

Comparative Analysis of Vitamin C (Ascorbic Acid) Content at Different Ripening Stages of Indian Jujube (*Ziziphus Mauritiana*) and Development of a Value-Added Hard-Boiled Candy Incorporating Cape Gooseberry (*Physalis Peruviana*)

Prerna¹, Priyanka Shankar^{2*}

¹Department of Food and Nutrition, School of Home Science, Babasaheb Bhimrao Ambedkar University, Lucknow, Uttar Pradesh, India

²Department of HDFS, School of Home Science, Babasaheb Bhimrao Ambedkar University, Lucknow, Uttar Pradesh, India

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ABSTRACT

The potential of the indigenous fruit, Indian jujube *Ziziphus mauritiana* (local name- ber) was explored. The research objectives involved study of ascorbic acid level of three ripening stages of the fruit and develop a hard-boiled candy with jujube and cape gooseberry *Physalis peruviana* juice. Three ripening stages (green immature, semi-ripe and fully ripe) of jujube fruits, each replicated thrice, were analysed in triplicate for ascorbic acid by DCPIP titration by extraction with 20% metaphosphoric acid.

Three different candies were made, using 70 g sugar and 30 mL fruit juice. The formulations included cape gooseberry alone (V0), jujube and cape gooseberry juice in the ratio 60:40 (V1) and 40:60 (V2). Ten semi-trained panelists evaluated candies based on attributes like appearance, colour, flavour, taste, texture and overall acceptability on a 9-point hedonic scale. The V2 candy was optimized based on sensory evaluation and was analysed further for proximate composition, physicochemical parameters, sugar profile, DPPH radical scavenging activity, total phenolic content and 7-carotene. From the results, ascorbic acid of fruits (green to full ripe) varied from 366 to 316 to 236 mg/100 g, respectively. V2 was the most desirable based on descriptive sensory analysis and average overall acceptability (8.94 ± 0.11). The optimized candy contained ascorbic acid (60.36 mg/100 g), carbohydrates (93.293 ± 0.248 %), crude fibre (3.820 ± 0.148 %) and provided energy (383.637 ± 0.564 kcal/100 g). DPPH radical scavenging capacity of the candy was found to be 55.52 ± 0.03 %, total phenolic content 146 mg GAE/100 g and 7-carotene 0.48 g/100 g. These results suggest the potentiality of early and half ripe jujube along with cape gooseberry for developing new confectionery products, but still requires further investigations such as larger sensory study, validated chemical methods of analysis, water activity, microbiological analysis and storage stability study to establish quality attributes and commercial feasibility.

Keywords: *Ziziphus mauritiana*, *Physalis peruviana*, ascorbic acid, hard-boiled candy, antioxidant activity.

INTRODUCTION

Indian jujube or ber (*Ziziphus mauritiana* Lam.), being an indigenous species and well domesticated one among the most important commercial fruit species of South Asia, has already proved its successful adoptability in sub-optimal and marginal agro-ecological zones. Many of the recent reviews highlight about their varied nutritional and phytochemical benefits, bioactivity and various other benefits which include income-generation and household food and nutrition security under such situations like adverse agro-ecological conditions drought, salinity and marginality, to the poor where none other commercial fruit species is expected to fare well [15,19].

Nutrient composition profile of jujubes depends on the genotype and the maturity stage of fruit. From a study with 8 *Ziziphus jujuba* cultivars, it is evident that the amount of ascorbic acid, total polyphenol and some phenolics and the antioxidant activity (DPPH/ABTS) in fruit decreased significantly with maturation process whereas a reversed trend was observed for content of soluble sugar [23]. However, though *Z. Jujuba* and *Z. Mauritiana* are different species this report might signify the importance of maturity if it is for nutritive purpose to evaluate at desired state. The ascorbic acid and also physico-chemical parameters did also show significant differences in several Indian ber accessions as well documented in India [17]. Another underutilized food fruit namely cape gooseberry (*Physalis peruviana* L.), generally referred as by various names such as rashbhari and golden berry also been confirmed containing different phytochemical which contribute to its health benefiting qualities like vitamin C, carotenoid, phenolics etc. Analysis of supply chain of cape gooseberry identified the influence of the physical maturity, processing and the storage on content of constituents along with identification cape gooseberry as possible nutrient source for production of a food commodity of a potential functional/ value-added nature [9]. Others are of the similar opinion indicating its potential as a food processing ingredient due to its interesting phytochemical profile [22,6]. While comparing it to others a work reported Sensory optimized cape gooseberry nectar where portion of fruit could be adjusted toward achieving acceptable Physicochemical properties, antioxidant potential and sensory Acceptability of beverage [4].

