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Original Research Paper

Biochemical quality comparison of forced air dried osmo-dehydrated cashew apple products infused with spice mixture and sugar

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ABSTRACT

Cashew apple is a pseudo-fruit available abundantly during harvest seasons (March to July) and majority of them goes as waste because of their perishability and poor shelf life. However, the absence of distinct exocarp and seeds are some of the potential advantages for processing utility. Hence, in the present study, osmo-dehydrated products were prepared from two maturity stages *i.e.* breaker and ripe stages using sugar, spice mixture and were referred to as cashew fig and chew, respectively. The drying efficiency and product recovery were conquered by cashew chew and fig, respectively. Based on the biochemical and organoleptic qualities, ripe fruits were found suitable for preparation of chew and fig. The tannin content responsible for acridity got reduced (chew of ripe stage 1.18 to 0.53 mg/g and chew of breaker stage 1.85 to 0.68 mg/g) during the process of osmo-dehydration. Excluding total antioxidant activity, all other biochemical properties were found to be improved compared to their respective controls.

Keywords: Bio-chemistry, cashew apple, chew, fig, value addition

INTRODUCTION

Cashew crop was introduced from Brazil in the 16th century and was initially appreciated for its magnificent, juicy false fruit known as the cashew apple. The juice of this fleshy receptacle is rich in minerals, vitamins, and polysaccharides, offering instantaneous energy to the consumers (Runjala & Kella, 2017). However, the distinctive physiological characteristics of cashew apple, *viz*., rapid rates of respiration and ethylene production along with delicate skin hinders their storage, transport, and marketability. Additionally, these fruits pose a sense of acridity/astringency in the throat, while, consuming rendering them moderately acceptable to consumers. There are some other reasons contributing for leaving overripe cashew apples as plantation waste including bulk production in the season, inappropriate harvesting and handling practices, more economic importance for the nut, and decayed cashew apples improving the soil's health (Preethi et al., 2019). The cashew apple fruits are abundant in fibre, minerals, ascorbic acid, antioxidants, phenols and sugars. Though few fermented and non-fermented beverages such as vinegar, cider, fenny, wine, ready-to-serve drinks, syrup, and juice, are readily available in the market, while, technologies for preparation of pickles, candies, probiotic juices, enzyme preparations, emulsions, surfactants, and cattle feed from cashew apple pomace has been standardized (Sobhana et al., 2011) and these processes require manual labour, cumbersome equipment, and substantial investment.

With this outlook, simple and easily adaptable osmo-dehydration techniques for whole and sliced cashew apples using different osmolytes was tried. In order to standardise suitable maturity stage of cashew apple for development of these products, two stages *i.e.* breaker and ripe stages (Fig. 1) were selected (Adiga et al., 2019). Both the stages ensured complete maturity of raw cashew nut (RCN) since it is the major economic part focused for income generation. The biochemical quality and sensory acceptability of these products was studied in comparison to their respective controls (dehydrated fruits without osmolytes).

Fig. 1 : Breaker stage (a) and ripe stage of cashew apple (b)

MATERIALS AND METHODS

The cashew apples of two different stages *i.e.* breaker stage (BS) and ripe stage (RS) were harvested manually from low lying branches of plantations of ICAR-Directorate of Cashew Research, Puttur, Karnataka, India located at 12º 45^{1} N and 75º 15^{1} E with 90 meters above mean sea level. Cashew apples were precooled to room temperature and sorted for uniform size, bruise and debris free fruits. Fruits were washed under running water and wiped using a clean, dry cotton cloth to remove the adhering moisture, air dried for 5 to 10 min and used for further processing.

Product preparation

Cashew apple fig

The proximal and distal ends of cashew apples were chopped off using a sharp stainless-steel knife and soaked in sugar solution of 70 °Brix containing 0.06% potassium metabisulphate (KMS) as a preservative (Kaushalya & Weerasooriya, 2011). Since, whole cashew apple is used; gentle horizontal slits are made on four sides of cashew apple to encourage osmosis. The strength of sugar syrup was sustained at 60 °Brix for three days. The cashew apple slices were periodically agitated in sugar syrup to ensure proper soaking and to avoid microbial contamination. After three to four days, the sugar syrup was filtered and the cashew apples were dried in a cabinet dryer at 40 to 45 °C for about 12 to 13 hours. This product was referred as 'Cashew fig' (Fig. 2). The sugar syrup concentration and drying temperature optimized by Azoubel & Murr (2003) were adopted. Similar fruits dried without osmosis act as control and referred to as Cashew apple whole (CAW).

