International Journal of General Engineering and Technology (IJGET)
ISSN(P): 2278–9928; ISSN(E): 2278–9936
Vol. 10, Issue 1, Jan–Jun 2021; 57–64

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

DESIGN AND DEVELOPMENT OF FRUITS AND VEGETABLES PROCESSING EQUIPMENTS

Ramya V

Research Scholar, Processing and Food Engineering, CTAE, MPUAT, Udaipur, India

ABSTRACT

Fruits and vegetables processing equipments are very well used and needed for every type of industry nowadays. Processing of the fruits and vegetables is important for their use for direct consumption or as a food ingredient. During processing, the emphasis is there on preserving the color, taste, texture and nutrition of the food product with improvement in its shelf life. Some of the basic processes used in the processing industry are grading, freezing, washing, peeling, slicing, size sorting and reduction, canning, packaging, dehydration etc. In the selection of the processing method that can be used in a particular situation, the type of produced outcome, the cost associated with it and the market demand of the produce, all are considered. Hence, the aim of the present paper is to study and analyze the factors that play a crucial role in designing and development of different equipments that can be used for the processing of fruits and vegetables of different types and for different applications.

KEYWORDS: *Fruits, Vegetables, Processing Equipments, Shelf Life, Produced Outcome, Cost Associated, Market Demand*

Article History

Received: *28 May 2021* | ***Revised:*** *29 May 2021* | ***Accepted:*** *01 Jun 2021*

INTRODUCTION

The major horticulture products i.e. fruits and vegetables, along with being consumed raw, can also be used as ingredients for subsequent food processing operations. The quality of the food products obtained after processing depends significantly on the type of processing equipment being used. Due to the variety of processing methods and food products, many different specialized unit operations have been developed overtime in the food processing industry. So, an ample choice is available in the food processing equipments in the market both for the application of small as well as large industries (Terefe et. al, 2014).

During processing, the main aim of the process is always to preserve the color, flavor, texture and nutritional value of the food material that is being processed in any way, improving its time till which it can be stored and used (Saravacos et. al, 2002). While making the selection of the processing method, the factors that are considered are:

- Type of the final product expected or required.
- Cost associated with the implementation of the method.
- Demand of processed product in the market.

Some Basic Processes for Fruits and Vegetables:

- Peeling
- Slicing
- Size reduction
- Size sorting
- Washing and cooling treatments
- Dehydration
- Freezing
- Canning etc.

The processed foods usually go through one or many independent unit operations for food processing before becoming the final product for consumption (Gomez et. al, 2011). With fast modernization in the technologies, more specialized and technically advanced equipments can be designed that can also perform multi-unit operations, thus enhancing their performance.

Some of the advanced technologies that are used in different types of processing of fruits and vegetables (Martin-Belloso et. al, 2010) are:

- High pressure processing (HPP)
- Electrical impedance spectroscopy (EIS)
- Vacuum frying
- Hurdle technology
- Ohmic heating and others.

The deployment of any of these technologies depends solely on the above mentioned factors both in the large scale as well as small scale or home based industries.

LITERATURE REVIEW

Dar et. al (2020) in their research analyzed various methods for processing fresh fruits and vegetables that will be helpful to retain the quality parameters of the product. Some of them include washing the sample with hydrogen peroxide, organic acids, ozone and warm water. Also, use of anti-microbial edible coatings and controlled environment for packaging has increased the shelf life of fruits and vegetables. But loss of nutritional value undoubtedly takes place during processing and storage of fresh fruits and vegetables. Hence, need is there to design and develop food processors so as to retain the nutritional, organoleptic and shelf-life stability of FFVs.

Sarkar et. al (2019) in their study listed out the different processing methods and equipments that are being used by the small scale industries. Some of the common processing methods used by the handlers of the small scale enterprises include drying, juicing, freezing, pickling in acid or salt, canning, bottling etc. Many types of equipment based on different

technologies are available in the market for the same intended task. Their choice depends entirely on the type of the outcomes desired from the sample and the involved budget of the enterprise.

Lok et. al (2013)developed an integrated grating and slicing machine for the starchy vegetables like potatoes, lentils etc. The purpose of this machine was to increase the productivity by reducing the cost, time and number of independent unit operations. The final design of machine was found to have the production range of 750 to 1200 kgs per hour for grating and 250 to 400 kgs per hour for slicing.