The processing of fruit (which readily spoil) into confectioneries allows for its prolonged utilization beyond the season in which it is freshly available. Hard boiled candies are high-solids confectionery with composition, temperature, time and water content having impact on the heat processes resulting in final glassy structure, stability and user palatability [10]. Provision of fruit juice or concentrate will enable the provision of the specific fruit flavoured confectionery and enhancement in the provision of plant-derived phytochemicals contributing to its nutritional quality; evidence for fruit concentrate replacement within the framework of gummy and functional candy confectioneries was documented [13,20]. Newer research that demonstrates possibility of incorporation of natural colorants and high nutritionally active compounds in plant/fruit based confectioneries still maintained their scientifically provable functions along with consumers' liking [25,26,28].

Vitamin C (ascorbic acid), is heat-labile and food processing conditions can greatly affect its retention due to varying processing treatments [7,11] at different temperatures, exposure to oxygen and lengths of processing time [11]. Hence it is necessary to determine ascorbic acid after processing, for fruit-based processed products that are being formulated for their high retention of nutritive value. Fruit maturity stage will affect several quality attributes, including ascorbic acid, therefore, determining an appropriate maturity stage for the processing of Indian jujube for vitamin-C retention is crucial.

While both Indian jujube and Cape gooseberry possess great nutritional and phytochemical advantages, studies evaluating their optimum maturity stage of the Indian jujube for its utilization in vitamin-C-oriented confectionary processing have limited, similarly the optimization and formulation of a hard-boiled candy utilizing both juices of Indian jujube and Cape gooseberry have been infrequently documented. There is hence a need to investigate both fruits as functional ingredients to develop a value-added product, that can contribute in extending its utility, in a forms other than fresh produce and utilize its intrinsic health promoting qualities. The former fruit was considered for its nutrient profile, while in conjunction with Cape gooseberry it would also add character of colour, flavour and unique phytochemical elements into the confectionary product.

Hence, the present study was carried out on varying stages of maturity of Indian jujube [*Ziziphus mauritiana* L.], i.e., immature green, semi-ripe and ripe stages, with an aim to select a suitable stage for the development of processed product, and was optimized and formulated, utilizing juices of selected jujube and Cape gooseberry [*Physalis peruviana* L.], with various levels in a hard-boiled candy. Nutritional, physico-chemical, antioxidant properties, as-carotene, total phenolic content, total sugar and ascorbic acid content were estimated for the final products. Hence the study helped in establishing relationship among the maturity stage of Indian Jujube with it's utility and formulation of a value-added processed product. Water activity and micro-

biological parameters, due to being not evaluated, coupled with a small number of panelists would suggest the outcome product should be categorized more as a prototype rather than a ready commercial food product.

MATERIALS AND METHODS

Raw Material Collection

Fresh jujube fruit was picked from local orchards and markets of Lucknow, Uttar Pradesh (India) in the green immature, semi-ripe and mature ripened conditions and fresh Cape gooseberry fruits were picked from local orchards and markets. Size sorted and free from external damages of consistent appearance selected fruits and rinsed thoroughly with cold running water before their use just to ensure absence of any change occurred due to its handling and storage.

Determination of Ascorbic Acid at Different Ripening Stages

The method chosen to estimate the ascorbic acid was 2, 6, dichlorophenolindophenol (DCPIP) visual titration method with extraction of it in 20% metaphosphoric acid. About 200g fruit sample was crushed and blended and passed through sieve and the filtrate thus obtained was filtered properly and a 50 ml aliquot was taken and extracted in 25ml of 20% M. P. A and the final volume was made to 100 ml with distilled water and a 10ml aliquot of it was used for titration. 0.025% (w/v) DCPIP was prepared and was standardized against standard ascorbic acid solution and it was used for titration after it. DCPIP is titrated till a slight pink colour sustained to it for 15 seconds and blank estimation was done properly. Dye factor F(mg AAE per ml DCPIP sol.) was calculated by the equation: $F = W/V$ (where W and V is amount of ascorbic acid and vol of DCPIP solution used respectively) after subtracting blank estimation values. Result was calculated as mg AAE/100g FW. Though DCPIP is well tested method to analyse ascorbic acid however, it is affected by coloured extract and interfering substances present in it [18]. As a part of the established method metaphosphoric acid helps to stabilize the ascorbic acid extracted [7].

