*Bio. Res. Today 2025, 7(8):227-230*

**Biotica Research Today**

e-ISSN: 2582-6654

*August, 2025*

**Article ID: RT1835** **Popular Article**

# Functionalization of Puffed Extruded Snacks through Horticultural Industrial Waste: Transforming Waste into Value

**Alka Joshi, Bindvi Arora, Brijesh Kumar Yadav*, Shruti Sethi and Sindhu P.M.**

*Division of Food Science and Postharvest Technology, ICAR-IARI, Pusa, New Delhi (110 012), India*

Open Access

**Corresponding Author**

Brijesh Kumar Yadav

✉: bkybhu98@gmail.com

***Conflict of interests:*** The author has declared that no conflict of interest exists.

***How to cite this article?***

Joshi, A., Arora, B., Yadav, B.K., *et al*., 2025. Functionalization of Puffed Extruded Snacks through Horticultural Industrial Waste: Transforming Waste into Value. *Biotica Research Today* 7(8), 227-230.



## Abstract

Using extrusion technology, horticultural waste such as overripe banana, grape pomace and tomato pomace can be converted into puffed snacks. Besides being polyphenols and antioxidants-rich as well as a source of dietary fiber, these wastes enhance extruded food products. Overripe banana and tomato pomace snack foods transform by-products into eco-friendly snacks while adding fiber and bioactive compounds. Additionally, extrusion enhances the nutrient bioavailability, texture and flavor of food while reducing waste, thus supporting a circular economy.

**Keywords:** Foam-mat drying, Food extrusion, Horticultural waste, Tomato pomace

## Introduction

Food extrusion is a food processing technology that integrates various unit operations such as mixing, cooking and molding to create a large range of food products. It entails the extruding of raw material through a die under particular conditions of shear, pressure and temperature. The high-temperature short time (HTST) process provides different advantages such as continuous operation, high productivity and capacity to form a variety of textures and shapes.

Concerns over food waste and the necessity for sustainable food production have stimulated interest in the valorization of horticultural wastes as valuable resources. Wastes made by horticulture contain fruit pomace, peels and vegetable by-products are typically high in dietary fibre, vitamins, minerals and bioactive compounds such as antioxidants. Adding these wastes to extruded food products presents an attractive solution for valorization, transforming potential environmental liabilities to healthy and functional food ingredients. Division of FS&PHT, ICAR-IARI has developed extruded puffed products utilizing tomato pomace, grape pomace and overripe banana as functional ingredients for puffed extrudates as an enriched source of lycopene-fiber, anthocyanins-fiber and natural sweetener-fiber, respectively.

The extrusion process can effectively handle these diverse waste streams, transforming them into palatable and texturized products. The heat and shear forces during the extrusion cooking causes cell wall disruption of horticultural wastes, potentially enhances the bioavailability of nutrients and functional compounds.

Addition of horticultural waste impacts the techno-functional characteristics of extruded foods. For example, adding fibre-containing ingredients can change the expansion ratio, bulk density and textural features like hardness and crispness. Research indicates that within moderate amounts of fruit and vegetable waste to snacks, it will improve their nutritional value through increased dietary fibre and antioxidant activity, attributing to the presence of phenolic compounds and other bioactives.

The inclusion of horticultural wastes influences the techno-functional properties of extruded products. For instance, incorporating fiber-rich ingredients can alter the expansion

**Article History**

RECEIVED on 27th July 2025 RECEIVED in revised form 10th August 2025 ACCEPTED in final form 11th August 2025

ratio, bulk density and textural qualities such as hardness and crispness. Studies show that adding moderate levels of fruit and vegetable waste to snacks can boost their nutritional profile by increasing dietary fiber and enhancing antioxidant capacity, owing to the presence of phenolic compounds and other bioactive substances.

Extruding horticultural waste offers several benefits in terms of nutrition as this process improves the digestibility of certain components and also helps in retaining valuable micronutrient. Moreover, incorporating fibre rich wastes can contribute to satiety and improved gut health. The developed extruded snacks can be nutrient dense, affordable and contribute to a more sustainable food system by reducing waste and adding value to underutilized resources.

