Cashew apple processing

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Introduction

The cashew apple was given priority over cashew kernel during the initial introduction era due to its wider and attractive spectrum and ready consumption. Cashew apple is a reservoir of minerals and vitamins especially vitamin C and polysaccharides, protein and fibre and hence acts as the best thirst quencher and instant energy supplier to the exhausted travelers. But there are certain limitations such as poor shelf life, susceptible to microbial infection and tannin content which hinders the extensive utility and commercialization of cashew apple and their products. Hence despite of processing, cashew apple is left over as a plantation waste along with other recyclable cashew biomass to improve the physio-chemical and biological properties of the soil. Though the leftover cashew apples improves the soil physico-chemical and biological properties, the *in-situ* decomposition emits unpleasant odour in the plantation and hence, proper disposal or value addition of cashew apple is essential. This paper provides the details on proper utilization, industrial and homestead valorization of cashew apple.

Botany of Cashew apple

Cashew belongs to the family *Anacardiaceae* having drupe fruit type. Cashew apple is actually a swollen fruit stalk derived from a tissue called thalamus or receptacle hence considered as *false fruit* and the distinct layers like exocarp, meso and endocarp are absent in cashew apple. The development and maturity of cashew apple are coherent with the nut maturation. The cashew apple can reach up to an average length × breadth of 11 × 5 cm which is 8 to 10 times more than that of respective nut size. The matured cashew apples are spherical or cylindrical or pyriform in shape. During maturation and ripening, the firm, fragile and green, immature cashew apples are turned to soft and juicy with the different colours (red, orange and yellow) depending on the varieties (Berry and Sargent, 2011).

Cashew apple valorization

Non-alcoholic beverages

Cashew apple juice

Freshly harvested cashew apples are washed in running water and ensured to be free from soil debris or microbial spoilage. The juice extraction can be achieved through basket press, screw press or hydraulic press. Poly Vinyl Pyrollidone is added at the rate of 10 g or defatted soy-meal 180-200 g per 8 to 10 lit of cashew juice and passed through muslin cloth for clarification. After 20 to 40 min the clear supernatant is added with sugar at the rate of 0.5 kg per litre of juice and preservatives such as sodium benzoate and citric acid 6 g each (Sobhana *et al.,* 2011).

Cashew apple squash

The procedure for preparation of juice and squash is similar. But the consistency of squash can be achieved by adding more sugar and citric acid. Freshly harvested cashew apples are washed in running water and ensured to be free from soil debris or microbial spoilage. The juice extraction can be achieved through basket press, screw press or hydraulic press. Poly Vinyl Pyrollidone is added at the rate of 10 g per 8 to 10 lit of cashew juice and passed through muslin cloth for clarification. After 20 to 40 min the clear supernatant is added with sugar at the rate of 3 kg per litre of juice and preservatives *viz.,* 6 g of sodium benzoate and 100 g of citric acid. The squash can be diluted with three times of water and serve (Sobhana *et al.,* 2011).

Cashew apple syrup

The clarified cashew apple juice is added with 2 kg of sugar per 1 lit of juice and kept under moderate heat. The mixture is frequently stirred till the sugar completely dissolves. Dissolve 15 g of citric acid in a small quantity of the above syrup. Add this to the large quantity with continuous stirring. The syrup can be diluted with five times of water and serve (Sobhana *et al.,* 2011).

Ready to serve beverage (RTS)

The required amount of water with sugar (200 g sugar / 1 L water) and citric acid (5g) are boiled with continuous stirring. Amount of 200 ml clarified cashew apple juice and 100 ml of

any fruit juice are added after switching off the flame. The content is cooled and packed in aseptic condition (Sobhana *et al.,* 2011).

Cashew apple sauce

Cashew apple sauce is an important byproduct made out of well ripe less firm cashew apples. The cashew apple pulp has removed for lumps and added with ingredients such as onion powder, garlic powder, red chili powder, salt and vinegar. The ingredients are mixed thoroughly with cashew pulp and cooked till it reached sauce consistency. The consistency can be confirmed with drop test method.

Alcoholic beverages

Cashew apple feni

The cashew apple feni is prepared through fermentation and distillation process. Matured and ripened cashew apples are collected, juice extracted, fermented and subjected to the distillation process. By distillation method, the concentration of alcohol can be adjusted to the required level. Cashew feni has been awarded the Geographical Indication registration in 2009 as a special alcoholic beverage from Goa. The hydrocarbons, volatile and mineral constituents of cashew feni are ethanol (42.85%), acetic acid (12.28%), ethyl acetate (55.97%), acetaldehyde (18.28%), furfural (3.22%) and copper (1.04%) (Sobhana *et al.,* 2011).

