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DEVELOPMENT OF SMALL SOYMILK AND SOYA PANEER MAKERS

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Abstract

Soybean provides a cheaper and protein rich alternative to animal protein. In Bangladesh, utilization of soybean in food items are scarce due to unavailability of suitable processing machines. Soymilk production and pasteurization machines can assist in increasing the human consumption of soybean by making soymilk and soya paneer. Thus, the experiment was conducted during 2019-21 to develop soymilk making machinery to increase consumption of soybean as human foods. Soymilk making machines consisted of a blender and a pasteurizing unit. The holding capacity of the blender and the pasteurizing units were 2 liters and 6 liters per batch, respectively. In the improved model, the operational time of the blender was 15 seconds corresponding to 83.68% blending efficiency to prepare soymilk for each batch. Time for raising the interlayer water temperature up to 100 ºC was 37.67 minutes. The soymilk was prepared within 20 minutes pasteurizing. The soya paneer was prepared and sensory evaluation was done. The panelists showed their satisfactions both on soymilk and soya paneer.

Keywords: Soymilk, Soya paneer, Small machine, Capacity, Efficiency.

Introduction

Soybean holds significant importance globally and within various industries due to its versatility and nutritional value. Soybean production in Bangladesh is relatively low compared to other crops, and the country relies heavily on import of soybean to meet her internal demand. However, during the year 2022, area under soybean production in Bangladesh was 58563 hectares with the production of 98646 metric tons (BBS, 2022). Most of the cultivable soybean varieties are 'BARI Soybean- 5', 'Sohag', 'BARI Soybean-6', and 'Davis' in Bangladesh (Islam and Khatun, 2021). Soybean provides a cheaper and high protein rich alternative substitute to animal protein. The costs and return analysis revealed that soybean production is a profitable enterprise with rate of return of 62% (Salam and Mia, 2013). Important scope for use of soybean in livestock feed has increased the production demand in Bangladesh (Islam and Khan, 2021; Jadhao *et al*., 2020). Alternate use of this nutritive soybean for human consumption could create greater market demand. The regular consumers of dairy milk and its products have reported the increased risk of certain health problems such as cow milk allergy

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which has contributed in the acceptability and popularity of soya milk (Gana and Gbabo, 2017; Gbabo *et al*., 2012; Jinapong *et al*., 2008). Soya milk has social, economic, nutritional and medicinal benefits for its consumers (Amusa *et al*., 2005). Different soya foods like soya milk, soya biscuits, soya chapatti can be prepared from soybean. It has also diabetic, medical, industrial and agricultural importance (Hossain *et al.*, 1992). Soy protein directly lowers serum cholesterol levels. The soy cotyledons store proteins which are important for human nutrition. Soybean contains isoflavones having potential anticancer effects. It contains two primary isoflavones called Genistein and Daidzein and a minor one called Glycitein. They retard bone loss in premenstrual and postmenstrual women, and the soluble fiber in soy foods control blood sugar. Soy foods are quite important to human being as they reduce the risk of heart disease. Regular consumption of soya food delays the process of aging and also improves mental and physical abilities, memory power, and haemoglobin levels of children who have used soy foods, for a long time, as supplementary foods. Soymilk is an aqueous liquid obtained from the extraction of milk from soybean (Afroz *et al*., 2016). The extraction process involves grinding of soaked soybean with water to produce slurry, mixed of the slurry with water in order to separate the milk from chaffs and sieving of the milk from the paste (Gbabo *et al.*, 2012). Soya paneer is known for its extraordinary nutritional benefits, as well as its versatility. Soya paneer is a soft cheese-like food made by curdling soymilk using a coagulant (Raja *et al.*, 2014). Gana and Gbabo (2017) designed, built, and tested a mini soy milk production and pasteurization plant having a capacity of 750 liters in 8 hours of daily operation. Test results showed the blending efficiency was 88.16% and the milk yield was 98.52%. Pasteurization was done at 84 °C for 30 seconds. The machine effectively extended the shelf life of raw soya milk for 24 hours to 48 hours at room temperature and up to 144 hours when refrigerated at 4 ºC. The soya milk is coagulated either by salt or by acid followed by pressing to form soya paneer (Raja *et al*., 2014). Calcium chloride, magnesium chloride, citric acid and acetic acid are the commonly used coagulants. This product came into existence about three decades ago which could be stored up to one year (Banerjee *et al.*, 2019). Waghmare *et al.* (2022) designed and fabricated a soymilk extraction machine with 86.5% efficiency. In Bangladesh, the lack of machinery for processing soybeans into products like tofu and other soy-based foods, aside from oil extraction, presents a notable challenge. This limitation impacts the country's ability to diversify its soybean utilization beyond oil production. Without appropriate processing equipment, Bangladesh may face several implications. Hence, the design of the soymilk production and pasteurization plant would assist in increasing soyabean in human consumption. In Bangladesh, uses of soybean for these food items have limitations due to unavailability of suitable machines. Therefore, the experiment was conducted to develop soymilk and soya paneer making machineries to increase consumption of soybean as human foods.

