Technology Development For Cashew Apple Processing In Konkan Region – A Review

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Abstract

Cashew is mainly cultivated for its nuts. The kidney shaped nut is the real fruit while apple attached to it is the juicy swollen peduncle having rich reserve of vitamins and minerals. The typical colour of the apple at full ripe stage varies with genotypes and is generally yellow, golden yellow, cherry coloured or red. Full grown cashew apple weighs about 50 to 100 g, but depends upon genotypes. The production of cashew apple in Maharashtra is estimated to be around 14-15 lak ton year^{-1}. Various technologies have been developed by Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli for the utilization of fresh cashew apple into various value added products. Processing of cashew apple is an economically viable enterprise in cashew growing tracts especially for Women Self Help Groups. These products are also useful for strengthening of present processing industries.

Keywords: Cashew apple, processed products, juice, syrup, RTS, wine

Introduction

Cashew (*Anacardium occidentale*) was introduced to India from Brazil about 500 years ago as a crop of afforestation and soil conservation. It is now well adapted to Indian agroclimatic conditions. In India cashew is grown on an area of 10.27 lakh ha., with production of 7.25 lakh metric tons and productivity of 706 Kg ha^{-1} (Saroj *et al.* 2016). Cashew fruit composes cashew nut and cashew apple which is technically a swollen peduncle. It is about 6-7 times greater in weight than that of a raw nut. At present about 90-95 per cent cashew apple is wasted, owing to its rapid perishable nature, lack of sophisticated harvesting techniques, improper post harvest handling and non-adoption of cashew processing technologies (Salvi *et al.* 2016).

The genus name *Anacardium* which means "shaped like heart" is derived from the shape of apple (Mini 2007). Though cashew apple is very juicy, sweet, spongy somewhat fibrous having a unique smell with thin waxy skin is not normally consumed fresh owing to its astringency and acrid principles. It is rich in vitamin C, sugars and contain considerable amount of tannins and minerals mainly calcium, iron and phosphorus. Ripe cashew apple content 88 to 90 percent moisture , carbohydrates (12.3 per cent), proteins (0.2%), fat (0.1%), crude fibre (0.9%), calcium 10.0 mg 100 g^{-1}, iron 0.2 mg 100 g^{-1} (Mini 2007). Vitamin C 261.0 mg 100 g^{-1}, minerals (0.2%), thiamin 0.02 mg 100 g^{-1}, riboflavin 0.5 mg 100 g^{-1}, nicotinic Acid 0.4 mg 100 g^{-1} and vitamin A 39.0 IU (Mini 2007). Cashew apples can be utilized for value added products such as juice, syrup, canned fruits, pickles, jam, chutney, candy, etc (Khanvilkar *et. al.* 2016). At present cashew apple is extensively used only in Goa for preparation of fermented product *fenny* (Mini 2007).

Fresh Consumption

Cashew apple is a non-climacteric fruit. Quality of

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cashew apple is determined by astringency, acidity, sweetness, firmness, size and shape. The composition of cashew apple changes according to variety (Table 1) (Fernades 2010) as well as variety and storage conditions (Table 2) (Antarkar 1986). In a study conducted at Dapoli it was observed that among the released varieties Vengurle-8 was superior for its maximum TSS (14 °Bx). Total sugars (10.37%), reducing sugars (9.61%), titratable acidity (0.32%), ascorbic acid (199.08 mg 100 m^{-1}), and tannin (0.15%) as compare to other varieties (Fernandes 2010).

The astringency of cashew apple is determined to a large extent by the tannin content (phenolic compound) which varies from 0.06 to 0.22 g 100 g^{-1}. The pH of the apple deviates between 4.1 to 4.7 and total sugars from 6.7 to 10.5 percent. Ripe cashew apple contains 0.76 to 1.17 percent pectin (Mini 2007).