Cashew apple wine

The required quantity of cashew apples is cleaned in running water for removal of debris and immersed in 5% salt solution for 2-3 days for tannin reduction. The apples are then exposed to steam of 15 lb for 15 min. This can be done using a pressure cooker or autoclave. The steamed apples are crushed using squeezer or grinder to collect juice and filtered through muslin cloth. The preservative sodium metabisulfite is added at 1g/litre juice to arrest the microbial growth. Sugar @ l kg and tartaric acid @ 6g are added to the juice with continuous stirring till it reaches 17°Brix. The bacterial culture *Saccharomyces cerevisiae var. bayanus* is added to the prepared mixture at the rate of 2% (v/v) and the fermentation process is to be carried out at room temperature (28±3°C) for 6 days. The TSS of final product stage is 2–3°Brix (Sobhana *et al.,* 2011).

Cashew apple vinegar

Cashew apple vinegar preparation consists of two stages a) alcoholic fermentation, b) acidic fermentation. Yeast @ 2.0 g in 20 ml coconut water is added and kept for 12 hours to make starter solution. To clarify the cashew apple juice, cooked and cooled sago gruel @ 5g is added along with starter solution into 1 lit of extracted unclarified cashew apple juice. This solution is kept for twelve days for alcoholic fermentation in narrow-mouthed plastic bottles, with cotton plugging. After twelve days, the fermented supernatant juice is separated through filtration (to obtain alcoholic ferment) into a wide mouth glass container or clay pot and added with thrice the quantity of mother vinegar for acidic fermentation. This container is kept tied with a muslin cloth, allowing air passage, for 15 days. The clear juice portion is filtered to a clean stainless steel vessel and pasteurized by keeping in boiling water for 10 minutes, cooled and bottled on the 16th day to get vinegar with 5 to 6% acidity. For continuous vinegar production, the filtrate can be used as mother vinegar (Sobhana *et al.,* 2011).

Osmo-dehydrated products

Cashew apple sweet candy

Whole cashew apples or cashew apple slices are soaked overnight (10-14 hr) in sucrose solution of concentrations ranging from 50-70°Brix, enriched with 2%. Calcium chloride and 0.6% potassium metabisulphate (KMS) at ambient conditions. The apple slices in solution should be frequently turned upside down manually or through agitator to ensure complete immerse, which will otherwise lead to microbial infection. The sugar solution concentration can be maintained at 60°Brix for 3-4 days. The cashew apple slices are separated from sugar solution and spread over a clean dry stainless steel tray for air drying. Dehydration using cabinet dryer at 50°C for 3-4 hr is advisable for rapid dehydration process. When whole apples are used, slits on four sides can be made using bamboo splints to encourage osmosis.

Cashew apple spice candy

Whole cashew apples or cashew apple slices are soaked overnight (10-14 hr) in salt mixed with turmeric powder, chilli powder, pepper powder, 2% calcium chloride and 0.6% potassium metabisulphate (KMS) at ambient conditions. The apple slices in solution should be frequently turned upside down manually or through agitator to ensure complete coating of spice mixture, which will otherwise lead to microbial infection. The slices should be retained in spice mixture for at least 2 days. The cashew apple slices are spread over a clean dry

stainless steel tray for air drying. Dehydration using cabinet dryer at 50°C for 3-4 hr is advisable for rapid dehydration process. Cashew apples slices are more preferred for this method than whole apple processing.

Cashew apple chew

Well ripened firm and freshly harvested cashew apples were washed and air dried for 5 to 10 min. cashew apples (500 g) are cut into cubes of desirable size and mixed thoroughly with spice mixture made of Cumin, Clove, Cardomom, cinnamon and sugar (optional). The mixture was spread as single layer over a clean dry stainless steel tray for dehydration under 28-30°C for 3-4 days for moisture removal. Frequent stirring or turning of sliced cashew apples is essential to avoid microbial infection. The sweet spice mixture acts as an osmolyte and the released aqueous solution from cashew apple are again impregnated into spice coated cashew slice to increase the retention of vitamin-C. This can be taken as such like a mouth freshener or along with betel leaves (Preethi and Shamsudheen, 2019).

Cashew apple fig

Whole fresh and firm uniform sized cashew apples are selected and washed with running water. The apple base and distal end are removed by chopping and soaked in sugar solution of concentrations ranging from 50-70°Brix and 0.6% potassium metabisulphate (KMS) as preservative. If whole apple is used, gentle slits are made on four sides of cashew apple using bamboo splint or stainless steel knife to encourage osmosis. The sugar solution concentration should be maintained at 60°Brix for at least 3-4 days. The apple slices in solution should be frequently stirred to ensure complete immersion, to avoid microbial infestation. After 3-4 days, the sugar solution is drained off and the separated cashew apples are dehydrated using cabinet dryer at 40-45°C temperature for 7-8 hr (Preethi and Shamsudheen, 2019).