Fig. 2 : Osmo-dehydrated cashew apple products, a. chew and b. fig

Cashew apple chew

The proximal and distal ends of firm cashew apples were removed and cut into cubes of 1 cm^3 size. The cashew apple slices (500 g) were mixed thoroughly with 50 g spice mixture (4 parts of spice powder + 1 part of sugar) of 45 °Brix and left marinated overnight. After 48 h, the coated cashew apple slices were spread as a thin layer over a clean dry stainless steel tray for dehydration in a cabinet dryer at 40-45 °C temperature for 9-10 h (Azoubel & Murr, 2003). To prevent microbial contamination, the slices were often agitated or tossed. The sweet spice mixture functions as an osmolyte, and the aqueous solute liberated from the slices was re-impregnated for the preparation of cashew chews. Similar slices of cashew apples dehydrated without any infusion were considered as control and are referred to as cashew apple slices (CAS). The TSS of the osmolytes was measured using portable hand refractometer (0-90%) at room temperature (30±2°C).

The treatments of the dehydration experiment were Breaker stage - cashew apple whole (BS-CAW), BS-Fig, Ripe stage - cashew apple whole (RS-CAW), RS-Fig, Breaker stage - cashew apple slices (BS-CAS), BS-Chew, Ripe stage - cashew apple slices (RS-CAS) and RS-Chew. The dry product recovery percentage was calculated on weight by weight basis (w/w) using the formula, product recovery (%) = (Initial cashew apple weight - Dry product weight) × 100 ÷ Initial cashew apple weight. Drying rate was calculated using the formula, Drying rate = (initial cashew apple weight - dry product weight) ÷ time taken for drying and expressed in g/min (Reddy et al., 2023).

Biochemical parameters such as ascorbic acid (mg/100 g), Tannin (mg/g), total sugars (%), reducing sugars (%), phenols [mg gallic acid equivalents

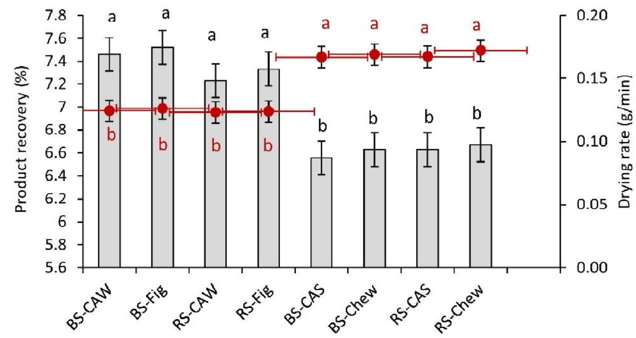
(GAE)/100 g], flavonoids [mg catechin equivalents (CE)/100 g] and total antioxidant activity in cupric ion reducing antioxidant capacity method [mg ascorbic acid equivalents (AAE)/100 g] were estimated referring to Ranganna (1986). The prepared samples were coded and subjected to sensory analysis with a semi-trained panel of 50 members using a nine-point hedonic scale.

In the current investigation, the study of different parameters (n=10) were evaluated with analysis of variance and Fisher's least significant difference at 1% level (p=0.01) using the online SAS (version 9.2) tool, and the results were reported as the mean ± standard deviation of 10 replicates.

RESULTS AND DISCUSSION

The major portion of cashew apple is water accounting for 60-85% depending on the variety, growing conditions, physiological aspects like photo-assimilates synthesis, dry matter accumulation and other biotic and abiotic factors. Since, this is one of the extremely hydrated commodity, the drying rate was comparatively high in cashew apple than in any other fruits and vegetables (Kumar & Sagar, 2014). The product recovery and variation in drying rate using osmolytes *i.e.* sugar and spice mixture is depicted in Fig. 3. Slicing and spice mixture infusion are the processing steps that hastened the drying efficiency of 'Cashew chew' by increasing its surface area exposed to drying environment. Prominent significant difference in drying rate and product recovery was noticed between the osmotic products. In 'Cashew fig', among the control and sugar treated samples, diffusivity, water loss and solid gain were acute in sugar treated osmo-dehydrated product and relative results were obtained by Mini & Archana (2016) in cashew apple and Sujayasree et al. (2022) in Amla. According to Pravitha et al. (2021) while preparing coconut chips, sugar and jaggery were identified as an effective osmolytes and the statement is in line with present experimental result. Likewise, spice mixture inherited with sugars predominantly reducing sugars increased the drying ability and product recovery percentage in 'Cashew chew'.