Materials and Methods

A set of soymilk machine was designed. Some factors were taken into consideration in order to design the machines. The design parameters considered were feed rate, power requirement, shaft speed of the blender, hopper capacity etc. Small prototype of blender was targeted to develop with locally available stainless-steel materials and single- phase electric motor which seems be easily functional by the progressive farmers and small entrepreneurs. The experiment was conducted during 2019-21. A pasteurizing heater is an important part which was designed along with a blender part.

Machine components

A mini plant was constructed using stainless steel materials and it is made of the following components:

i) Blending unit: This unit was made of the sub-component parts like outer casing, hopper, delivery tube, blending chamber, blending blade, shaft, pulley, V-belt and 2200-watt electric motor as shown in Fig. 1. A blender unit were designed and developed for making soymilk. The specification of blender is shown in Table 1. The blender unit was operated with electric motor having 48000 rpm speed. The blender was designed for continuous feeding and operation. Two liters per batch was fed. The weight of the blender unit was 11 kg.

Table 1. Specification of the blender

Parameters	Measurement
Overall dimension	900 ×350 ×350 mm
Dimension of the stand	600 ×350 ×350 mm
Dimension of the blending chamber	300 × 125 × 125 mm
Dimension of the blending blade	80×60 ×30 mm
Speed of the blade	48000 rpm
Source of power	2.2 kW electric motor
Capacity of blender	2 liter/batch
Weight of the blender	11 kg

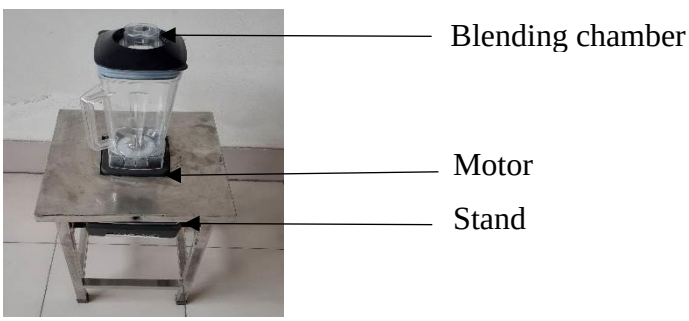

Fig 1. Blending unit for Soymilk making machine.

ii) Pasteurization unit: This unit is made of the following sub-components: inner casing, outer casing (water jacket), milk inlet and outlet valves, water inlet and draining valves, and external casing as shown in Fig. 2.