Packaging and storage

The moisture, TSS, reducing sugar, total sugar, titratable acidity, ascorbic acid and tannin content in cashew apple continuously declined from in storage after harvesting, whereas the pH increases irrespective of cashew varieties, storage conditions and packaging material. The decrease was greater at ambient temperature (30.5-34°C, 80.5 percent RH) followed by cool chamber (26.0-27°C, 99 percent RH) and low temperature storage (13°C ± 1,94 percent RH) The decrease was more in cashew apple without packaging treatment followed

Table 1. Chemical composition of apple juice of cashewnut varieties.

	Chemical composition of cashew apple juice							
Cashew nut variety	TSS (°Bx)	Total sugars (%)	Reducing sugars (%)	Tritatable acidity (%)	pH	Ascorbic acid (mg $100ml^{-1}$)	Tannins (%)	Protein
Vengurla-1	10.08	9.09	7.35	0.15	4.24	183.16	0.131	0.332
Vengurla-4	10.20	8.70	6.75	0.12	4.40	184.92	0.135	0.490
Vengurla-6	7.00	5.70	3.04	0.07	4.45	90.24	0.121	0.262
Vengurla-7	10.40	8.18	5.31	0.15	4.28	113.25	0.138	0.402
Vengurla-8	14.00	10.37	9.61	0.32	3.96	199.08	0.151	0.385
S.E.±	0.054	0.153	0.058	0.001	0.014	0.632	0.0009	0.006
C.D. at 1%	0.228	0.641	0.242	0.007	0.059	2.634	0.0040	0.0267

Source: Fernandes 2015

Table 2. Changes in chemical composition of cashew apple juice at ambient temperature (30.5-34.0°C, 85 per cent relative humidity) and low temperature storage (13°C, 94 per cent relative humidity) storage.

Storage period (month)	Sample	TSS (%)	Total sugars (%)	Acidity (%)	pH	Ascorbic acid (mg $100gm^{-1}$)	Tannins (%)
*	Vengurla-1	15.0	13.07	0.233	4.40	259.0	0.43
	Vengurla-2	14.2	11.73	0.259	4.15	292.7	0.40
4	V1 AT	10.6	9.00	0.385	4.20	188.16	0.38
	V1 LT	11.0	9.30	0.356	4.30	214.03	0.32
	V2 AT	10.0	7.65	0.387	4.00	251.66	0.36
	V2 LT	10.3	8.00	0.370	4.10	275.18	0.30
8	V1 AT	8.2	7.50	0.422	3.80	149.60	0.33
	V1 LT	8.5	7.90	0.384	4.00	198.59	0.29
	V2 AT	7.7	6.60	0.435	3.60	215.93	0.31
	V2 LT	8.0	7.00	0.410	3.80	235.20	0.25

Source: Antarkar 1986. * = immediately after preparation, AT= Ambient temperature, LT= Low Temperature

by polythene bag pack (Manjerakar 2005). The cashew apple can be stored only for one day without packaging under ambient temperature (30.5-34°C, 80.5 percent RH). The shelf life can be extended to three days when packed in polythene bag. The polythene bag acts a barrier and prevent moisture loss through respiration and transpiration. In cool chamber cashew apple can be kept up to 3 days without packaging and if packed in polythene packaging the shelf life can be extended up to 5 days (26.0-27°C, 99 percent RH). In cold storage (13 ± 1°C) the packaging in polythene bag resulted in extension of shelf life of cashew apple up to 11 days. Whereas, without polythene bags it was 7 days. In vengurle-4 and Vengurle-6 greater shelf life was noticed as compared to vengurle-1 and Vengurle-7 (Manjarekar 2005).

Cashew apple juice

Nutritious and refreshing beverages like juice, juice concentrates, squash and syrup can be prepared from the unfermented juice of cashew apple by adding varying concentrations of sugar, citric acid and preservatives. When fresh cashew apple juice stored the TSS, total sugars, pH, ascorbic acid and tannin content decreases and acidity and alcohol increasesirrespective of varieties and storage conditions (Antarkar 1986, Bhuwad 2016). The decrease or increase in chemical composition was greater at ambient temperature than low temperature storage. The bacterial and fungal count of cashew apple juice also aggravates, irrespective of varieties and storage conditions (Bhuwad 2016). The apple juice of variety Vengurla-1 exhibited minimum loss of TSS and total sugars at low temperature at the end of storage period whereas, the juice of Vengurla-2 recorded minimum loss of pH, ascorbic acid, maximum loss of tannin content and maximum retention of acids at low temperature at the end of storage (Antarkar 1986). The chemical composition of juice extracted from cashew apples without proximal end is superior as compared whole cashew apples for chemical composition (Bose 2010). The cashew apple juice of Vengrula-4 was palatable for colour, flavour and overall acceptability upto six months in cold storage conditions (12 ± 1°C) (Antarkar 2010). (Table 4, 5) (Figure 2).