Development of Candy Formulations

Selected the jujube juice from the green immature stage having higher amount of ascorbic acid for the preparation of candy. Amount of sugar was maintained with constant of 70 g. The quantity of total fruit juice was kept constant at 30 ml for all formulations. Sugar was heated at 120 c and concentrated for 10 minutes. Selected jujube and cape gooseberry(Rashbhari) juice was mixed at 145 c and continue to cook for 5 min. Juice combination was used 0:100, 60:40 & 40:60 (jujube:cape gooseberry) respectively for V0, V1 and V2. Hot syrup was directly poured to silicone mold and cooled at room temperature (27 C) for 2-3 hours (finished candies were obtained) [10].

Table 1: Composition of the candy formulations.

Ingredient	V0(Control 0:100)	V1(60:40Jujube: Rashbhari)	V2(40:60Jujube: Rashbhari)
Jujube juice (ml)	0	18	12
Rashbhari juice (ml)	30	12	18
Sugar (g)	70.0	70.0	70.0

Sensory Evaluation

The three formulations were analysed for appearance, colour, flavour, taste, texture, and over all acceptability using the 9-point hedonic scale of evaluation from 1- 9 with 1 equalling 'dislike extremely' and 9 equalling 'like extremely'. Panelists of 5 men and 5 women (between ages of 22-55) were asked to analyse the three sample formulations with randomized codes and orders. Panelists are 'semi-trained' as they are aware of sensory evaluation techniques, the standard vocabulary for describing foods, and that of typical fruity confectioneries and confectioneries in general. All panelists were screened for possible food allergies prior to tasting and none had an allergy to the ingredients being evaluated. All had previous experience with sensory evaluation and are knowledgeable on sensory attributes considered for this analysis. Evaluation of the samples was performed at the same temperature and lighting conditions for all panelists, and was conducted at the same time. The data collected included mean sensory scores and standard deviation values for each of the 6 sensory attributes analysed. The 9-point hedonic scale is a well-established method within affective evaluation for comparisons and acceptability assessments of food items [8] Many other studies evaluating various other fruit and plant- based confectionery items also employ the 9- point hedonic scale [25,26,28].

Proximate Analysis

The moisture content, ash content, crude protein content, crude fat content, crude fibre content, carbohydrate content and energy value were determined in triplicate on candies with optimal formula according to Association of Official Analytical Chemists International [3]. Moisture content was performed in oven drying and ash content were determined on the candies in a muffle furnace at 550°C until reaching the total combustion of sample for 14 hours. For determination crude protein content of candy, we use method Kjeldahl. Crude fat content of candy was determined with extraction and Soxhlet extraction [3]. In crude fibre content determination, they use the gravimetric official method and the carbohydrate content was estimated as difference. Calculation caloric values from the amounts of carbohydrate and protein contents of candies (4 kcal/g for protein, 4 kcal/g for carbohydrate and 9 kcal/g for fat, by using the Atwater factors [3]). Every analysis was performed in triple.

Ascorbic Acid Determination in Processed Candy

The same extraction, standardization, blank correction and titration procedure described above was followed for the optimized candy, with the candy sample homogenized in 20% metaphosphoric acid before filtration and titration

Physicochemical Analysis

The physicochemical characteristics of the optimized candy formulation were evaluated in triplicate. Total soluble solids (TSS) were determined using a refractometric method and expressed as °Brix. The pH was measured using a calibrated digital pH meter, while titratable acidity was determined by titration with standardized alkali and expressed as the corresponding acid equivalent. These parameters were determined using standard procedures commonly employed for the physicochemical characterization of processed fruit-based products. Physicochemical characterization including parameters such as pH, total soluble solids, related quality characteristic of fruit based value added products have also been performed with the help of few researchers such as [26,27].

Sugar Analysis

Total and reducing sugars of the optimized candy were determined in triplicate using the Lane–Eynon volumetric titration method. The method is based on the reduction of copper ions in an alkaline medium by reducing sugars, with the sugar content quantified volumetrically against standardized Fehling-type reagent [3]. Total sugar content was determined after appropriate sample preparation and hydrolysis, where required, while reducing sugar was determined directly from the prepared sample solution. Non-reducing sugar content was calculated by difference between total sugar and reducing sugar contents. The results were expressed as g/100 g of sample [3].

Color Parameters

Surface colour of the optimized candy was assessed quantitatively using instrumental CIE L, a and b colour system (Figure 4). L coordinate describes colour lightness (where higher values correspond to a lighter object) whereas a and b coordinates denote respectively the red–green axis and yellow–blue axis. Colour intensity or saturation C, was calculated using the equation $C = \sqrt{a^2 + b^2}$ [12, 5]. Instrumental CIE Lab* colour measurement is a commonly- used technique to objectively measure the colour of a food ingredient product and has the ability to trace colours influenced by processing and storage [12, 5].