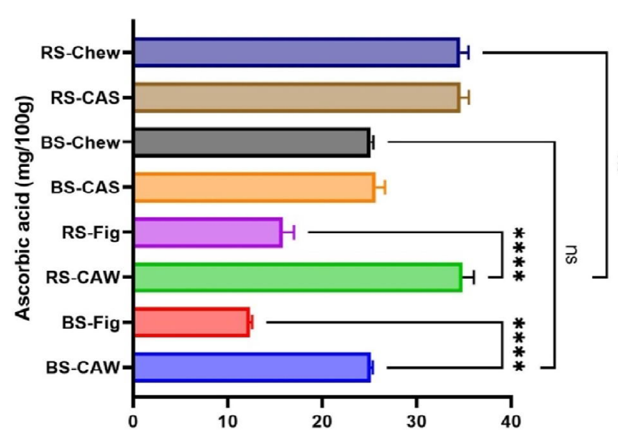
The biochemical properties and their suitability for osmo-dehydrated products development from two maturity stages of cashew apple were studied (Table 1). Cashew apple is one of the predominant bio-source of ascorbic acid similar to fruits like guava,



BS: breaker stage; RS: ripe stage; CAW: cashew apple whole; CAS: cashew apple slices; bars represent the mean values with standard error bars; bars with same different alphabet(s) are significant at 99% confidence level; bars with different alphabets are non-significant (NS) at 99% confidence level

Fig. 3 : Product recovery percentage and drying rate of cashew apple osmo-dehydrated products

citrus and pineapple (Preethi et al., 2019). Between the two maturity stages, ascorbic acid in dehydrated cashew apples of ripe stage (34.85 mg/g) was higher than that of dehydrated cashew apples of breaker stage (25.16 mg/g). Though the ascorbic acid content was lesser in cashew apple slices compared to wholly dehydrated cashew apples, the trend between the maturity stages was similar. In osmo-dehydrated products, the ascorbic acid is tremendously reduced in Cashew fig irrespective of their maturity stages (12.34 and 15.83 mg/g) compared to Cashew chew (25.13 and 34.63 mg/g). In cashew apple, the water soluble vitamins (C and B) were embedded in liquid phase. During sugar infusion, the sugar syrup was



BS: breaker stage; RS: ripe stage; CAW: cashew apple whole; CAS: cashew apple slices

The bars represent the mean values with standard error bar; ****: highly significant at p=0.01

Fig. 4 : Comparison of ascorbic acid content in chew and fig of different maturity stages with their respective whole and slices

Table 1 : Biochemical properties of osmo-dehydrated cashew apple products

Parameter	BS-CAW	BS-Fig	RS-CAW	RS-Fig	BS-CAS	BS-Chew	RS-CAS	RS-Chew
Ascorbic acid (mg/100 g)	$25.16^{b}\pm1.45$	$12.34^{d}\pm0.56$	$34.85^{a}\pm1.05$	$15.83^{c}\pm0.21$	$25.68^{b}\pm1.12$	$25.13^{b}\pm1.02$	$34.63^{a}\pm1.25$	$34.62^{a}\pm1.13$
Total sugars (%)	$15.41^{b}\pm0.45$	$16.17^{a}\pm1.05$	$15.96^{b}\pm1.65$	$16.38^{a}\pm0.15$	$15.54^{b}\pm0.56$	$16.08^{a}\pm0.24$	$15.56^{b}\pm1.08$	$16.25^{a}\pm1.00$
Reducing sugars (%)	$5.45^{e}\pm0.12$	$7.42^{d}\pm0.24$	$10.13^{b}\pm0.25$	$10.56^{a}\pm0.18$	$5.63^{e}\pm0.23$	$8.90^{c}\pm0.26$	$10.28^{b}\pm0.23$	$10.40^{b}\pm0.25$
Tannins (mg/g)	$1.85^{e}\pm0.03$	$0.89^{c}\pm0.00$	$1.21^{d}\pm0.01$	$0.53^{a}\pm0.00$	$1.85^{e}\pm0.00$	$0.68^{b}\pm0.00$	$1.18^{d}\pm0.01$	$0.53^{a}\pm0.00$
Total phenols (mg GAE/g)	$1.16^{a}\pm0.00$	$0.80^{b}\pm0.01$	$0.44^{d}\pm0.00$	$1.2^{a}\pm0.01$	$1.12^{a}\pm0.00$	$0.76^{b}\pm0.00$	$0.42^{d}\pm0.00$	$0.69^{c}\pm0.12$
Total flavonoids (mg CAE/g)	$0.12^{b}\pm0.00$	$0.09^{c}\pm0.00$	$0.11^{b}\pm0.00$	$0.10^{b}\pm0.00$	$0.12^{b}\pm0.00$	$0.16^{a}\pm0.00$	$0.11^{b}\pm0.00$	$0.18^{a}\pm0.00$
TAA (mg AAE/g) (NS)	0.02 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	0.03 ± 0.00	0.03 ± 0.00

TAA: total antioxidant activity; BS: breaker stage; RS: ripe stage; CAW: cashew apple whole; CAS: cashew apple slices

Mean values with the same alphabets and no alphabets are non-significant (NS) at 99% confidence level; mean values with the different alphabet(s) are significant at 99% confidence level

diluted with liquid phase of cashew apple in fig preparation. Whereas, the liquid phase was again and again impregnated in chew making process and thus this product got enriched with ascorbic acid compared to Cashew fig. The ascorbic acid in chew is non-significant compared to the fig of respective maturity stages (Fig. 4).

