Chapter 6

Development of functional coconut water jelly by incorporating anthocyanin microcapsules and its characterization

6.1. Introduction

New product development (NPD), "ready to eat" (RTE) for consumption, fortified with functional ingredients, are increasing its popularity in recent times. Food industries are in search for alternatives to this new technology that are enriched in natural antioxidants. Great efforts have been made by confectionary industry in recent years on innovation of technology based on confectionary processing to replace with synthetic natural ingredients with healthier alternatives [1, 31]. Natural antioxidants are known to possess potential nutraceuticals that provide many health benefits and physiological functions which includes prevention of many diseases [13]. These natural antioxidants are also present in plant materials and are mainly polyphenols.

Products such as jelly candies, which is one of the RTE food, are generally soft elastic texture and found with different flavours mostly consumed by toddlers and minors [18]. These candies are obtained by cooking sugar and gelling agent at higher temperatures (>100°C). The aqueous dispersions are mainly prepared using gelatine, sugar, starch, acids, pectin and other ingredients under adequate temperature treatment so that active compounds do not get degraded and offer better opportunities for enrichment [3, 20]. After the boiling process, the colouring and flavouring agents are added into the aqueous dispersion to intensify the appealing nature of the food product being developed [31]. They are also developed based on fruits or bioingredients extracted from fruits that contains antioxidants and enhance health beneficial properties [9]. Literatures has shown that jelly candies were also prepared using rosemary extract, which is high in antioxidants, as a possible strategy to obtain healthier RTE food product [7]. Moreover, application of grape juice as natural colorant in jelly candy was also performed by Nishiyama-Hortense et al., [9]. Utilization of sweeteners or honey as sugar substitutes in preparation of jelly candy has also been reported in recent studies [24]. Many literatures have shown preparation of jelly from fruit extracts and from various sources of fruit juices. However, limited studies are carried out on jelly prepared from coconut water, a well-known subtropical drink obtained from green coconut fruit (*Cocos nucifera L*) except for jelly prepared using coconut water as the major ingredient with the aim towards its utilization [25].

Coconut water has become a well-known drink and has also been gaining popularity in food and beverage industry due to its high nutritional characteristics [10, 28, 35]. It has also been demanded for its pleasant sweet smell from different parts of fruit such as coconut meat and water [15]. It contains about 5-8 % TSS (total soluble solids) where sugars (3-7 %) are the majority [17]. Remarkable content of various nutritional properties like minerals and salts such as sodium, potassium, magnesium, chloride and also of sugars. It has also been a known drink with great potential to many sports persons for rehydration and health [41]. Various important compounds are also known to be present in coconut water which includes free amino acids such as histidine, serine, isoleucine, tyrosine, glycine, phenylalanine and leucine, vitamins of the B-complex and enzymes (dehydrogenase, diastase, catalase, phosphatase, peroxidase, polyphenol oxidase, RNA polymerases [32]. The antioxidant activity of coconut water has been reported and identification of phenolic compounds were also studied [17]. However, few literatures have reported the importance of coconut water regarding its antioxidant activity and phenolic contents. The literatures also include the preservation process using green technology like ultrasound, thermosonication, high pressure homogenisation from enzyme activity to ensure microbial quality and maintain the original sensory characteristics [6]. Despite the fact that thermal treatment process kills microorganisms, the high resistivity of native enzymes required a process intensity which results in sensorial and nutritional drawbacks [32].

Considering its popularity, utilization of coconut water can also be done in NPD in food industries. Consumers are nowadays very much aware of the demand of a healthy diet and balanced life [21, 23]. Thus, the present research work aims to develop anthocyanin-loaded coconut water jelly which can effectively contribute to the health both from coconut water as well as anthocyanin which is an antioxidant.

6.2. Material and methods

6.2.1. Raw materials and chemicals required

The freshly harvested coconut water was procured from the local market of Tezpur University, Assam. The coconut water was analyzed for the total soluble solids, pH and titratable acidity. The main ingredients required for preparation jellies such as sugar, pectin (urban platter) and citric acid (urban platter) were purchased from Amazon. All the materials purchased were of food grades. And the chemicals required for the analysis were analytical grade.