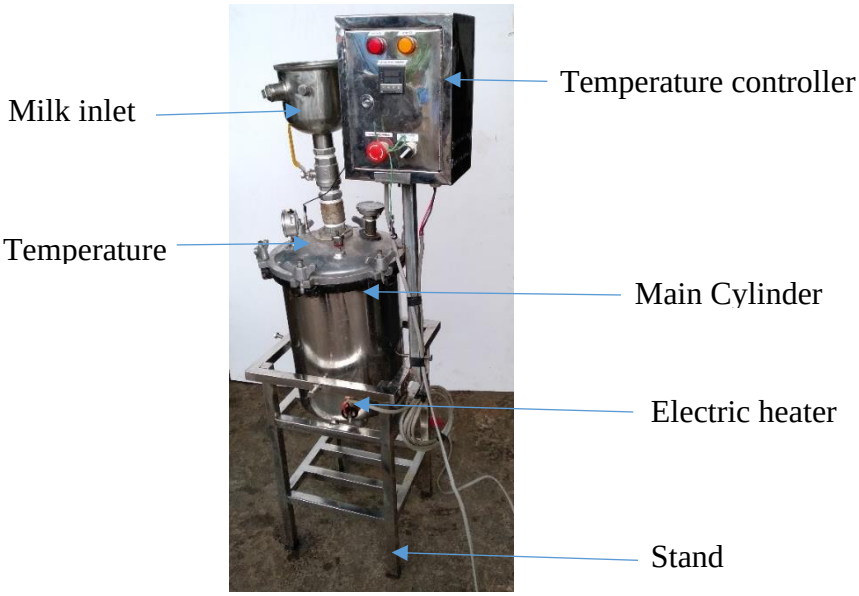

Fig 2. Pasteurization unit for Soymilk making.

The specification of pasteurizing unit of the soymilk blender is shown in Table 2. The pasteurizing unit consisted of two cylinders. The inner cylinder was used to keep soymilk and the outer cylinder for hot water. Capacity of the inner cylinder was 6 liters. The space between the cylinders was filled with water and then it was heated with a 2000-watt heater. The temperature of the water was monitored with a sensor (200±1 ºC) connected to a control box. The weight of the pasteurizing unit was 28 kg.

Table 2. Specification of the pasteurization unit

Parameters	Measurement
Overall dimension	1440 mm ×540 mm ×440 mm
Dimension of the main cylinder	300 Ø ×390 mm
Dimension of the inner cylinder	200 Ø ×230 mm
Dimension of the hopper	140 Ø ×150 mm
Dimension of the stand	600 mm ×380 mm×380 mm
Dimension of the control box	300 mm ×220mm × 180 mm
Capacity of the unit	6 liters
Sensor range	200±1 ºC
Heater load	2000 watt
Weight of the unit	28 kg

iii) **Soya paneer press:** This unit was made of stainless Steel (Fig. 3). Paneer press was made with a round cylinder of 1.6 mm thick sheet with 5 mm stainless steel (SS) plate, 25 mm threaded shaft and other parts of SS. Most of the parts being made of ss steel, the machine required less maintenance. Operation of the unit was easy to give required pressure upon soy paneer. This machine consisted of inbuilt container. It was found an amazing machine with the capacity of making paneer in large quantity. The machine maintained the hygienic condition in retaining the quality of the produced paneer.

Fig 3. Soya paneer press.

Mode of operations of the machines for soya milk

The blending blade was fixed on the vertical shaft inside the blending chamber. Soaked and dehulled grain (400 g sample) of soybean was fed inside the blending chamber. Hot water (5:1=water: soybean) was also added to the soybean (Panchal *et al*., 2014; Rahim *et al*., 2022). The machine was then switched on for blending operation. The milk was poured into the pasteurization chamber from the blending machine. This was the raw soya milk. The water tank was then mounted on the pasteurizing heating machine. The boiling tank was filled with water to the required level. The milk was fed into the machine through the hopper. The temperature of the water was monitored by the temperature gauge. The hot water was hold inside the pasteurizer for the required time (35-38 minutes). The pasteurizer outlet valve was opened for outflow of the milk. The water jacket outlet valve was open for draining of the used water. Performance test of the soymilk was done at FMP Engineering Divisional workshop, BARI, Gazipur.