Cashew apple crisp

Cashew apple crisp is an important extruded product prepared out of cashew apple pomace powder. The methodology for preparation of cashew apple pomace powder has been standardized by ICAR-DCR, Puttur. By converting the perishable cashew apple pomace to powder form is helpful to store the raw material for diversified uses during off season. Corn flour (CF) and rice flour (RF) are the major ingredients in extruded product preparation. These ingredients are predominantly poor in minerals, proteins and fibre. Hence, to enrich the product with bio minerals, protein and fibre, cashew apple pomace powder (CAPP) was

added as one of the ingredient along with commercially available corn flour and rice flour. The optimised quantity of cashew apple pomace powder ranged from 5-25% for successful exit of extruded products (Preethi and Shamsudheen, 2019).

Biochemical characters of wet cashew apple products developed at ICAR-DCR, Puttur

The directorate has developed four self-stable cashew apple based products namely Cashew RTS, Cider, Jam and Jelly.

CashLime

Cash lime is a cashew apple and lemon juice blend RTS/Nectar prepared using cashew apple pulp. The nutrient rich drink can be stored under refrigerated conditions for maximum of five months with maximum retention of nutrients and biochemical quality parameters (TSS- 10.5°Brix, vitamin C - 72 mg/100 ml, Tannins - 76 mg/100 ml, Total Phenols - 58 mg/100 ml, CUPRAC Assay - 186 mg/100 ml and FRAP Assay - 123 mg/100 ml) compared to fresh one (TSS- 12°Brix, vitamin C - 86 mg/100 ml, Tannins - 76 mg/100 ml, Total Phenols - 72 mg/100 ml, CUPRAC Assay - 242 mg/100 ml and FRAP Assay - 169 mg/100 ml) whereas the samples stored at room temperature began to lose its quality after two months of storage.

Cashew Apple Cider

Cashew apple cider was analyzed for its functional nutrient value and shelf life. The product was stored at refrigeration temperature and room temperature as well. Based on biochemical behavior of the products at both the storage conditions, it was observed that the product stored at refrigeration temperature could retain maximum of its nutrients till completion of 24 months (vitamin C - 109 mg/100 ml, Total Phenols - 137 mg/100 ml, CUPRAC Assay – 84 mg/100 ml and FRAP Assay - 246 mg/100 ml) compared to fresh one (vitamin C - 220 mg/100 ml, Total Phenols - 205 mg/100 ml, CUPRAC Assay - 98 mg/100 ml and FRAP Assay - 452 mg/100 ml) whereas the samples stored at room temperature were found stable with maximum nutrient retention up to 12 months of storage without any detrimental change in sensory quality of the product.

Cashew Apple jam

Jam being a self-stable processed product due to its high TSS content (68°Brix) could retain maximum of its nutrients (vitamin C - 83 mg/ 100 ml, Tannins 103 mg/100 ml, Total Phenols -119 mg/100 ml, CUPRAC Assay 372 mg/100 ml and FRAP Assay 169 mg/100 ml) even

after five months of storage at room temperature compared to fresh preparation (TSS-68°Brix, vitamin C - 121mg/100 ml, Tannins - 112 mg/100 ml, Total Phenols - 134 mg/100 ml, CUPRAC Assay - 403 mg/100 ml and FRAP Assay - 200 mg/100 ml).

Cashew Apple Jelly

The trend of nutrient retention of jelly was found similar to that of jam. Jelly was also stored at room temperature and was observed for change in its nutrient content during storage. Jelly also being a self-stable processed product like jam. Due to its high TSS content (65.5°Brix) it could retain maximum of its nutrients (vitamin C - 91mg/100 ml, Tannins - 90 mg/100 ml, Total Phenols - 107 mg/100 ml, CUPRAC Assay - 282 mg/100 ml and FRAP Assay - 122 mg/100 ml) even after five months of storage at room temperature compared to fresh preparation (vitamin C - 142mg/100 ml, Tannins - 93 mg/100 ml, Total Phenols - 117 mg/100 ml, CUPRAC Assay - 316 mg/100 ml and FRAP Assay - 152 mg/ 100 ml).