Table 3. Changes in bacterial count (colony count x 10^{-3} $m1^{-1}$) and fungal count (colony count x 10^{-3} $m1^{-1}$) of cashew apple juice under ambient (27-29ºC) temperature.

Treatments	Changes in bacterial count			Changes in fungal count		
	6 months			6 months		
	S1	S2	Mean	S1	S2	Mean
Vengurla 1	6.17	4.04	5.10	8.38	5.40	6.89
Vengurla 4	5.13	3.32	4.22	8.00	4.20	6.10
Vengurla 6	6.47	4.00	5.23	8.50	5.58	7.04
Vengurla 7	5.84	3.58	4.17	8.25	4.50	6.38
Vengurla 8	6.13	4.13	5.13	8.63	5.25	6.94
Mean	5.95	3.81	4.88	8.35	4.99	6.67
	SE m ±	CD at 1%		SE m ±	CD at 1%	
Variety (T)	0.05	0.30		0.10	0.38	
Storage (S)	0.03	0.13		0.06	0.24	
Interaction (TxS)	0.08	0.30		0.14	0.54	

Source: Fernandes 2015

S1 – Ambient temperature, S2-Cold storage, NS – Non-Significant

The use of Potassium Metabisulphite @ 1000 ppm extended the shelf life of the cashew apple juice up to four days (Shimpi *et. al.* 2016). On the fifth day of storage fermentation of cashew apple juice was noticed while fungal growth was observed on sixth day and resulted in to the spoilage of cashew apple.

In another study, while preparing cashew apple RTS of improved varieties (Vengurla-1 to Vengurla-4) T.S.S. was adjusted to 15°Bx and acidity was adjusted to 0.5 percent. The reducing and total sugar content of RTS varied from 8.83 per cent (Vengurla-1) to 9.58 percent (Vengurla-4) and 10.53 per cent (Vengurla-4) to 12.56 per cent (Vengurla-1) respectively. The ascorbic acid content ranged between 275.43 mg $100g^{-1}$ (Vengurla-4) and 317.68 mg 100 g^{-1} (Vengurla-3), whereas tannin content varied from 0.25 per cent (Vengurla-4) to 0.36 per cent (Vengurla-2). The pH of RTS did not vary much due to adjustment of acidity of RTS to 0.5 percent (Shimpi *et. al.* 2016).

In the study of cashew apple syrup prepared from

Figure 1. Fruits of different cashew apple varieties at the end of storage, stored at cold storage (12±2°C) and stored at ambient temperature (27-29°C)..

Figure 2. Cashew apple juice stored at ambient temperature for 4 months (A), for 6 months (B) and at cold storage for 4 months (C), and 6 months (D).

Figure 3. Cashew Apple Syrup (A) and wine (B)

Table 4. Changes in colour score of cashew apple juice under ambient temperature (27-29ºC) and cold (12±1ºC) Storage.

Treatments	Changes in colour score			Changes in flavor score		
	6 months			6 months		
	S1	S2	Mean	S1	S2	Mean
Vengurla 1	6.38	7.00	6.69	6.50	6.75	6.63
Vengurla 4	6.63	7.25	6.94	6.75	7.00	6.88
Vengurla 6	6.25	6.75	6.50	5.75	6.63	6.19
Vengurla 7	5.75	6.50	6.13	5.63	6.63	6.13
Vengurla 8	5.88	6.25	6.06	5.88	6.13	6.00
Mean	6.18	6.75	6.46	6.10	6.63	6.36
	SE m ±		CD at 1%	SE m ±		CD at 1%
Variety (T)	0.19		0.70	0.18		0.70
Storage (S)	0.11		0.44	0.11		0.44
Interaction (T x S)	0.26		NS	0.25		NS

Source: Bhuwad 2016

S1-Ambient temperature, S2-Cold storage, NS-Nonsignificant

Table 5. Changes in overall acceptability of cashew apple juice under ambient temperature (27-29ºC) and cold (12±1ºC) Storage.