Londhe et. al (2013) in their study reviewed different methods of grading for fruits and vegetables. In India, most of the fruit growers carry out the process of grading manually. But it was costly and was affected by outside factors like shortage of labor in peak season. Also, it was considered to be inconsistent, less efficient and more time consuming. So, now the farmers are looking forward to machines that can alleviate the labor shortage, save time and improve the quality of the graded product. The variation in sizes of the fruits and vegetables demands for grading based on size, which consists of divergent roller type principle having parts of the equipment for inclination type graders.

Sonawane et. al (2011) designed and developed a power operated banana slicer for small scale food processing enterprises. It was developed based on the engineering properties of different varieties of banana, namely Nendran and Dwarf Cavendish. The slicer was found to have a slicing efficiency of about 94 % with an effective capacity of about 100 kgs per hour. The sliced product had a mean thickness of about 2 mm and mean roundness was about 0.84 and 0.70 for both the varieties.

MATERIALS AND METHOD

The present paper is a quantitative research for which the information has been gathered from studies of different authors like Londhe et. al (2013), Sonawane et. al (2011), Martin-Belloso et. al (2010), Evrendilek et. al (2012), Dar et. al (2020) etc.

For the process of slicing, some independent and dependent variables are there which act as parameters to test the design of a particular machine.

- **Independent Variables:** Type of material to be sliced and Revolutions per minute (RPM).
- **Dependent Variables:** Capacity of machine, breakage percentage, slicing efficiency, Mechanical loss, Performance efficiency, Roundness index, Effective capacity etc.

Here we have taken one such method of processing of bananas i.e. the battery operated banana slicer. The average capacity requirement for any small scale manufacturer is about 80 kg per hour. Hence, the rotary banana slicer is so developed for the intended purpose. On the basis of engineering properties of banana, the major components of the slicer device are follows (Sonawane et. al, 2011):

- **Feeder Assembly:** Consisting of feeding chute, push plate, its attachments and push rods. 6-9 bananas can be accommodated at a time with the length of the feeding chute to be 350 mm and that of push rod to be 230 mm.
- **Cutter Assembly:** Consisting of cutter plate, blades and ledger plates. Blades are made up of stainless steel for more hygiene. The length of the blade to be 115 mm and its thickness as 3 mm.
- **Power Transmission Assembly**
- **Prime mover:** Powered by 0.373 kW single phase electric motor.

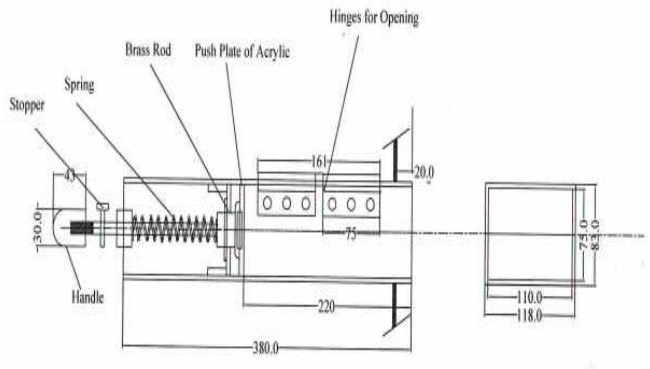

Figure 1: The Dimensional Details of the Feeder of Banana Slicer.

RESULTS AND DISCUSSION

The device works well for the two known varieties of the banana i.e. the Nendran and the Dwarf Cavendish. The efficiency of the developed power operated rotary banana slicer has been calculated using following equations:

- **Slicing Efficiency:** The efficiency of slicing of a machine can be determined in percent using the following expression (Sonawane et. al, 2011):

$$Slicingefficiency = \frac{W_T - W_d}{W_T} x\ 100$$

Where, W_T is the mass of total slices and W_d is the mass of damaged slices in kg. The banana slicer was found to have the efficiency of 93-94 % with the machine speed of 360 rpm.

- **Capacity of the Machine:** The operating capacity is the amount of slices produced per hour by the machine. It includes the time for feeding, compressing and cutting as well. Also, the effective capacity of the machine can be calculated using the expression (Sonawane et. al, 2011):

$$Effectivecapacity, kg/\square = \frac{OCxslicingefficiency}{100}$$

Where, OC is the operating capacity in kg/h and slicing efficiency is in per cent. The banana slices of our study has a working capacity of about 100 kg/hour with the 3-blade cutter made of stainless steel and best suited for the requirements of small scale processing industry.

- **Roundness Index:** This index defines the sharpness of the irregular shaped solid material and is used for the round-shaped slices only. It can be calculated using the expression (Sonawane et. al, 2011):

$$Roundness = \frac{A_p}{A_c}$$

Where A_p is the largest projected area of the particle and A_c is the area of the smallest circumscribed circle in m^2.