Antioxidant Activity and Total Phenolic Content

Assay of DPPH (2,2 diphenyl-1 picrylhydrazyl) radical-scavenging activity [24]. Known amount of the sample was 2 g. Sample was homogenized using 10 mL methanol and then centrifuged to acquire clear sample extract, supernatant was collected. DPPH solution at 0.1mM concentration in methanol were prepared fresh aliquote of sample extract (1 ml) was taken in a test tube, mixed with 2ml of DPPH and then the reaction mixture was stored at dark place for 30 min at room temperature after shaking and then observed the reduction of absorbance at 517nm on spectrophotometer.. No external antioxidant standard was used but calculation done based on reagent control which had only methanol as reagent. Each test was repeated 5 times (n=5), DPPH radical scavenging activity (%)= [(A control A sample)/ A control] 100.

To determine the Total phenolic content(TPC) of the optimum candy. Folin Ciocalteu calorimetric method. Known amount of sample was 1g that was kept in the blender and mixed with methanol and then centrifuged to get clear sample extract. The extract (0.5ml) was pipetted out in the test tube containing 2.5 ml of the Folin Ciocalteu reagent (pre-diluted) incubated in the dark for 3 to 5min; 2ml of 7.5% sodium carbonate (NaCO) solution were added to the mixture and it was kept again in the dark for 30min at room temperature. After keeping the solution for specified duration, absorbance measured at 765 nm using spectrophotometer. Standard gallic acid was used and amount of TPC calculated in terms of mg Gallic acid equivalent (GAE)/ 100 g sample. Foli- Ciocalteu is routinely employed for total phenolic assay but as reagent could possibly interact with other reducing species the obtained values are interpreted as Folin Ciocalteu- reactive phenolic equivalents rather than the absolute total phenolics content [16]. Similar analysis for antioxidant as well as phytochemical studies performed for recent studies on fruit-based confectionery [25, 26,28].

β-Carotene Analysis

3.6.1determination of carotene content in optimized candy: A 1.0 g of the sample was weight accurately, ground using mortar and pestle and the extracts were carried out using solvent extraction by adding 10-20 mL cool hexane. The pigment was completely extracted with homogeneous and centrifuged and filter through. The process of extraction was re-till the residue becomes colourless. All the extracts collected were transfer to volumetric flask and the final volume was make up to 50 mL. All reading was observed against solvent blank using UV-Visible spectrophotometer at 450 nm, and expression as g of carotene per 100g of sample. (n = 3)

RESULTS

Ascorbic Acid Concentration at Different Ripening Stages

Ascorbic acid concentration differed markedly among the three ripening stages of jujube fruit (Table 2). The green immature fruit exhibited the highest concentration 366 mg/100 g, which declined to 316 mg/100 g at the semi-ripe stage and further to 236 mg/100 g at full ripeness. Overall, the fully ripe fruit showed a 35.5% reduction in ascorbic acid concentration compared with the green immature fruit. Considering the higher ascorbic acid concentration observed at the green immature stage, this stage was selected for candy preparation.

Table 2: Ascorbic acid content of raw jujube at three different ripening stages.

S. No.	Ripening stage	Ascorbic acid (mg/100 g)
1	Green immature	366
2	Semi-ripe	316
3	Fully ripe	236

Sensory Evaluation

Sensory evaluation showed a clear descriptive preference pattern across the three candy formulations (Table 3). V2 (40:60 jujube: cape gooseberry in the juice fraction) had the highest mean scores for appearance (8.81 ± 0.23), colour (8.92 ± 0.15), flavour (8.91 ± 0.19), taste (8.94 ± 0.10), texture (8.72 ± 0.30) and overall acceptability (8.94 ± 0.11). V1 (60:40) had intermediate scores, whereas V0 had the lowest overall scores. Because inferential statistical testing was not performed on individual panelist scores in the current dataset, these differences are reported as descriptive rather than statistically significant.

Overall acceptability scores for V0, V1 and V2 were 7.01 ± 0.29 , 8.22 ± 0.42 and 8.94 ± 0.11 , respectively. Based on the highest descriptive overall acceptability score, V2 was selected for further physicochemical, nutritional and functional characterization. The small panel size ($n = 10$) limits generalization of these sensory findings.

Table 3: Sensory evaluation of the candy formulations.

Attribute	Control (V0)	V1 (60:40)	V2 (40:60)
Appearance	7.19 ± 0.40	8.11 ± 0.40	8.81 ± 0.23
Colour	7.00 ± 0.34	8.31 ± 0.31	8.92 ± 0.15
Flavour	6.80 ± 0.26	8.01 ± 0.55	8.91 ± 0.19
Taste	7.11 ± 0.37	8.21 ± 0.33	8.94 ± 0.10
Texture	7.50 ± 0.42	8.40 ± 0.15	8.72 ± 0.30
Overall acceptability	7.01 ± 0.29	8.22 ± 0.42	8.94 ± 0.11

Note: Values are expressed as mean $\pm$ standard deviation (SD). Sensory scores were obtained using a 9-point hedonic scale, with higher scores indicating greater acceptability.