## Overripe Banana Powder: A Natural Sweetener

In India, bananas mainly serve as fresh fruit and have a short postharvest life (12 to 14 days). Overripe bananas are rich in vitamins, minerals, dietary fibres, natural sweetners and contains 12.28% sugar. However, market value for overripe bananas is significantly low due to flavor defects, brown spots as well as extremely soft texture. Therefore, overripe banana is still underutilized and very little effort has been put to utilize its functionality in food applications due to handling challenges. Hence, the utilization of overripe bananas diversifies food products and reduces waste. However, it is quite perishable due to their climacteric nature, high respiration and ethylene production.

Postharvest loss of banana in India reached as high as 50% in recent years. These losses are mainly due to lack of modern technology during pre-harvest and postharvest stages, improper handling in transporting system, lack of storage facilities, outdated banana ripening procedures, as well as fluctuation in market prices. New products for better utilization of overripe banana are desirable and banana dehydration can serve as the basis for such developments. Developing new products is essential for effective utilization of overripe bananas and dehydration offers a promising foundation for such innovations. Various factors such as dense physical structure and high sugar content of banana restrict moisture mobilization during drying making it slow and challenging. Sankat *et al.* (1996) found that extended drying time required for banana slices, during which significant browning and darkening occurred.

An effective strategy for increasing banana drying speed includes modifying its physical form to enhance porosity, thereby improving internal moisture release. Foaming of the ripe fruit followed by hot air-drying is therefore suggested as a process for the dehydration of the banana. Foam-mat drying is a process in which liquid or semi solid foods are whipped into stable foams and then air-dried. During hot air-drying, it is desirable that the foam remains stable and retains its typical open structure to facilitate rapid drying and de-traying. It can produce high-quality and stable particles which can protect natural components and maintaining its appeal to the senses.

Foam mat drying is ideal for heat-sensitive, viscous and high-sugar foods where the product is whipped with a foaming agent to form a stable foam which is then dried using hot air. Unripe banana pulp has 70 to 80% starch and during ripening starch degrades to less than 1% with sucrose and fructose accumulating in fully ripe fruit. Thus, there is an increase in sugars, mostly sucrose constituting more than 10% and total soluble sugars of about 16% or more on fresh fruit weight basis (Anyasi *et al.*, 2013).

The high starch content of banana powder could be favourable for the extrusion process. Extrusion is a complex multivariate process which demands precise control, largely influenced by characteristics of raw material such as composition and moisture content and also extrusion parameter like barrel temperature, screw speed and feed moisture. Variation in feed composition, either by type or quantity of ingredients, along with any process condition that alters physical or chemical behavior of macromolecules during extrusion, can significantly impact the process efficiency and the quality of the final extrudate. Foam mat dried overripe banana powder with appreciable water solubility and absorption index has been tried for the development of puffed snacks in which the inherent composition of banana can contribute towards natural sweetness, banana flavour and dietary fiber owing to its significantly high sugar (~12%), intense flavour and fiber content (~2%, fwb) (Figure 1a).

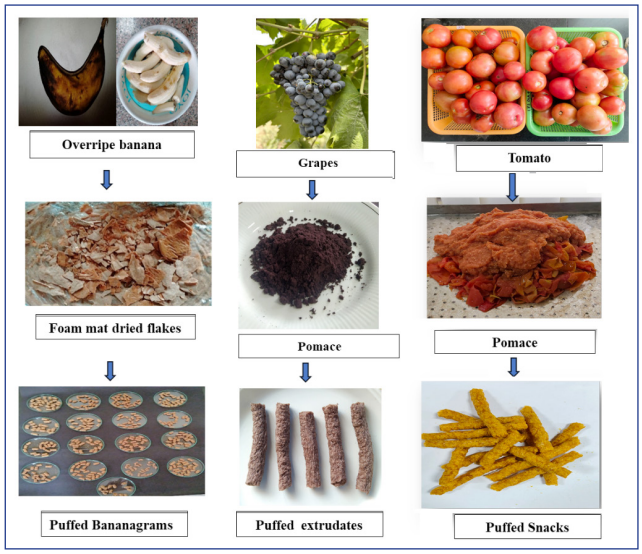


Figure 1: Puffed extrudates from: (a) overripe banana powder, (b) grape pomace and (c) tomato pomace powder