Preparation of Soybean Milk

'BARI Soybean-5' was taken for this experiment. Ten kilograms of whole soybeans were washed and soaked in water (1:3) at room temperature (20±5 ºC)

for 10 hours in normal water. Then the husks were separated from the beans by pressing the beans followed by washing with water. The beans were then ground in blender for different time spans. The ratio of beans to water was 1:5 (w/v) (Panchal *et al*., 2014). The resulted suspension was filtered. Then the suspension was inserted into the pasteurization unit. The outer temperature was more than 100 ºC and inner temperature was 100 ºC. The liquid was kept for 20 minutes in the pasteurization chamber (Chan, 2023; Saini and Morya, 2021; Giri and Mangaraj, 2012). Hot suspension was then allowed to drain out through the outlet and it was then cooled down to become soymilk. The process of soymilk preparation is presented in Fig. 4 through a flow chart.

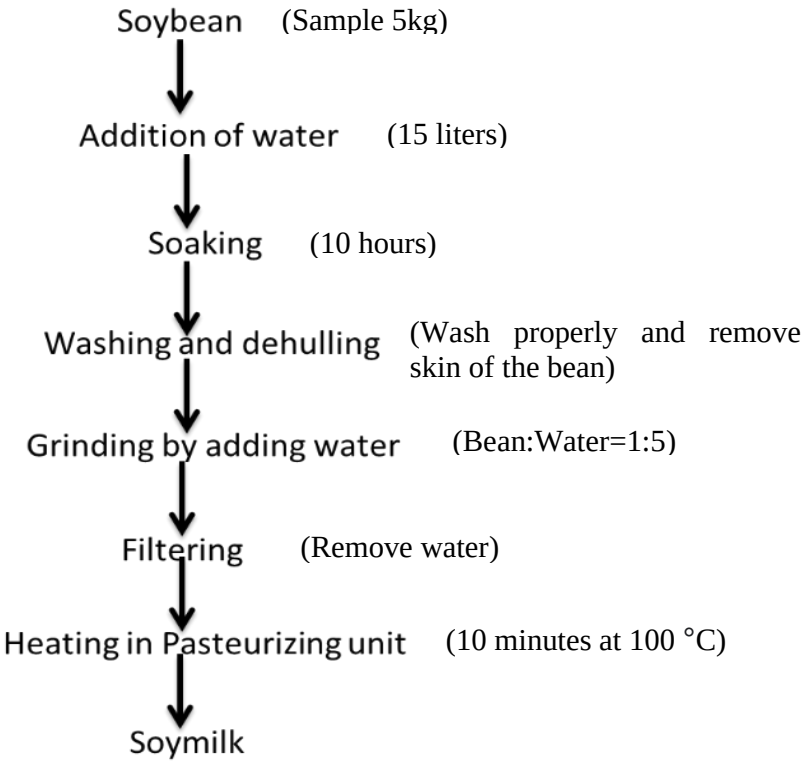

Fig 4. Flow chart for soymilk production.

Determination of machine blending efficiency

This is the measure of the degree by which the grains are reduced in size and was determined by Equation as reported by Nwaigwe *et al.* (2012).

$$E_B = \frac{A}{MT} \times 100 \quad (1)$$

where, E_B is the blending efficiency (%), A is the amount of the material passed through the sieve (kg) and MT is the total weight of the material fed into the machine (kg)

Preparation of Soya paneer

After preparing soymilk, when the soybean temperature of milk increased to 70-80 ºC, citric acid (1%) was mixed with soybean milk and stirred 1-2 times. The stirring operation was done continually with some intervals. Within 15-20 minutes the milk started coagulating and water became separated from it. However, in case of delayed or no coagulation, some more citric acid solution was added to speed up the action. The coagulated milk was separated instantly, else the tofu would not get soft. Once the milk and the water separated, a clean cloth was spread over a strainer and the milk was poured on it. Tofu was collected on the cloth and the water was strained down into the bowl when pressed with the soya paneer pressing device. Good quality soft tofu was found after pressing and waiting for 30-40 minutes. The tofu inside the cloth was freezed and it was then ready for use to make various dishes. The prepared soya paneer was evaluated by sensory evaluation. Ten panelists evaluated the soya paneer.