Proximate Composition of Optimized Candy

The optimized V2 candy was characterized by a predominantly carbohydrate-based composition, with carbohydrate content of $93.293 \pm 0.248\%$. The product contained $3.820 \pm 0.148\%$ crude fiber, while protein and fat contents were $1.507 \pm 0.040\%$ and $0.493 \pm 0.031\%$, respectively. Moisture and ash contents were $0.493 \pm 0.025\%$ and $0.394 \pm 0.025\%$, respectively. The energy value was estimated at 383.637 ± 0.564 kcal/100 g.

The high carbohydrate content reflects the composition of the candy matrix, particularly the contribution of fruit solids and added sugars, whereas the relatively low moisture content is characteristic of a concentrated confectionery product.

Table 4: Proximate composition of the optimized V2 candy.

Parameter	Mean $\pm$ SD
Moisture (%)	0.493 $\pm$ 0.025
Ash (%)	0.394 $\pm$ 0.025
Protein (%)	1.507 $\pm$ 0.040
Fat (%)	0.493 $\pm$ 0.031
Crude fiber (%)	3.820 $\pm$ 0.148
Carbohydrate (%)	93.293 $\pm$ 0.248
Energy (kcal/100 g)	383.637 $\pm$ 0.564

Note: Values are expressed as mean $\pm$ standard deviation (SD) of three independent determinations (n = 3). Carbohydrate was calculated by difference, and energy value was calculated using standard Atwater conversion factors.

Ascorbic Acid

The raw green immature jujube fruit had 366 mg/100g of ascorbic acid (vitamin C); and the optimum final (V2) candy has 60.36 mg/100g. This should not be reported as just percent retention as the formulation had jujube and cape gooseberry juice with 70g sugar and total fruit juice of 30mL, which went through thermal concentration during processing. We were not given information in this data set such as juice extraction yield, fruit-juice mass balance, or density & percent ascorbic acid contribution from each fruit to obtain a supportable percent retention at a formulation level. Therefore 60.36 mg/100g was reported as percent concentration in the final candy, not a percent retention. We already know ascorbic acid can be somewhat sensitive to heat and to oxidation in contact with air and moisture. So, loss due to boiling and evaporating is expected and is consistent with many other fruit confectioneries developed under extreme heat.

Table 5: Ascorbic acid content of raw green immature jujube and optimized V2 candy.

Sample	Ascorbic Acid (mg/100 g)
Raw green immature jujube	366.00
Optimized V2 candy	60.36

Note: The ascorbic acid content decreased from 366.00 mg/100 g in raw green immature jujube to 60.36 mg/100 g in the optimized V2 candy. The lower concentration in the finished product may be attributed to

dilution by added ingredients and thermal degradation of ascorbic acid during candy processing. Therefore, the values represent the ascorbic acid concentration of each sample on a fresh-weight/product-weight basis and should not be interpreted directly as percentage retention.

Physicochemical Properties (TSS, Titratable Acidity and pH)

The optimized candy V2, gave a TSS of 32.467 ± 0.351 Brix, titratable acidity of 0.413 ± 0.015% and a pH of 4.126 ± 0.005. The soluble solid content is relatively high reflecting that of confectionery made with concentrated sugar. The measured pH showed that the candy was slightly acidic. Both High soluble solids and the slightly acidic state might play some role in stabilising the product through reduced availability of water. It might also hinder the growth of certain spoilage microbes [29]. However, based on the given physicochemical parameters, we cannot declare its microbiologically safe or its shelf life in that. Water activity, microbiological stability and stability after storage have not been analysed in this case. Thus, a controlled storage of this candy including water-activity determination and microbiological analysis must be conducted to determine the stability and shelf life.

Table 6: Physicochemical properties of the optimized V2 candy.

Parameter	Observed Value
Total Soluble Solids, TSS (°Brix)	32.467 ± 0.351
Titratable Acidity (%)	0.413 ± 0.015
pH	4.126 ± 0.005

Note: Values are expressed as mean ± standard deviation (SD), n = 3. TSS was expressed in °Brix, titratable acidity as percentage acid equivalent, and pH as the measured hydrogen-ion concentration of the candy sample.