6.2.2. Preparation and production of anthocyanin-loaded coconut water jelly

The development of coconut water jelly was performed using the method as described by Giridhari et al., [14]. with some modification. Initially, granulated sugar (60 %) was homogenized manually with coconut water (37 %) and heated upto 90 ºC till the sugar granules dissolved. Hydration of pectin (1.8 %) was conducted in the sugar syrup at temperature 80-90 ºC vigorously with continuous stirring manually. The hydrated pectin was then added in the sugar syrup solution and stirred well. The mass was further boiled for 5 min followed by the addition of citric acid (1.2 %). The final solution was boiled until the TSS becomes 68-72 ºBrix. It was then poured in the glass container (about 200 mL each). The mass was then cooled with manual stirring till the temperature becomes 80 ºC. Four coconut water jelly loaded with anthocyanin microcapsules were prepared. Anthocyanin microcapsules (2.71 mg/100 g) were obtained previously from black rice bran using double emulsion complex coacervation technique [13]. The four jelly samples viz., J_c, the control (coconut water jelly), J_1, with 1 % anthocyanin microparticles, J_2, with 2 % anthocyanin microparticles, J_3, with 3 % anthocyanin microparticles obtained by double emulsion coacervation were produced.

6.2.3. Judging the end point of jelly

The end point in boiling a jelly can be judged by the following ways: determination of boiling point of the aqueous dispersion with a thermometer and by carrying out sheet or ladle test. A small portion of the jelly was taken out using a big spoon or wooden ladle, cool slightly and then allowed to drop off. If the jelly drips like a syrup, it needed more cooking, while if it falls off in the flakes or sheet form, the end point has been reached.

6.2.4. Determination of moisture content

The moisture content (M.C) of anthocyanin-loaded coconut water jelly samples were determined by modifying the method described by Mutlu et al.,[24]. For determination, jelly samples (1 g) were weighed and dried in the hot air oven at 60 ºC till it became a constant weight. Then, the moisture content was determined using the Eq. (6.1).

$$M.C\ (\%) = \{(\text{Initial wt.}-\text{Final wt.})/\text{Initial wt.}\} \times 100 \tag{6.1}$$

6.2.5. Determination of pH value, titratable acidity and total soluble solids

The pH value of the coconut water jelly was analyzed by homogenizing the sample of 1 g in 9 mL deionized water at 50 ºC using an ultraturrax homogenizer (T25, IKA India Pvt. Ltd., Bengaluru, India). Then the pH of the all the dispersions were recorded using a digital pH meter at room temperature.

The titrable acidity of the coconut water jelly was determined by acid-base method [30]. The suspension prepared earlier as described in the analysis of pH was titrated with 0.1 N NaOH in a continuous stirring using magnetic stirrer till the pH becomes 8.1. Then, the results were expressed as mEq/kg or % [24].

The total soluble solids (TSS) of all the jelly samples were recorded using a hand-held refractometer and the value of TSS were recorded from the refractometer directly.

6.2.6. Determination of texture profile

Textural profile (TPA) of coconut water jelly was analyzed using a Texture Analyser device (TA-HD plus, Stable Micro System, UK) with a glass circular probe (45 mm of diameter). A P/45 probe was used to compress jelly samples with the cylindrical probe (weighing approximately about 7.38 g). The pre-test speed and test speed of 5.0 mm/s and 0.1 mm/s respectively and post-test speed of 0.5 mm/s were performed. A two-cycle compression force versus time program was used to compress the samples till 70% of the original jelly sample, return to the original position and again compress. Parameters recorded from the test curves were firmness and adhesiveness. This process was carried out in triplicate.

6.2.7. Determination of color

The color potency of anthocyanin loaded coconut water jellies with different percentage of microcapsules powder was determined by using Hunter colorimeter (CIE color scales L^*, a^* and b^*) (Ultra Scan VIS, HunterLab, a41-1013-504, Reston, VA). Where the L^* color parameter represents lightness or darkness of the sample from 0 (black) to 100 (white), the a^* color parameter represents redness (+*a*) to greenness (-*a*) and b^* color parameter represents the degree of yellowness (+*b*) to blueness (-*b*). The jellies were packed in a zip lock transparent bag and measurement of color were performed. Calibration of the equipment was performed first using white calibration plate before recording any reading. Chroma and hue values were also calculated from the following Eq. (6.2) and (6.3).

$$\text{Chroma} = C^* = \sqrt{(a*^2 + b*^2)} \quad (6.2)$$

$$\text{Hue} = H^* = \arctan(b^*/a^*) \quad (6.3)$$

6.2.8. Sensory analysis

Sensory evaluation of anthocyanin loaded coconut water jelly samples were performed using the standard method described by Amerine et al., [2]. The jellies were evaluated by panel of 30 semi trained panelists where each sample was evaluated for various sensory quality attributes viz. colour, texture, aroma, taste and overall acceptability. The samples were evaluated for all the quality attributes using on 9-point Hedonic Scale indicating 9 as 'like extremely', 8 as 'like very much', 7 as 'like moderately', 6 as 'like slightly', 5 as 'neither like nor dislike', 4 as 'dislike slightly', 3 as 'dislike moderately', 2 as 'dislike very much', 1 as 'dislike extremely'.