Treatments	6 months		
	S1	S2	Mean
Vengurla 1	6.44	6.88	6.66
Vengurla 4	6.69	7.13	6.91
Vengurla 6	6.00	6.69	6.34
Vengurla 7	5.69	6.56	6.13
Vengurla 8	5.88	6.19	6.03
Mean	6.138	6.69	6.41
	SE m ±		CD at 1%
Variety (T)	0.14		0.54
Storage (S)	0.09		0.34
Interaction (TxS)	0.20		NS

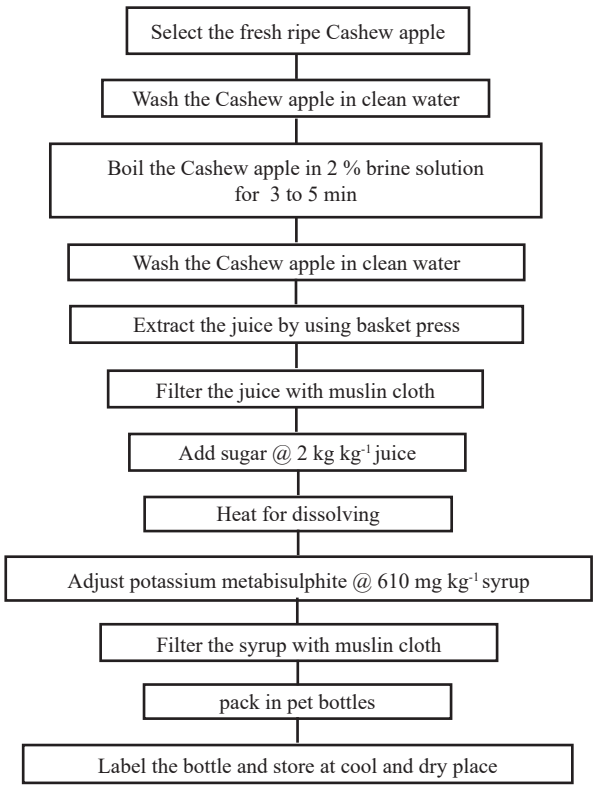
Source: Bhuwad 2016

S1-Ambient temperature, S2-Cold storage, NS-Nonsignificant

improved varieties (Vengurla-1toVengurla-4) by adjusting TSS to 60°Bx and acidity 2.0 percent, the reducing and total sugar content of cashew apple syrup varied from 32.46 (Vengurla-1) to 45.45 (Vengurla-2) and 53.54 (Vengurla-2) to 56.05 percent (Vengurla-4) respectively. Highest ascorbic acid content was recorded by Vengurla-3 (236.80 mg 100 g^{-1}), whereas lowest tannin content was recorded by Vengurla-4 (0.28 percent), pH did not show much variation and it ranged between 2.7 (Vengurla-1) and 2.9 (Vengurla-3) (Marathe 1989). The process is given in flow chart.

Cashew apple RTS of improved varieties (Vengurla-1 to Vengurla-4) was blended with Alphonso mango RTS in different proportions indicated that blending cashew apple nectar with Alphonso mango RTS, improves the organoleptic qualities when compared with RTS of Alphonso mango alon (Marathe 1989). Carbonated RTS prepared from straight syrup of cashew apple recorded 7.7, 8.0 and 7.85 score for colour, flavor and average sensory score at the end of 180 days storage. Average sensory score was found to be increased slightly at the

Flow chart for Cashew apple syrup



end of 180 days storage as compared to initial days storage (Chavan 1997).