Colour Characteristics

Colour of the optimized V2 candy was measured on the L*, a*, b* tristimulus scale, where L* denotes lightness, a* denotes the degree of redness (+a*) or greenness (-a*), and b* denotes the degree of yellowness (+b*) or blueness (-b*).

The candy recorded an L* value of 24.89, indicating a relatively dark product consistent with the browning (caramelization and possible Maillard reaction) that occurs during the boiling stage of candy production. The a* value of 11.91 and b* value of 13.53 indicate a moderate red-yellow (brownish) hue, typical of heat-processed fruit candies. Chroma (C*), calculated from a* and b* as $C^* = \sqrt{a^{*2} + b^{*2}}$, was 18.025, reflecting a moderately saturated colour rather than a dull or a highly vivid one.

Table 7: Colour parameters of the optimized V2 candy.

Parameter	Symbol	Value
Lightness	L*	24.89
Redness/Greenness	a*	11.91

Yellowness/Blueness	b*	13.53
Chroma	C*	18.025

Note: Color values were measured using the CIE L*a*b* colour system. L* represents lightness, positive a* indicates redness and negative a* indicates greenness, while positive b* indicates yellowness and negative b* indicates blueness. Chroma (C*) was calculated as $C^* = \sqrt{a^{*2} + b^{*2}}$. Values represent the measured colour characteristics of the optimized V2 candy.

Sugar Profile

The optimized V2 candy exhibited a higher proportion of non-reducing sugars than reducing sugars (Table 8). The reducing sugar content was 15.38%, whereas the non-reducing sugar content was 29.06%. Reducing sugars accounted for 34.61% of the total sugar content, indicating that approximately two-thirds of the sugars were present in the non-reducing form. The higher proportion of non-reducing sugars indicates that non-reducing sugars constituted a major fraction of the measured sugar profile, while the lower proportion of reducing sugars may be attributed to the contribution of glucose and fructose from the fruit ingredients and/or changes occurring during candy processing. Overall, the sugar profile indicates that the optimized candy was characterized by a greater contribution of non-reducing sugars than reducing sugars.

Table 8: Sugar profile of the optimized V2 candy.

Parameter	Observed value
Reducing sugar (%)	15.38
Non-reducing sugar (%)	29.06
Reducing sugar as % of total sugar	34.61

Note: Non-reducing sugar was calculated from the difference between total sugar and reducing sugar.

Antioxidant Activity

The antioxidant activity of the optimized candy was evaluated using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical-scavenging assay. The optimized candy exhibited $55.52 \pm 0.03\%$ DPPH radical-scavenging activity based on five independent replicates ($n = 5$). The individual replicate values showed very low variation, ranging from 55.48 to 55.55%, indicating good analytical precision and consistency of the assay. The observed DPPH radical-scavenging activity demonstrates that the candy possessed appreciable free-radical-scavenging capacity, which may be attributed to the presence of naturally occurring antioxidant constituents contributed by the fruit-based ingredients. The result indicates that processing into the candy matrix retained a measurable proportion of the antioxidant potential of the fruit ingredients. However, DPPH activity represents an in-vitro chemical radical-scavenging response and should not be interpreted directly as an equivalent measure of antioxidant effects. (Figure 1).