Sensory evaluation

The sensory attributes were performed based on the procedure of Joshi (2006) and Khan *et al.* (2021). It was performed using a 9- point hedonic scale, i.e. 9= Like extremely, 8= like very much, 7= Like moderately, 6= Like slightly, 5= Neither like or dislike, 4= Dislike slightly, 3= Dislike moderately, 2= Dislike very much and 1=Dislike extremely. Sensory quality attributes like colour, flavour, taste, texture, hardness and overall acceptability were evaluated by an expert sensory panelist.

Economic analysis

Economic analysis of the soymilk maker was done. Cost analysis included the operating cost of the machine. Operating cost of the machine included the fixed cost and variable cost. Fixed of the machine included capital consumption. Variable costs included labour, electricity, repair &maintenance. Three labour was required for operating the machine.

Fixed cost

Fixed cost of the machine included annual depreciation, interest on investment. Capital consumption included depreciation and interest.

i) Capital consumption (CC)

$$CC = (P - S)CRF + S \times i \qquad (2)$$

Where,

P=Purchase price, Tk

S=Salvage value, Tk

CRF= Capital recovery factor

$$CRF = \frac{i(1+i)^L}{(1+i)^L - 1} \quad (3)$$

Where,

i= Rate of interest

L=Life of machine, yr

ii) Shelter, T=3.0% of purchase price of the machine, Tk (4)

iii) Repair and Maintenance cost, M= 3.5% of purchase price of the machine, Tk (5)

Total fixed cost per year

$$FC = CC + T + \text{M} \quad (6)$$

Variable Cost

In calculation of variable cost, the following relations were assumed

i) Labour cost per hour, L_b=Tk man-h^{-1}

ii) Electricity cost per hour, E=Tk h^{-1}

Total variable cost

$$VC = L_b + E \quad (7)$$

Operating cost

$$AC = FC + VC \quad (8)$$

Results and Discussion

Performance of blender for soaked soybean sample is shown in Table 3. Blending efficiency varied with the operating time. But the incremental rate of the blending efficiency was nearly static (83.68% - 83.74%) after 15-35 seconds operation. So, the operational time 15 seconds was selected with 83.68% blending efficiency to prepare soymilk for each batch. Thus, the capacity of the blender was 4 l/m considering 15 second blending time and 15 second discharge time.

Table 3. Performance of blender for soaked soybean

Operating time, Sec.	Blending efficiency (%)
10	75.29
15	83.68
20	83.68
25	83.74
30	83.74
35	83.74

Performance of pasteurizing unit for soymilk making is shown in Table 4. The average time for heating the interlayer water up to 100 ºC was 37.67 minutes. Time for raising the milk temperature up to 100 ºC was 05 minutes. Water temperature was 5-10 ºC higher than the soymilk temperature. The soymilk was prepared with 20 minutes pasteurizing. Then the same was drained out from the pasteurizing unit as shown in Fig 5. Thus, the capacity of the pasteurizing unit was 18 l/h.

Table 4. Performance of pasteurizing unit for soymilk making

Trial No.	Inter layer water volume, liter	Time for heating the interlayer water up to 100 ºC, minutes	Amount of milk, liters	Time for getting milk temperature 100 ºC, minutes	Pasteurizing time for each batch, minutes	Temperature, ºC	
						Milk	Inter layer water
01	8	38	4.5	05	20	100	108
02	8	38	4.5	05	20	100	110
03	8	37	4.5	05	20	100	110
Average	8	37.67	4.5	05	20	100	109.33

Fig 5. Prepared soymilk.