In our case, the chip size with average roundness of 0.84 and 0.70 for Nendran and the Dwarf Cavendish respectively is obtained at moderate operating speed.

Also, it has been seen that the thickness of the slice affects the quality of the chip produced; which is found to be uniform for both the varieties with maximum deviation of ±0.2 mm. On the financial analysis of all the machinery parts and the raw materials used, the overall cost of developed banana slicer was found to be more economical and efficient than the others.

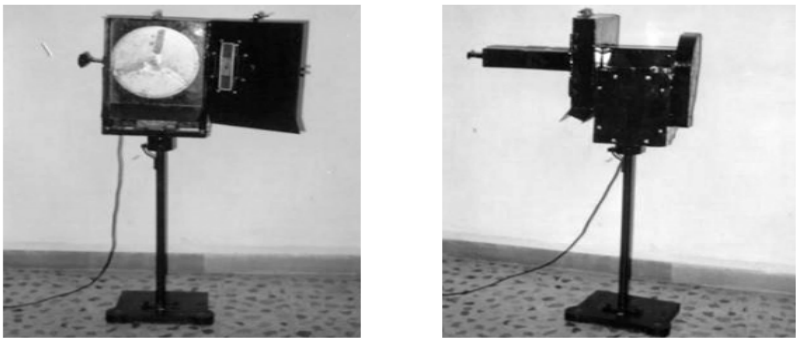

Figure 2: Banana Slicer Front and Side View.

CONCLUSIONS

In the changing scenario and with the consumer becoming more aware and demanding towards the products for their consumption and use, even the fruits and vegetables need a fair amount of processing which can be in any form, may be its grading, peeling, slicing, canning, sorting or any other. Processed foods have got an edge over the raw ones in terms of demand and value in the market. So, it is very important to design and develop processing equipments wisely so that maximum returns can be achieved out of them with minimum investment in terms of operating capacity, processing efficiency and cost associated with it so that the intended objective of the industry can be achieved to move hand in hand with the current times.

REFERENCES

1. *Londhe, D.H., Nalawade, S.M., Pawar, G.S., Atkari, V.T. and Wandkar, S.V., 2013. Grader: A review of different methods of grading for fruits and vegetables. Agricultural Engineering International: CIGR Journal, 15(3), pp.217-230.*
2. *Sonawane, S.P., Sharma, G.P. and Pandya, A.C., 2011. Design and development of power operated banana slicer for small scale food processing industries. Research in Agricultural Engineering, 57(4), pp.144-152.*
3. *Saravacos, G.D. and Kostaropoulos, A.E., 2002. Handbook of food processing equipment (pp. 331-381). Kluwer Academic/Plenum.*
4. *Martin-Belloso, O. and Fortuny, R.S., 2010. Advances in fresh-cut fruits and vegetables processing. CRC press.*
5. *Gómez, P.L., Welti-Chanes, J. and Alzamora, S.M., 2011. Hurdle technology in fruit processing. Annual Review of Food Science and Technology, 2, pp.447-465.*
6. *Terefe, N.S., Buckow, R. and Versteeg, C., 2014. Quality-related enzymes in fruit and vegetable products: effects of novel food processing technologies, part 1: high-pressure processing. Critical reviews in food science and nutrition, 54(1), pp.24-63.*
7. *Evrendilek, G.A., Baysal, T.A.N.E.R., Icier, F.İ.L.İ.Z., Yildiz, H., Demirdoven, A. and Bozkurt, H., 2012. Processing of fruits and fruit juices by novel electrotechnologies. Food Engineering Reviews, 4(1), pp.68-87.*
8. *Shirmohammadi, M., Yarlagadda, P., Kosse, V. and Gu, Y., 2012. Study of mechanical deformations on tough skinned vegetables during mechanical peeling process (A Review). GSTF Journal of Engineering Technology, 1(1), pp.31-37.*

9. *Farahnaky, A., Azizi, R. and Gavahian, M., 2012. Accelerated texture softening of some root vegetables by ohmic heating. Journal of Food Engineering, 113(2), pp.275-280.*

10. *Sarkar, B., Sundaram, P.K. and Anurag, A.P., 2019. Processing Equipments for Small Scale Processing Enterprises. ICAR Research Complex for Eastern Region, p.99.*

11. *Dar, A.H., Bashir, O., Khan, S., Wahid, A. and Makroo, H.A., 2020. Fresh-cut products: Processing operations and equipments. In Fresh-Cut Fruits and Vegetables (pp. 77-97). Academic Press.*