Though, the variation in total sugar content of BS and RS remains non-significant, there was an increase observed in the content of reducing sugars with due time of cashew apple maturity and thus, the reducing sugar content in dehydrated cashew apples was in the range of 5.63 - 10.28%. Conversion of non-reducing sugars to reducing sugars without altering the total sugar content is a general phenomenon during fruit ripening. Though, cashew apple is a pseudocarp, similar occurrence was noticed here. The sugars were high in both the osmo-dehydrated products prepared from RS cashew apple though they are statistically non-significant with the products of BS cashew apple. Altogether, the soft tissue of RS fruit relatively encouraged osmosis in fruit based osmotic products (Yadav & Singh, 2014) and, similarly in this study, high sugar values in RS based osmo-dehydrated products were recorded. The total and reducing sugars in chews were higher than Cashew fig irrespective of their maturity stages which could be due to the procedural practice of using commercial sugar-sucrose as osmolyte during cashew fig preparation. The results obtained are comparable with the sugar incorporated osmo-dehydrated *Malus* fruit, wherein the polysaccharides like sucrose (non-reducing sugar) and glucose (reducing sugar) were boosted, whereas, the fructose (reducing sugar) remained the same with slight decrease in organic acids (Dixon & Jen, 1977).

The tannin content (3-5 mg/ml) in cashew apple results in its astringency and acridity rendering it as an undesirable character (Preethi et al., 2019). Between the maturity stages, BS has more tannin (1.85 mg/g) than RS (1.18-1.21 mg/g) in dehydrated whole as well as sliced cashew apple. Both the osmolytes *i.e.* spice mixture and sugar, effectively reduced the tannin content to 0.53-0.89 mg/g in cashew apple during product development. Similar reduction of tannins through osmosis was reported (Singh et al., 2019).

Maturity stages of cashew apple played a vital role in the total phenolic content of cashew apple and their products. The dried cashew apple slices of BS had more total phenols (1.12 mg GAE/g) than RS (0.42 mg GAE/g). Whereas in the products, Cashew fig prepared using RS were appraised for the highest total phenols (1.2 mg GAE/g), while, Cashew chew from RS were recorded for greater total flavonoids (0.18 mg CE/g). When the osmo-dehydrated products

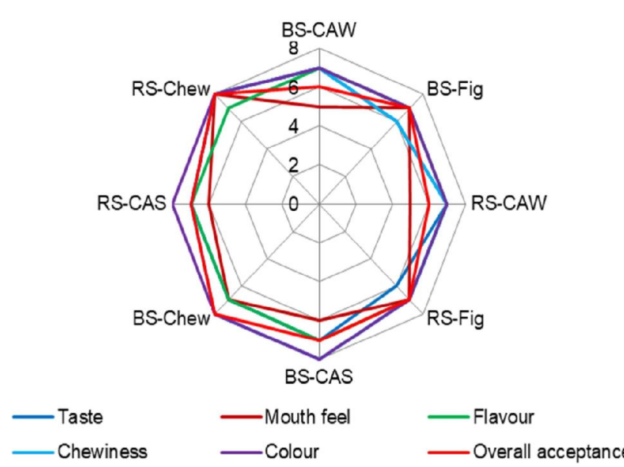


Fig 5 : Organoleptic evaluation of osmo-dehydrated cashew apple products

N=50; BS: breaker stage; RS: ripe stage; CAW: cashew apple whole; CAS: cashew apple slices were compared, chew had greater flavonoids than fig because of addition of flavonoid rich spices (Ashokkumar et al., 2020) as osmolytes. The total flavonoids in cashew chew of RS cashew apple (0.18 mg CE/g) were on par with that of BS cashew apple (0.16 mg CE/g). The treatments had no significant effect on the total antioxidant activity of osmo-dehydrated cashew apple products.

According to the organoleptic characters (Fig 5), Chew prepared from RS cashew apple scored the highest. The average score of overall acceptance ranged between 6 to 8 indicating chew from both stages secured the highest score and the dehydrated whole cashew apple were the least preferred.

CONCLUSION

The cashew apple processing techniques available currently requires huge investment and are labour intensive. These products *i.e.* cashew chew and fig were developed using simple technology called osmo-dehydration using spices and sugar. Among these two products, chew was found to be highly acceptable with respect to biochemical and organoleptic properties. It also had the potential to be used as a refreshing mouth freshener. Since, very less quantity of sugar was used as osmolyte; this product could be relished by weight watchers and diabetic patients, whereas, cashew apple fig mimics the taste of dates and thus, can be consumed as a regular snack.

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