Fig 6. Pictorial flow chart of preparing soya paneer.

Soya paneer was prepared (Fig. 6) and sensory evaluation was done. The sensory evaluation results are shown in Table 5. The sensory evaluation showed encouraging feedback by the panelists. Overall acceptability was evaluated by the expert sensory panelists. The average score obtained by the panelist was indicating that the soymilk and soya paneer were liked very much.

Table 5. Sensory evaluation of soymilk and soya paneer

	Colour	Flavour	Taste	Texture	Hardness	Overall acceptability
Milk	8.14	7.43	7.86	8.71	-	Like very much (8.04)
Soy paneer	7.50	7.58	7.75	8.75	8.50	Like very much (8.02)

Financial Analysis:

Economic analysis of the soymilk making machinery is shown in Table 6. The operating cost of the machine is 499062.23 Tk/year, respectively among which fixed cost is 19787 Tk/year and variable cost is 479275 Tk/year. Net return of the soymilk maker is 1008000 Tk/year. The BCR of the machine is 2.02.

Table 6. Economic analysis of the soymilk making machinery

Price of the machine, Tk	75000
Salvage value (10% of P), Tk	7500
Bank interest, i= 10%	0.1
Life, year	5
Capital recovery factor, CRF	0.26
Fixed cost, Tk/year	19787.23
Labour required, Person/day	3
Labour charge, Tk/day	600
Labour cost, Tk/year	60000
Working days, day/year	100
Working hour, h/day	8
Electricity cost, Tk/year	14400
Repair & maintenance, Tk/year	2625
Shelter cost, Tk/year	2250
Raw Soybean price (5kg/h and 100 Tk/kg), Tk/year	400000
Variable cost, Tk/year	479275
Total operating cost, Tk/year	499062.23
Soymilk making capacity, L/h	18
Wholesale price of soymilk, Tk/L	70
Net return, soymilk, Tk/yr	1008000
Benefit-cost ratio	2.02

Conclusion

A blender was developed for making soymilk. Holding capacity of the blender and pasteurizing unit was 2 liters and 6 liters, respectively. The operational time 15 seconds was selected with 83.68% blending efficiency to prepare soymilk for each batch. The soymilk was prepared with 20 minutes pasteurizing. The soya paneer was prepared and sensory evaluation was done. The panelists showed their satisfaction on soymilk and soya paneer. The colour, flavour, taste, and texture were reported good enough for the product. The machines and the production technologies for soymilk and soya paneer preparations can be recommended for small entrepreneurs in Bangladesh.

References

Afroz, M. F., W. Anjum, M. N. Islam, M. A. Kobir, K. Hossain, A. Sayed. 2016. Preparation of soymilk using different methods. *J. Food Nutri. Sci*. **4** (1): 11-17. [doi: 10.11648/j.jfns.20160401.13]

Amusa, N. A., O. A. Ashaye, A. A. Aiyegbayo, M. O. Oladapo, M. O. Oni, and O. O. Ajolabi. 2005. Microbiological and nutritional quality of hawked sorrel drinks (soborodo) (the Nigerian locally brewed soft drinks) widely consumed and notable drinks in Nigeria. *J. Food Agric. Envir*. **3**(3-4): 47–50.

Anonymous. 2022. Statistical Yearbook of Bangladesh 2021, Bangladesh Bureau of Statistics (BBS), Statistics Division, Ministry of Planning, Government of People's Republic of Bangladesh, Dhaka. P. 133.