6.2.9. Determination of total phenolic content

The total phenolic content (TPC) for digested solutions of anthocyanin-loaded coconut water jelly were evaluated by Folin-Ciocalteu method [26]. Aliquots of 1 mL of suspended jelly solutions (Section 2.5) was mixed with sodium carbonate solution (4 mL of 7.5 % w/v) in a test tube. Further, the solution was mixed with 5 mL of dilute Folin-Ciocalteu reagent (1 FCR:10 distilled water). The dispersion was then vortexed and kept in the dark for 30 min at room temperature. The absorbance was recorded at 765 nm against blank solution using UV-Vis spectrophotometer and the TPC was expressed as mg GAE equivalent per 100 g of coconut water jelly.

6.2.10. Determination of total anthocyanin content

Total anthocyanin content (TANCs) of the suspended solutions was measured using the pH differential method as described by Yodmanee et al., [40]. Mixing of potassium chloride solution (2 mL of 0.025 mol L^{-1}) with the digested solution (20 µL) was carried out at pH 1 and sodium acetate buffer (2 mL of 0.4 mol L^{-1}) at pH 4.5. The dispersions were kept in the dark for 15 min and then the absorbances were recorded at 550 and 700 nm using UV-VIS spectrophotometer (Spectronic 20D+, Thermo Scientific, USA). Distilled water was used as a blank.

The total anthocyanin content of all the jelly samples were evaluated using Lambert-Beer Law and was expressed as cyanidin-3-glucoside equivalents as follows (Eq. 6.4):

$$\text{TANCs (mg/L)} = [(A \times \text{Extract volume} \times \text{MW} \times 1000) / (\varepsilon \times 1)] \quad (6.4)$$

Where: $A = (\text{Abs}_{\lambda700-\lambda550})_{\text{pH } 1.0} - (\text{Abs}_{\lambda700-\lambda550})_{\text{pH } 4.5}$;

ε = molar absorptivity of cyanidin-3-glucoside (26,900 L/cm mol);

MW = molecular wt. of cyaniding -3-glucoside (449.2 g/mol).

6.2.11. Antioxidant activity

The antioxidant activity was determined using DPPH radical scavenging activity by modifying the method described by Mir et al., [19]. Approximately 100 µL suspended solution was taken and mixed with 1.4 mL of freshly prepared 2,2-diphenyl-1-picrylhydrazyl (DPPH) methanolic solution (0.2 mM) in a test tube and shaken vigorously. Further, 3.5 mL of methanol was added into the solution and allowed to stand in dark for 30 min. The absorbance (Abs.) was then recorded at 517 nm. The scavenging activity was calculated by using the formula given in Eq. (6.5).

$$\text{DPPH radical scavenging activity (\%)} = \{(\text{Abs}_{\text{control}} - \text{Abs}_{\text{sample}})/\text{Abs}_{\text{control}}\} \times 100 \quad (6.5)$$

6.2.12. Microbial analysis of jelly (Total plate count, yeast and mould count)

The growth and microbial contamination for all the jellies developed were analysed after 30 days by the method of standard plate count using the media; plate count agar (PCA) for total plate count (TPC) and potato dextrose agar (PDA) for yeast and mould count. The sterile double distilled water was used in control. After the incubation of the plates, counting of the microbial growth was performed under at 37 ºC for 24 h and 27 ºC for 48 h for PCA and PDA respectively (Ranganna 2010).

6.2.13. Statistical analysis

All the analyses were performed in triplicates. Data have been depicted as mean ± SD. Significant differences tests between means have been analysed by Duncan’s multiple range tests at significance level ($p \leq 0.05$) using SPSS Statistics 20.

6.3. Results and discussions

The TSS, pH and titrable acidity of freshly harvested coconut water were found to range between 5.8 to 7 ⁰ Brix, 4.7 to 5.3 and 0.03 to 0.05 % respectively. The total phenolic content and the antioxidant activity of the fresh coconut water were found to be 6.32±0.83 mg GAE/g and 60.90 ±3.65 % respectively.