Limitations of cashew apple utility in product development

Pre-harvest factors

Pest infestation

The pest and disease of cashew apple have received attention in the recent past, after the realization of its commercial importance for value addition and processing. There are a few pests that infest either cashew apple or cashew nut or both such as cashew apple and nut borer (CANB), thrips and fruit flies. The female adults of CANB lay eggs on the cavity space at apple and nut junction at tender stage and later bore and feed the tender apple and nut resulting in its premature fall. In general, one borer in apple and three to four borers in nut was observed. In both apple and nut, CANB was located near to the junction and not at the distal end of apple cavity. **Thrips:** Thrips rasp the wax layer of cashew apple and suck the sap causing net like cork over the apple body. Sometimes, the cracks over the corky surface cause secondary infestation by fruit flies and microbes (Maruthadurai *et al.,* 2012).

Cashew apple cracking

The etiology for cashew apple cracking is ambiguous. The reports say that cashew apple cracking is varietal specific (eg. NRC selection - 2) and inherited to progenies when this is used as one of the parents in breeding programmes. Few reports say that cashew apple oriented towards southern and western sides are more prone to cracking (70% to 80%) than the northern and eastern side. The incidence was less noticed in the apples borne in inner

branches, whereas the apples in the upper branches exposed to sunlight are prone to apple cracking. The micro or macronutrients may also have a marked effect on cracking (Preethi *et al.,* 2019).

Cashew apple and nut drying

The etiology for cashew apple and nut drying is unknown. Genetic inheritance or nutrient deficiency/toxicity or disease infection may be the reason for cashew apple and nut drying.

Microbial infection

The delicate nature of skin facilitates the entry of pathogens.

Post-harvest factors

Physiology of cashew apple

Though cashew apple follows non-climacteric respiration pattern, high respiration rate (62 to 72 ml kg^{-1} hr^{-1}) and steady increase in ethylene expression rate was observed (200 to 400 ml kg^{-1} hr^{-1}). Drastic reduction in ethylene release rate and emission of volatile compounds at the post-harvest stage is unique to cashew apple. A sudden increase in abscisic acid at pedicel and all over the cashew apple at the later phase of development tends to reduce the retention capacity and firmness.

Post-harvest spoilage

Due to delicate nature of skin, cashew apples are prone to quick pre and postharvest attack of fruit flies which facilitates the entry of fungal inoculums such as *Rhizopus*, *Aspergillus* and *Colletotrichum*. To avoid the pathogen entry and to disinfect apple surface, quick dip with 0.25% citric acid or 0.3% ascorbic acid or 0.1% sorbic acid is recommended before fresh consumption or product development.

Tannin content

Tannins are referred to as an anti-nutritional factor that interfere with the assimilation of proteins in the body, resulting in non-availability of nutrients. The acrid feeling while consuming fresh cashew apple or cashew apple juice is owing to the presence of tannins (35%). Hence, tannin reduction and de-tanning is an important step prior to going for any product out of cashew apple.

De-tannification using bio-products

Bio-products available in nature are the cheapest and safest source of detannification. Cassava starch is readily available and effectively reduces tannin at the rate of 39.8%, but requires more than 8 hr for clarification which leads to fermentation (Jayalekshmy and John, 2006). Hence, refrigeration with clarification is recommended in this method to avoid fermentation. Rice gruel is a rapid (20 to 40 min) and effective clarifying agent but the quantity of gruel to be added at the rate of 1:2 (Juice: Gruel) leads to dilution of fruit juice and alter the taste. Some recently identified de-tanning agents such as defatted soybean meal, dried potato starch and bajra starch (rich in starch and iron) were tested for their efficiency in tannin reduction at ICAR-Directorate of Cashew Research, Puttur and found to be more efficient to reduce tannin at the rate of 34.3%, 28.6% and 24.0%, respectively.

De-tannification using chemicals

Poly vinyl pyrolidone (PVP) is one of the most effective chemicals that precipitates tannin in cashew apple juice (34 to 35%). But PVP is very expensive and not readily available in the market. Gelatin powder is the most common and readily available de-tanning agent (35 to 36%). It works well even within the range of 3 to 10g for one litre of cashew apple juice. Enzymes like tannase can also be used as best tannin precipitant but its sourcing and affordability is a dispute.

Steaming and blanching

These are the integral operations in processing for the inactivation of enzymes and sterilization of apple surface. Steaming of cashew apples (0.4 N/m^2) for 5 to 15 min or boiling in salt water (40 to 50°C) for 15 min reduces the tannin content in cashew apples.

Microfiltration

This method is also in practice but requires tedious pre-treatments like the use of clarifying agents prior to filtration and is expensive as well.

Conclusion

Cashew apple and their products have a potential market in the domestic and international forum. Though there are some limitations, certain physical and chemical processing steps are to be followed to bring out quality and palatable cashew apple products with significant nutritive properties.

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