Banerjee S., R. Pandey, T. Gorai, S. L. Shrivastava and S. Haldar. 2019. Review on Soy Milk and Other Soy Milk Based Products. *Int. Res. J. Food Nutri*. **1** (1): 1-6. [https://scirange.com/pdf/irjfn.2019.1.5.pdf]

Chen L. 2023. Beverages and health. Encyclopedia of Human Nutrition (Fourth Edition). 2:276-284 [https://doi.org/10.1016/B978-0-12-821848-8.00113-X]

Gana, I. M., and A. Gbabo, 2017. Design of mini plant for soya milk production and pasteurization. *Agril. Eng. Int.: CIGR J*. **19**(4): 45–53.

Gbabo, A., I. M. Gana and S. M. Dauda. 2012. Effect of blade types on the blending efficiency and milk consistency of a grains drink processing machine. *Aca Res. Int.* **2**(3): 41–49.

Giri, S. K. and S. Mangaraj. 2012. Processing influences on composition and quality attributesof soymilk and its powder. *Food Eng. Rev*. **4**(3):149-64.

Hossain, M. I, M. A. Matin, M. S. Alam and M. Ahmed. 1992. Socio-economic study of soybean in some selected areas of Bangladesh. *Bangladesh J. Argi. Res.* **17**(1): 7-12.

Islam M. R. and H. Khatun. 2021. Problems and prospects of soybean production in Bangladesh. *Ann. Bangladesh Agric*. *25* (2): 97-104. [www. doi .org /10.3329 /aba .v25i2.62416]

Jadhao, A. B., S. M. Bhalerao, A. V. Khanvilkar, V. R. Patodkar, A. Y. Doiphode, S. N. Jadhav and M. N. Rangnekar. 2020. Replacement of maize with soybean hulls in concentrate mixture on nutrient digestibility and haemato-biochemical parameters of growing goats. *Haryana Vet.* **59**(1):135-136.

Jinapong, N., M. Suphantharika, and P. Jamnong. 2008. Production of instant soymilk powders by ultrafiltration, spray drying and fluidized bed agglomeration. *J. Food Eng*. **84**(2): 194–205.

Joshi, V. K. 2006. Sensory Science: Principles and Application in Food Evaluation. Agrotech Publish Academy, Jaipur (India).

Khan, M. H. H., M. M. Molla, A. A. Sabuz, M. G. F. Chowdhury, M. Alam and M. Biswas. 2021. Effect of processing and drying on quality evaluation of ready-to-cook jackfruit. *J. Agril. Sci. and Food Tech.* **7** (2):19-29.

Panchal, I, D. K. Sharma and K. Nagajjanavar. 2014. Optimization of process parameters in Soymilk for maximum production and quality by manufacturing unit. *Annals of Agri-Bio Res.* **19**(2):304-307.

Rahim, A, M. A. Islam, A. Iqbal, F. Akter and M. A. R. Mazumder. 2022. Effect of soymilk on the nutritional, textural and sensory quality of pudding. *J. Bangladesh Agril. Univ.* **20**(3): 304–312.

Raja, J., H. A. Punoo and F. A. Masoodi. 2014. Comparative study of soya paneer repared from soymilk, blends of soymilk and skimmed milk. *J. Food Process. & Tech.* **5**:2: 1-2. [DOI: 10.4172/2157-7110.100030]

Saini, A. and S. Morya. 2021. A Review based study on soymilk: Focuses on production technology, prospects and progress Scenario in last decade. *The Pharma Innovation J.* **10**(5): 486-494 https://doi.org/10.22271/tpi.2021.v10.i5g.6254

Salam, M. A. and M. A. M. Miah. 2013. Socio-economic assessment of oilseed crops production in Bangladesh. *Ann. Bangladesh Agric*. **17**(1&2): 241-262.

Waghmare A., P. Dekate, H. Kamble, Y. Dharmik. and A. Umarkar. 2022. Design and fabrication of soya milk extracting machine. e-ISSN: 2582-5208 *Int. Res. J. Moder. in Eng. Tech. Sci.* .**4** *(5): 1-5.* [https : // www . irjmets .com /uploadedfiles/paper /issue_5_may_2022/24499/final/fin_irjmets1653906688.pdf*]*