## Grape Pomace: A Bioactive-Rich Resource

Grape pomace, a solid waste generated from maceration and fermentation stages of wine making accounts for about 8.49 million tonnes annually worldwide (Antonić *et al.*, 2020). Grape pomace which is a major industrial waste from wineries, consist of complex mixture of residual pulp, wine lees, skins, seeds and stems. Although it is rich in plyphenols, anthocyanins, antioxidants, reserveratrol, dietary fibre and polysaccharide, making it a valuable source of bioactive compounds and essential nutrients.

The grape pomace produced during winemaking poses a critical problem regarding waste management. The majority of wineries either consider pomace as waste material that

requires disposal or only use it as animal feed or composted fertilizer. Pollution of freshwater systems poses significant surface-water pollution, depletion of oxygen levels within aquatic and terrestrial ecosystems and engaging disease-carrying pests (Dwyer *et al.*, 2014). These compounds along with polyphenols pose antimicrobial properties that during grape pomace landfill disposal can drastically decrease biodegradation. Grape pomace's lack of composting essential nutrients makes it financially unviable as composting feedstock (Dwyer *et al.*, 2014). Moreover, grape pomace's uncontrolled decomposition leads to a significant increase of greenhouse gases released into the atmosphere.

Grape pomace should not be considered as waste; rather, it should be utilized in innovative technologies to extract useful bioactive compounds from it. This not only support the sustainable management of the byproduct, but it also falls under the definition of the circular economy. A notable example of this is the use of grape pomace in the manufacture of extruded foods, particularly in the formulation of high-fiber snacks. The use of grape pomace enhances the nutritional value of the extrudates by enriching them with beneficial bioactive compounds such as polyphenols, antioxidants and anthocyanins, which render them functionally more useful (Figure 1b).

## Tomato Pomace: A Nutrient-Rich By-Product

Processing tomatoes results in 20 to 25% pomace, which is a by-product that poses challenges but is also a good source of fiber (25.4-50.0%) and protein (15.4-23.7%), and other minerals accounting for (Altan *et al.*, 2008). Tomatoes are perishable and thus require processing into puree, paste and juice which increases their availability for the entire year and adds economic value. Since tomato pomace is made up of fiber, seeds and pith, it is recommended that foam mat drying be utilized to transform it to a uniform, free-flowing mass and to optimize it for the development of free-flowing tomato pomace powder. Proteins from casein, soy and whey also work well as foaming agents. The foam mat drying of tomato pomace powder will help preserve the essential nutrients and organoleptic properties of color and flavor. This powder can be used in extrusion cooking for the manufacture of fiber-enriched puffed snacks which improves snack nutrition value while also natural coloring and appealing texture. This transformation of pomace into value-added products aids in waste reduction, lowers and mitigates environmental impacts, supports sustainable food systems and increases alternative snack options.

After ketchup and juice preparation, the leftover pulp, seeds and skin form tomato pomace which generally discarded as waste and its disposal poses significant environmental threat. Tomato pomace has potential value as animal feed, fertilizer, or even biofuel but it could be costly due to inadequate infrastructure. Food industry struggles due to waste accumulation, handling and its disposal. The idea of recovery of food waste and transforming it into useful by-products that promote environmental sustainability is becoming popular globally.

Tomato pomace powder is a favorable ingredient for the extrusion process owing to its high fibre content. Extrusion cooking is considered a high temperature, short time process to create fiber-enriched products. Within extruder, food mixture undergoes thermomechanical cooking under elevated temperature, pressure and shear forces produced by the screw-barrel mechanism. The resulting cooked material is then shaped and textured as it passes through the die.

