches itself from the endosperm. The drier seed coat promoted more efficient shelling, but the colder and thicker endosperm hardly loses water, making it wet and heavy. The wet and heavy shelled seeds lead to higher shelling capacity.

The larger fraction of injuries incurred by raw seeds compared to frozen seeds can be attributed to the quality of the seed flesh during shelling. Although it needs further investigation, as no studies of a similar nature have yet been published, it is presumed that expansion of water within the seeds during freezing and the volume hysteresis of the seed during thawing, respectively, provided greater shrinkage to frozen seeds than that of the raw seeds during drying. Further decrease in volume of the seeds means an increase of the clearance between the seeds and the shelling cylinder; thus, reducing the amount of contact friction between the cylinder and probably leads to less physical injuries of the seeds.

Separator loss of the sheller can be considered insignificant as there was only one recorded event where seeds exited at the shell outlet. This happened during the shelling of the raw seeds dried for 9 hours, which only amounted to less than 0.1% of the feed weight.

The fabricated jackfruit seed sheller can be used more efficiently, 57% - single pass, if the jackfruit seeds are dried for 12-15 hours at 60ºC at around 57%. The single-pass shelling efficiency of the sheller is affected by the initial condition and the length of drying of the seeds. Raw seeds have higher shelling efficiencies at shorter drying times compared to frozen seeds but from 9 hours of drying onward their efficiencies are similar. Shelling efficiency increases with drying time. Raw seeds have a slower increase at 1.5%-hr-1, frozen seeds have a sharp rate of increase at 3.56%-hr-1. The single-pass shelling capacity of the sheller is dependent on the initial condition of the seeds. Raw seeds have a constant shelling capacity of 390 – 420 kg-h-1. Frozen seeds have a shelling capacity of 250-335 kg-hr-1 for the first 6 hours and 527-534 kg-hr-1 onwards.

Acknowledgements

The authors would like to thank the Department of Food Science and Technology at the Visayas State University and Baybay Women's Association Jackfruit Processing Plant for the free and ample supply of jackfruit seeds.

References

Amoah, F. and Bobobee, E. (2018). Development and performance evaluation of a motorized Jatropha curcas seed cracker-winnower. Journal of Agricultural and Biosystems Engineering, 3:103-111.

Ameru, A. K., Adeniyi, A. O. and Fadele, O. K. (2015). Development and performance of a jatropha seed shelling machine based on seed moisture content. Journal of Biosystems Engineering, 40:133-144.

Basalo, J. A. and Lina, D. P. (2020). Enhancing graft-take success in jackfruit (*Artocarpus heterophyllus* Lam.) var. "Eviarc Sweet" seedlings by pre-grafting treatments. Mindanao Journal of Science and Technology, 18.

Braga, J. D., Lauzon, R. D. and Galvez, L. A. (2019). Physicochemical characterization of used coconut oil from vacuum frying of jackfruit (*Artocarpus heterophyllus* lam) pulp EVIARC sweet variety as affected by frying cycle. Philippine Journal of Science, 148.

Department of Agriculture - Bureau of Agricultural Research (2022). BAR intensifies support to jackfruit R&D. Department of Agriculture - Bureau of Agricultural Research. https://bar.gov.ph/index.php/media-resources/news-and-events/150-bar-intensifies support-to-jackfruit-r-d?fbclid=IwAR1JMb_UIW1Sk4lh2NI-fj_HFe7YbpkuP9sKnL3Z sthUpmhKzrB--hhMEIY

Galvez, L. A. and Dizon, E. I. (2017). Physico-chemical and Functional Properties of Two Jackfruit (*Artocarpus heterophyllus* Lam.). Annals of Tropical Research, 39:100-106.

Hettiaratchi, U. P. K., Ekanayake, S. and Welihinda, J. (2011). Nutritional assessment of a jackfruit (*Artocarpus heterophyllus*) meal. Ceylon Medical Journal, 56:54-58.

Ikubanni, P. P., Komolafe, C. A., Agboola, O. O. and Osueke, C. O. (2017). Moringa seed dehulling machine: A new conceptual design. Journal of Production Engineering, 20.

Kheiralla, A. F., Tola, E. H., Korsha, A. N. and Eltigani, A. Y. (2015). Development and evaluation of jatropha seeds sheller for biofuel production. American-Eurasian Journal of Agricultural & Environmental Sciences, 15:630-639.

Lauzon, R. D., Amestoso, F. J. and Galvez, L. A. (2013). Processing of Jackfruit into High Value Food Product. Philippine Council for Agriculture, Aquatic, and Natural Resources Research Development (PCAARRD). (Project Terminal Report).

Lauzon, R. D., Galvez, L. A., Amestoso, F. J. and Vinculado, J. P. (2019). Effects of selected fruit development factors on the quality and acceptability of vacuum-fried EVIARC sweet jackfruit (*Artocarpus heterophylus* Lam.) pulp. Annals of Tropical Research, 41:118-133

Lim, B. Y., Shamsudin, R., Baharudin, B. H. T. and Yunus, R. (2015). A review of processing and machinery for *Jatropha curcas* L. fruits and seeds in biodiesel production: Harvesting, shelling, pretreatment and storage. Renewable and Sustainable Energy Reviews, 52:991-1002.

Orge, R. F. (1982). Construction and evaluation of a hand-operated peanut sheller. (BSAE Undergraduate Thesis). Baybay City, Philippines: Visayas State University.

Orias, R. R. (1980). Design and development of a groundnut sheller. (BSAE Undergraduate Thesis). Baybay City, Philippines: Visayas State University.

Sobowale, S. S., Adebiyi, J. A. and Adebo, O. A. (2016). Design and performance evaluation of a melon sheller. Journal of Food Process Engineering, 39:676-682.

Stephen, A. I. and Lukham, A. A. (2015). The design and construction of a melon shelling machine using locally available materials. International Journal of Engineering Research and Technology (IJERT), 4:311-316.

Swami, S. B., Thakor, N. J., Haldankar, P. M. and Kalse, S. B. (2012). Jackfruit and its many functional components as related to human health: a review. Comprehensive Reviews in Food Science and Food Safety, 11:565-576.

Ting, R. P., Casas, E. V., Peralta, E. K. and Elauria, J. C. (2012). Design, fabrication, and optimization of jatropha sheller. International Journal of Optimization and Control Theories & Applications, 2:113-127.

(Received: 6 August 2024, Revised: 6 May 2025, Accepted: 10 May 2025)