Unfermented value added products from raw and ripe cashew apple

Different types of unfermented products can be made by using the ripe cashew apple pulp and juice beverage like nectar i.e. ready to serve (RTS), squash, syrup, blended syrup of cashew apple with kokum and karonda, jam, sweet chutney, preserve and candy. The pickle is prepared from unripe mature cashew apple. Precedure for preparation of Cashew apple syrup is given below.

Acceptance and palatability of cashew apple products

The cashew apple products prepared from different varieties of cashew under study were organoleptically acceptable for 12 months at ambient temperature storage. Vengurla-7 variety was superior for preparation of cashew apple pickle, syrup, blended syrup of cashew apple syrup with kokum and karonda, sweet chutney,preserve and candy; Vengurla 4 for nectar and squash and Vengurla-1 for cashew apple jam. During the storage of a year the organoleptic score for pickle, RTS, squash and syrup increased significantly while in blended syrup, jam, sweet chutney, preserve and candy it declined irrespective of the varieties under study. On the basis of organoleptic evaluation, the cashew apple candy (8.15) preserve (7.93), syrup (7.43) and blended syrup of cashew apple with kokum and karonda (7.85 and 7.64, respectively) rated as most palatable products from cashew apple (Manjarekar 2005). The Vengurla-8 was most suitable for preparation of jam followed by Vengurla-1 and Vengurla-5. However, no variety showed significant difference with respect to sensory evaluation score for nectar (Salvi *et. al.* 2016b).

Cashew apple juice powder can be prepared by using maltodextrin and tricalcium phosphate. Maltodextrin levels exhibited a significant variation with respect to physical parameters of juice powder such as recovery per cent, bulk density, colour and chemical parameters TSS, acidity, ascorbic acid, reducing and total sugars of the cashew apple juice powder. All the quality parameters decreased with increase in maltodextrin levels except recovery and pH. Sensory evaluation for RTS of cashew apple juice powder showed decreasing results with increasing maltodextrin levels. Based on the overall acceptability, the addition of maltodextrin @ 10 or 20 per cent is useful for the preparation of high quality spray dried cashew apple juice powder (Khanvilkar 2016).

The Vengurla-8 was most suitable for preparation of jam followed by Vengurla-1 and Vengurla-5. However, no variety showed significant difference with respect to sensory evaluation score for nectar (Salvi *et al.* 2016b).

Chemical composition of different cashew apple products during storage

In cashew apple pickle prepared from different varieties during the storage period of 12 months at ambient temperature conditions, the TSS, pH and B:acid ratio decreased significantly and the titratable acidity increased noticeably due to lactic acid fermentation. The cashew apple RTS, squash, syrup, blended syrup of cashew apple with kokum and karonda, jam, sweet chutney, preserve and candy prepared from all the varieties of cashew apple under study exhibited significant increase in T.S.S., pH and °Bx:acid ratio while the titratable acidity decreased significantly during the storage period of 12 months (Manjerakar 2005.)

Fermented beverages

Cashew apple juice on fermentation gives wine with characteristic aroma. This can also be used for distilling good quality alcohol. With this view studies carried out for physico-chemical parameters and used for preparation of wine from the cashew apple (Figure 4) revealed that a period of 4 days was adequate for preparing wine from cashew apple. The treatment with 10 per cent inoculum gave higher wine yield (570-571 m kg^{-1} fruits) with highest alcohol percentage (13.24 to 13.31 percent) and of standard quality (score=14). Hence, use of 10 per cent inoculum was recommended for obtaining good quality wines from cashew apple. The organoleptic evaluation of the wines revealed that standard quality wine of attractive deep orange red colour could be produced from ripe cashew apples (Manor 1999).