Tomato pomace adds natural colour and flavour to the extruded products, enhancing their appeal to consumers without synthetic additives. Inclusion of tomato pomace in extrusion products promotes sustainability by utilizing tomato processing waste that would be otherwise be discarded, thus conserving the environment. The developed puffed snack has good acceptability score, minimal fat and is a good source of antioxidants (Figure 1c). Similar to tomato, for carotenoid enhancement pomace of carrot and red capsicum has also been tried by researchers since both of them are an enriched source of antioxidants (Figure 2).

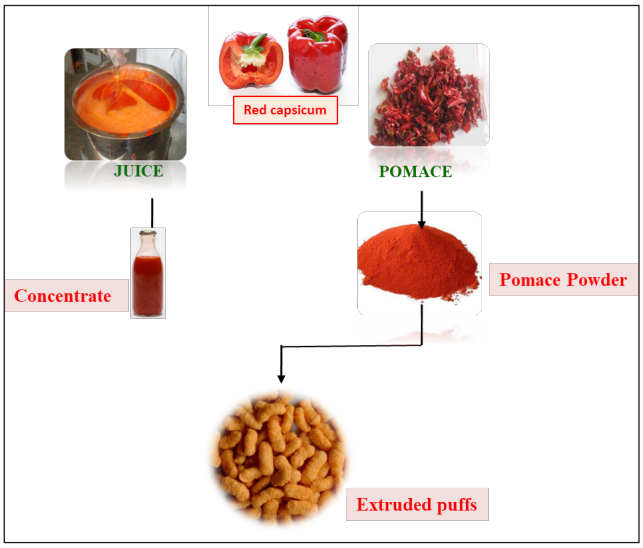


Figure 2: Extruded puffs developed from red capsicum pomace

## Conclusion

Strategies such as foam-mat drying and extrusion can efficiently help in utilizing tomato, banana and grape juice industry waste into nutrient rich puffed snacks since tomato pomace enhances lycopene and fibre, banana powder imparting natural sweetness and grape pomace enriches bioactive compounds. Simple unit operations of foam mat drying and extruder can help in the development of puffed extrudates, which, owing to their crisp nature and low bulk density, are preferred by all age group. The optimization of extrusion parameters helps in achieving desirable textural and sensory attributes in the puffed extrudates. The process of developing pomace powder and extruded puffed snack from them can create new opportunities for using over ripe banana, tomato pomace and grape pomace, which otherwise are treated as a zero-value waste. The developed snacks are low-fat, fibre rich and nutrient-dense, provide sustainable alternatives to traditional snacks.

## References

Altan, A., McCarthy, K.L., Maskan, M., 2008. Evaluation of snack foods from barley-tomato pomace blends by extrusion processing. *Journal of Food Engineering* 84(2), 231-242. DOI: https://doi.org/10.1016/j.jfoodeng.2007.05.014.

Antonić, B., Jančíková, S., Dordević, D., Tremlová, B., 2020. Grape pomace valorization: A systematic review and meta-analysis. *Foods* 9(11), 1627. DOI: https://doi.org/10.3390/foods9111627.

Anyasi, T.A., Jideani, A.I.O., Mchau, G.R.A., 2013. Functional properties and postharvest utilization of commercial and noncommercial banana cultivars. *Comprehensive Reviews in Food Science and Food Safety* 12(5), 509-522. DOI: https://doi.org/10.1111/1541-4337.12025.

Dwyer, K., Hosseinian, F., Rod, M., 2014. The market potential of grape waste alternatives. *Journal of Food Research* 3(2), 91-106. DOI: https://doi.org/10.5539/jfr.v3n2p91.

Sankat, C.K., Castaigne, F., Maharaj, R., 1996. The air drying behaviour of fresh and osmotically dehydrated banana slices. *International Journal of Food Science & Technology* 31(2), 123-135. DOI: https://doi.org/10.1111/j.1365-2621.1996.332-35.x.