12. *Lok, C.Y., Mazlina, M.S. and Tuah, B.H., 2013. Development of an integrated grating and slicing machine for starchy vegetables. Journal of Food, Agriculture & Environment, 11(1), pp.141-145.*

13. *Murdia, L.K., Wadhwani, R., Wadhawan, N., Bajpai, P. and Shekhawat, S., 2016. Maize utilization in India: an overview. American Journal of Food and Nutrition, 4(6), pp.169-176.*

14. *Shekhawat, S., Rathore, N.S. and Kaushik, R.A., 2014. Advances in processing and product development of aonla (Emblica officinalis) in Indian context-A review. International Journal of Food and Nutritional Sciences, 3(6), p.242.*

15. *Tanwar, S., Jain, S.K. and Rathore, N.S., 2019. Hygienic design and fabrication of vegetable slicer cum shredder. In International conference on recent trends in agriculture, food science, forestry, horticulture, aquaculture, animal sciences, biodiversity and climate change (pp. P5-11).*

16. *Tanwar, S., Jain, S.K. and Rathore, N.S., 2019. Multipurpose vegetable slicer cum shredder.*

17. *Shekhawat, S., Jain, S.K. and Rathore, N.S., 2017. Development of multipurpose vegetable slicer cum shredder. Research journal of agricultural sciences, 8(3), pp.678-680.*

18. *Shekhawat, S., Jain, S.K. and Rathore, N.S., 2017. Design of multipurpose slicer-cum shredder for production of potato (Solanum tuberosum) chips. Green Farming, 8, pp.1370-1375.*

19. *Shekhawat, S., Jain, S.K. and Rathore, N.S., 2016. Cucumber (cucumis sativus) Slicing Through Multipurpose Vegetable Slicer cum Shredder. Biotech Today: An International Journal of Biological Sciences, 6(2), pp.68-70.*

20. *Tanwar, S., Jain, S.K. and Rathore, N.S., 2021. Evaluation of techno-economic feasibility of the developed multipurpose vegetable slicer cum shredder.*

21. *Tanwar, S., Jain, S.K. and Rathore, N.S., 2021. Performance evaluation of slicer cum shredder for commercialization.*

22. *Kumari, K., Srivastava, H. and Shekhawat, S., 2015. Ohmic heating: an alternative food processing technology. Trends in biosciences, 8(8): pp 2002-07.*

23. *Shekhawat S., Jain S. K. and Meena A., 2015. Foam mat drying characteristics of fruits: A review. Trends in Biosciences, 8(8): pp 1997-2001.*

24. *Murdia, L. K., Wadhawan, N., Shekhawat, S. and Bajpai, P., 2016. Evaluation of textural properties of qpm based puffed corns. Advances in life sciences, 5(20): pp 9465-74.*

25. *Shekhawat S. and Jain S. K., 2016. Effect of various foaming agents in foam-mat drying of pineapple juice. Advances in life sciences, 5(2): pp 667-677.*