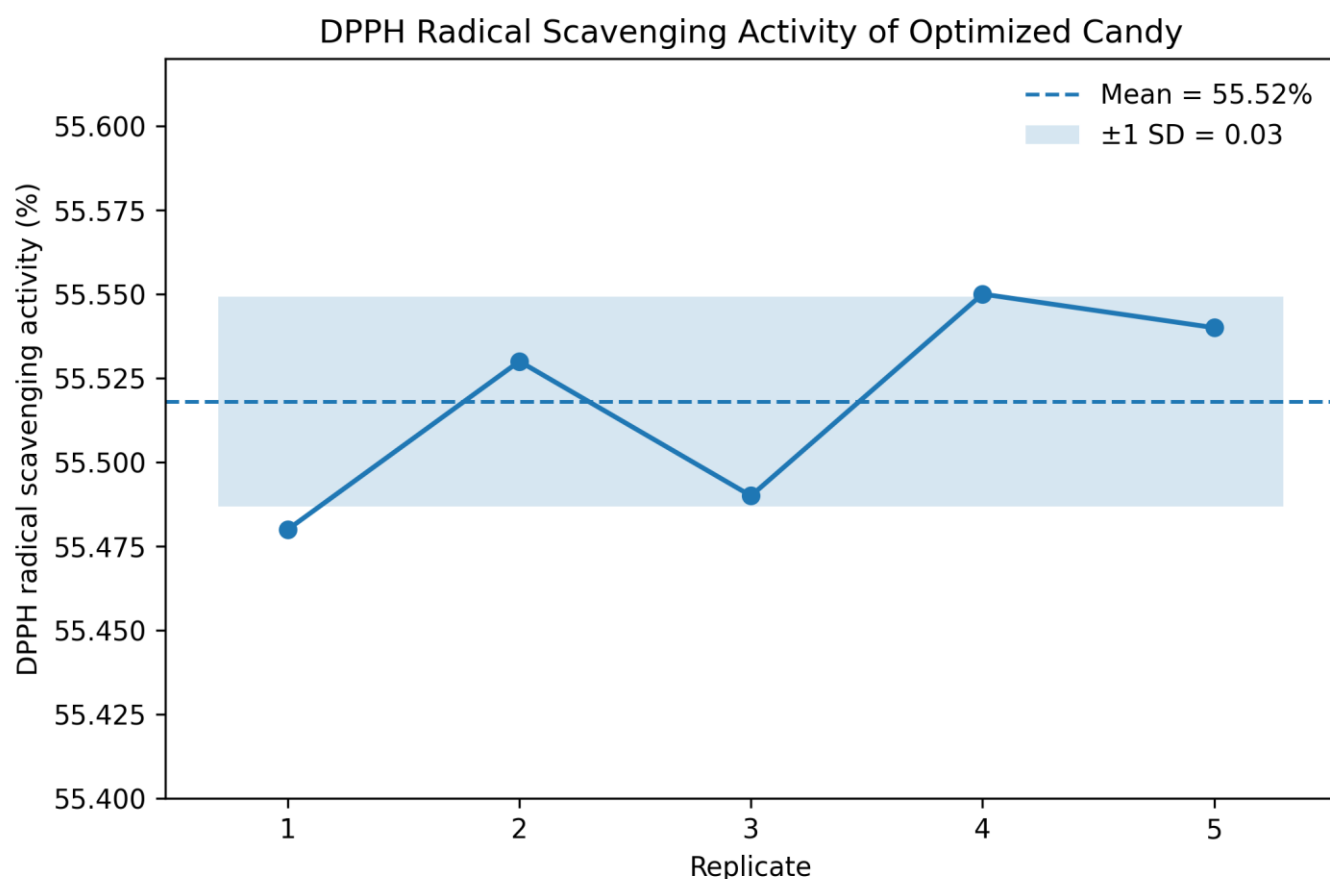


Figure 1: DPPH radical-scavenging activity (%) of the optimized candy across five analytical replicates. The dashed line represents the mean value (55.52%), and the shaded band represents ± 1 standard deviation (0.03%; $n = 5$).

Total Phenolic Content

The total phenolic content (TPC) of the optimized candy was 146 mg GAE/100 g. The measured TPC indicates the presence of Folin–Ciocalteu-reactive compounds in the optimized candy, consistent with the antioxidant activity observed in the DPPH assay. However, the present study did not determine individual phenolic compounds or establish the extent of phenolic retention during processing.

Beta-Carotene Content

The optimized candy contained 0.48 $\mu\text{g}/100\text{ g}$ β -carotene. The detection of measurable β -carotene indicates that carotenoid compounds were retained in the product after processing. However, the present study did not quantify the individual carotenoid profile or determine carotenoid retention during processing. Further chromatographic analysis would be required for compound-specific confirmation.

DISCUSSION

A trend of declining ascorbic acid concentrations from 366 to 236 mg/100g for the three ripen stages, is found in concurrence to the build-up of this nutrient component in certain species of jujubes. Reduced content of ascorbic acid, in conjunction with decreased values of certain other phenolic compounds, was recorded for fruits of *Z. Jujuba* during fruit growth with accompanying increment of soluble sugar content [23].

These finding appear more of *Z. Mauritiana* fruits grown in Lucknow than were observed for any other species but as a whole these values and conclusions are supported by recent research. Comparison of quantitative values in studies conducted with different species/cultivar/location and methodology must always be interpreted with caution. A highest vitamin C concentration in unripe fruits support the premise of raw material

selection on the condition of highest possible initial vitamin C content. This choice must not be in the singular direction for each product type, on the contrary mature fruits should perhaps be chosen as the raw material for certain applications, which in some part is due to preference by humans for sensory characteristics such as sweet taste, flavour transformation with an accompaniment of change in colour and texture [23]. Distinct variation in cultivars has been reported and described with respect to vitamin C contents and other physicochemical constituents for Indian jujubes germplasms [17].