In the study effect of method of juice extraction (J_1- Juice extraction from whole cashew apple, J_2- Juice

extraction from cashew apple without proximal end) and fining agents (F_1-Gelatin, F_2-Bentonite, F_3-Casein, F_4-Activated charcoal, F_5-PVPP, F_6-Silica gel, F_7-Control) on chemical composition of cashew apple wine observed that interaction $J_2 F_2$ recorded minimum T.S.S., total and reducing sugar and maximum alcohol content. The treatment combination J_2F_3 and J_2F_7 recorded higher titratable acidity and J_2F_3 recorded lowest pH Interaction J_1F_1 recorded maximum ascorbic acid and interaction J_2F_1 recorded minimum tannin content. The higher protein content was recorded by interaction J_1F_1 (Bose 2010). While sensory evaluation of cashew apple wine revealed that wine prepared from J_2 method of juice extraction improved the quality of wine as compared to J_1, irrespective of fining agents. The fining agent bentonite was found to achieve maximum score for overall quality followed by gelatin (Bose 2010). Among the different wines prepared, interaction $J_2 F_2$ gained higher average score for all sensory attributes (Bose 2010).

Vengurla–4 recorded lowest T.S.S., total sugars, reducing sugars and higher protein and alcohol. Vengurla-6 recorded lowest pH and tannin, Vengurla–7 recorded high titratable acidity and Vengurla–8 recorded higher ascorbic acid. Among the pH levels 3.5 and 3.0 pH were found to be good with respect to chemical composition. With respect to sensory quality the wine prepared form Vengurla-6 at pH 3.0 and at pH 3.5 obtained maximum score for overall quality (Fernandes 2010).

During fermentation study, it was observed that the period of 11 to 15 days was found to be adequate for fermentation in blended juices. At the end of fermentation TSS was found to be 8.20 to 9.27°Bx in different treatments. The yeast count during fermentation was found to be increased at the initial stages of fermentation and then showed decreasing trend towards later stage of fermentation (Sadgir 2015).

The wine obtained from different blends contains 10.08 to 12.91 per cent alcohol, 8.02 to 9.27°Bx T.S.S., 0.85 to 1.28 per cent total sugars, 0.18 to 1.08 per cent reducing sugars, 0.19 to 0.64 per cent non-reducing sugar, 0.66 and 1.03 per cent titratable acidity, 22.67 to 68.00 mg $100g^{-1}$ (Mini 2007) ascorbic acid, 0.18 to 0.77 percent protein, 0.04 to 0.31 percent tannins and having 3.57 to 3.67 pH. The maximum wine recovery (83.2 percent) and benefit cost ratio (4.38) was obtained in the treatment of wine prepared by sole cashew apple juice. Blending of cashew apple and pineapple juices before fermentation helped in reducing astringency with improvement in taste, bodycolour, aroma, overall acceptability and overall quality of wine when compared to sole cashew apple wine (Sadgir 2015). The study was concluded with suggestion that 40:60 blend of cashew apple: pineapple juice was best for preparation of wine.

Energy Production and Industrial Uses: *Fuel*

Sustainable development can only be possible with the use of renewable energy and biomass which is the major renewable energy source. Konkan region of Maharashtra has large availability and great potential of producing biomass. Cashew apple is used as cattle feed, for preparing some value added products and beverages but still have great scope to use this surplus biomass. Cashew apple has good properties to act as a substrate for alcohol production also. Ethanol production process from cashew apples using solar energy was studied. The performance of specially designed solar still used for distillation of fermented cashew apple juice for ethanol production was studied and the results indicated that it is possible to produce 3.5 liters of low concentration ethanol from distillation of 10 liters of fermented cashew apple juice in a single day using solar still (Chopade 2016).

Conclusion

The large production of cashew apple is almost waste and only trace amount is used for processing in Maharashtra. Cashew apple is highly nutritious and comparable with many other tropical fruits. Various technologies have been developed by Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli for the economic utilization of fresh cashew apple by processing it in to various value added products such as cashew nectar (RTS), squash, syrup, jam and wine. Similarly, fallen fermented/ waste apple can be efficiently used to convert it into compost, vermin-compost and animal feed etc. Processing of cashew apple is an economically viable enterprise in cashew growing tracts. Women Self Help Groups can

very well take up this enterprise, thereby contributing to the cause of women empowerment. If legal permission is available for production of fermented products like liquor and wine, it can substantially enhance the income from cashew apple processing many folds.

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