26. *Shekhawat S., Jain S. K. andRathore, N. S., 2016. Optimization of egg albumin concentration in FMD of pineapple juice. Green Farming. 7(6): 239-242.*
27. *Shekhawat S., Jain S. K. andRathore, N. S., 2017. Evaluation of nutritional and organoleptic parameters of foam-mat dried pineapple powder. Green Farming, 8(2): 238-243.*
28. *Shekhawat S. and Kumari K., 2013. Role of food safety in developing quality of food products. Food safety and recent trends in dairy and food industry, 34-40.*
29. *Shekhawat S., Rathore, N. S. and Singhal A., 2013. Studies on shelf life of bread. New vista in food processing with quality assuarance for augmenting rural prosperity.*
30. *Shekhawat S., Rathore, N. S., Mudgal V. D. and Jain S. K., 2013. Quality tests for foam-mat dried pineapple powder. New vistas in food processing with quality assurance for augmenting rural prosperity.151-154.*
31. *Shekhawat S. and Chandaliya K., 2014. Efficiency enhancement of coal and oil fire boiler. Recent advances in wireless communication & artificial-intelligence, 93.*
32. *Shekhawat S. and Chandaliya K., 2014. Advancement in refrigeration: A review. Recent advances in wireless communication & artificial-intelligence, 114.*
33. *Shekhawat S., Rathore, N. S., Mudgal V. D. and Jain, S. K. 2014. Quality tests for Foam-mat dried Pineapple Powder. 48thAnnual convention of Indian society of agricultural engineers (ISAE) and Symposium on engineering interventions in conservation agriculture. 11.*
34. *Shekhawat, S., Rathore, N. S. and Singhal, A. 2014. Quality assurance of yeasted bread on the basis of mold growth. 48thAnnual convention of Indian society of agricultural engineers (ISAE) and Symposium on engineering interventions in conservation agriculture. 57.*
35. *Shekhawat, S., Rathore, N. S. and Kaushik R. A., 2014. Advances in processing and product development of Aonla in Indian context- A Review. 5th International conference on Advances in food technology and health sciences, 35.*
36. *Shekhawat, S., Jain S. K. and Bajpai P., 2015. Effects of parameters on grain quality in storage: an overview. Second international conference on bio-resource and stress management, 425.*
37. *Bajpai P., Mogra R., Shekhawat, S., 2015. Blending of oil: Benefits and future projections 17th Indian Agricultural Scientists & Farmers' Congress on Agri-Innovation for Enhancing Production & Rural Employment, 33.*
38. *Shekhawat, S. and Bajpai P., 2015. Processing of dairy products for rural employment. 17th Indian Agricultural Scientists & Farmers' Congress on Agri-Innovation for Enhancing Production & Rural Employment, 11.*
39. *V. Ramya, Jain N.K., V. Lavanya and Shekhawat S., 2016. Application of membrane separation technology in food processing industry. National conference on food processing and technology. 112-113.*
40. *Shekhawat S., Murdia L. K., Wadhawan N. and Bajpai, P., 2016. Impact of high pressure processing: recent scenario of food industry. National conference on food processing and technology. 120.*

41. *Shekhawat S., Murdia L. K., Wadhawan N. and Bajpai, P., 2016. Enhance consumer acceptability of quality protein maize. International conference on recent advances in food processing and biotechnology. 254-255.*

42. *Bajpai, P.,Murdia L. K., Wadhawan N., Shekhawat S., Singh M., 2016. Evaluation of nutritional and organoleptic parameters of quality protein maize flour based nankhatai. International conference on growing trends in food technology nutrition for public health care. 16.*

43. *Shekhawat S.,Wadhawan N., Murdia L. K. and Bajpai, P., 2016. Technological development of QPM based coconut cookies. International conference Agricultural Sciences and food technologies for sustainable productivity and nutritional security. 47.*

44. *Murdia, L. K., Wadhawan, N., Bajpai, P. and Shekhawat, S., 2016. Value addition in maize. 5th National seminar proceedings on coarse cerals development-Challenges & opportunities in the country, 55-58.*

45. *Tanwar S., Jain, S. K. and Rathore, N. S. 2019. Multipurpose vegetable slicer cum shredder. Lambert academic publishing (International book market service Ltd.,). 978-613-9-46454-8.*

46. *Tanwar S., Jain, S. K. and Rathore, N. S. 2019. Handbook on foam-mat drying. Satish Serial Publishing House. 978-93-88020-00-0.*

47. *Tanwar S., Jain, Mudgal V. D. and Jain S. K., 2020. Manual of Dairy Engineering. Satish Serial Publishing House. 978-93-88892-95-7.*

48. *Tanwar S., Mudgal V. D. and Meena K. K., 2019. Manual of Dairy Process Engineering. Satish Serial Publishing House. 978-93-88889-00-1.*

49. *Neelam Rathore, N. L. Panwar, Amor Gama & Fatiha Yettou (2019) Solar map of India under clear sky conditions, International Journal of Sustainable Energy, 38:5, 415-446, DOI: 10.1080/14786451.2018.1527334*

50. *Rathore N, Panwar NL. Strategic overview of management of future solar photovoltaic panel waste generation in the Indian context. Waste Management & Research. April 2021. doi:10.1177/0734242X211003977*

51. *Kirtika Sharma, Surendra Kothari, N. L. Panwar & Neelam Rathore (2020) Design and development of solar energy powered maize milling machine, International Journal of Ambient Energy, DOI: 10.1080/01430750.2020.1712241*

52. *More M., Agrawal C., Sharma D., Rathore N., Samar K. (2021) Development of Pellet Machine for Utilization of Biogas Slurry. In: Rakesh P.K., Sharma A.K., Singh I. (eds) Advances in Engineering Design. Lecture Notes in Mechanical Engineering. Springer, Singapore. https://doi.org/10.1007/978-981-33-4018-3_48*

53. *Neelam Rathore, Surendra Kothari, N.L. Panwar (2018), Analysis of monocrystalline panel and polycrystalline panel, Green farming, 9(3):575-578*