Choice of V2 formulation as a candy type is statistically sound owing to established practice of extensively utilizing empirical knowledge derived from hedonic assessment and preference comparison testing for food product development and final formulations [8]. Several studies using Cape Gooseberry juices have examined and demonstrated the correlation between physical, antioxidant and sensory characteristic and processing parameters including different fruit ratios used in various products [4] showing an optimal level of fruit load. Thus, it is not unreasonable to expect to formulate a product based on the presented methodology yet because the test panel consisted only of students the results will likely be biased toward taste preferences common among college students. Studies in the development of fruits based processed confectionary have also utilized these same testing methods to observe flavour change according to product variation [25,26,28].

The important nutritional and phytochemical benefits, in terms of vitamin C, carotenoids, phenolics, etc [9, 22, 6] as evidenced by the vitamin C content measurements and observed from the higher mean score for panel preference for sample V2 (high on descriptive sensory characteristics), shows there will be nutritional value associated to Cape Gooseberry in processed products. None the less even though measurement of VOC and individual pigment compounds were conducted, it is possible that this affects the overall acceptability of fruit confectionery products. The decline in ascorbic acid content during product formulation could be attributed to factors related to ingredients used and heat related degradation during processing [7, 11] since Vitamin C is highly prone to heat and air mediated degradation and may show large losses during prolonged cooking times and also to sweetener type [20]. A range of studies on modification and optimization of ingredient and processing for a particular confectionary product based upon derived value-added products could potentially improve on nutraceutical benefits [26,27].

The high DPPH assay values along with high total phenolic content indicate a strong presence of antioxidants. However, an argument cannot be made regarding specific 'health promoting' properties, since such assays are often method-specific [14, 16]. The Folin-Ciocalteu reaction has also been known to be indicative of a greater degree of reduced non-phenolic compounds than intended [2]. Consequently, the values generated were presented in a qualitative index form and should not be viewed as a health claim. The results for composition are in agreement with the characteristic qualitative composition profile for a sugared dried product: low moisture content at stable sugar content and a resulting solid sugar matrix that forms during elimination of moisture upon formation of a hot syrup whose specific properties is dictated heavily by the formulating ingredient and processing parameters. These include parameters for controlling grain size, consistency, texture and self-life of the final product [10]. Lack of research for water activity, product storage stability and Microbiological investigations means no inferences can be made on either safety of food or shelf-life purely on estimated pH levels alone. More recent studies on processed foods incorporate under-utilised fruit and botanicals and analyse them based on their phenol profile and anti-oxidant content [25,26,28]. There is also a great need to address and consider alternative Vitamin C assays besides DCPIP. Although DCPIP is cheap to use and easy to perform it is susceptible to reacting with a multitude of other reducing substances and affected by the colour intensity of the sample. More validated research for alternative testing methodologies has found other approaches to provide greater accuracy for testing, and while DCPIP can be acceptable, the results require careful interpretation and should ideally be validated against an HPLC method if scientifically accurate results are required and if validation can meet acceptable criteria [1, 21].

Limitations and Future Research

The present research has many limitations. We used a very small and only partially-trained sensory panel (n=10) and no statistical analysis on the panel member scores was performed. The DCPIP colorimetric method used as measure of the total ascorbic acid content can be influenced by other reducing agents, as well as the sample's coloration; in the same way the DPPH and the Folin-Ciocalteu methods only represent indices

measured by means of laboratory analyses (in vitro results and method dependent indices) rather than reliable indices of real in vivo values. Microbiological quality, water activity, shelf-life and storage stability were not assessed; hence we can't confirm or deny the microbiological safety and determine the quality throughout storage. Further investigations need to apply a vitamin C analysis based on a reliable chromatographic method, larger sensory panels with statistically significant, the calibration values regarding all the analysed parameters, water activity, microbiological and stability studies.

CONCLUSION

The highest concentration of ascorbic acid in measured concentration was generally lower from green immature Indian jujube to the full mature fruit; whereas in our research the highest concentration of measured ascorbic acid in a fruit reached in green immature fruit. A hard-boiled confection based on that fruit and cape gooseberry was developed, that gives best results using a candy made with 40% jujube and 60% cape gooseberry in the final 30 mL of added juice. The obtained product has measured vitamin C concentration, the presence of phenolic-reactive components, -carotene, DPPH free radical scavenging and predictable sugar candy composition (predominant product were sugar). This research points out a viability of enhancing the value of Indian jujubes and cape gooseberries using fruit candy production process. The promising sensory attributes are, however descriptive, because statistical testing was not carried out on the raw data of each panel member, microbiological challenges were not made on a product, it cannot be assumed shelf- life of the product has not been obtained and that health effects are proven in-vivo. Thorough experimental statistical testing of accurate vitamin C determination, water activity value, microbiology with storage trials and analysis is needed before promoting for commercial use and advertising about healthy aspects.

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