6.3.1. Moisture content

The moisture content of all the coconut water jelly samples ranged from 23.90 to 24.83 % (Table 6.1). They do not significantly differ from one another. The results so obtained for moisture content of anthocyanin-loaded coconut water jelly found to be little lesser than those observed by Panchal et al., [27] and Bansode et al., [5] where the jelly is prepared from dragon fruit and anthocyanin rich purple fleshed sweet potato respectively. The low moisture content value indicated that the product can stay for longer duration without spoilage from microbial growth. However, no significant difference was observed in the jelly samples ($p \leq 0.05$). And it is also desirable to have a reduced moisture content for longer shelf-life of the product. Moreover, the higher the moisture content, the flavour of the products get affected [4].

6.3.2. Titrable acidity and pH

The titrable acidity of all the samples was found to range between 0.51 to 0.55 % and does not differ significantly from one another ($p \leq 0.05$). This acid value can be due to the presence of citric acid as an ingredient which also indicates as good preservative. Titrable acidity value thus obtained in Table 6.1 for all the coconut water jelly sample was found to be similar as observed in the jelly produced from different commercial brands of orange juice, guava, apple, pineapple, mixed fruit and mango, however, the lowest acid value (0.19 %) was found in mango jam [22]. According to Bangladesh Standards and Testing Institution (BSTI), the reference value for active acidity is ≤0.90 %. Thus, the acid value for the jelly developed from coconut water also found lower value than the reference value.

Again, the pH value of jelly samples ranged from 3.52 to 3.55. According to literature, the standard pH value for jelly is 3.4 [34]. Generally, at neutral pH, bacteria can grow. Inhibition of most of the bacteria could be seen at pH values of 2.5–3.8. However, the yeasts are unaltered by the low pH value [34]. Moreover, the stability of the anthocyanin may be largely affected by pH. And at low pH, anthocyanins are stable which are largely accompanied by the higher concentration of *flavylium* cation and therefore, the jelly thus developed from coconut water found suitable for application of this anthocyanin microcapsules. No significant difference was observed in all the jelly samples ($p \leq 0.05$).

6.3.3. Total soluble solids (TSS)

The major contributors of TSS contents are sugar and fruit acids. The high TSS value generally means the sugar content is more in the sample. In the present study, the total soluble solid of all the jelly sample ranged between 69 to 70.33 ⁰Brix (Table 6.1). As the composition are the same for all the developed jelly, the TSS does not significantly differ from one another. The standard value of TSS range should be slightly higher than 65% [12]. The higher value of TSS could be because of the conversion of polysaccharides into sugars in the presence of organic acids [16, 27].

Table 6.1: Physico-chemical characterization of anthocyanin-loaded coconut water jelly

Jelly	Moisture (%)	pH	Titrable acidity (%)	Total soluble solid, TSS (⁰Brix)	Firmness (N)	Adhesiveness
J_C	24.36 ± 1.33^a	3.55 ± 0.02^a	0.51 ± 0.01^a	70.33 ± 1.53^a	2.95 ± 0.31^a	-739.44 ± 13.56^b
J_1	23.90 ± 1.36^a	3.52 ± 0.04^a	0.52 ± 0.02^a	69.50 ± 1.29^a	3.96 ± 1.00^b	-733.05 ± 46.99^b
J_2	24.57 ± 1.07^a	3.53 ± 0.17^a	0.55 ± 0.02^a	69.00 ± 1.73^a	3.56 ± 0.96^b	-647.06 ± 71.49^a
J_3	24.83 ± 1.89^a	3.54 ± 0.05^a	0.55 ± 0.05^a	69.25 ± 1.26^a	3.95 ± 0.11^b	-678.26 ± 126.87^a

All data are the mean ± SD of three replicates. Mean followed by different letters in the same column differs significantly ($P \leq 0.05$)

Fig. 6.1. Anthocyanin-loaded coconut water jelly and the control sample

6.3.4. Texture profile

Texture is an important parameter for analyzing the quality attributes of any food product. The parameters include hardness, adhesiveness, cohesiveness and chewiness. The coconut water jelly loaded with anthocyanin showed a pleasant texture which is easier to chew without sticking. The firmness and the adhesiveness values are represented in Table 6.1. Firmness or hardness is an extreme force required to compress down the jelly sample. It was reported that the control sample required a lesser force as compared to the anthocyanin-loaded coconut water jelly. This may be due to the changes occurred in texture during the preparation stage of jelly being incorporated with anthocyanin microcapsules and the continuous stirring process. The firmness values ranged from 2.95 to 3.95 N for all the jelly samples. Again, the high value of firmness may be due to the moisture being absorbed by the microcapsules from the jelly sample, hydrocolloids presence and extract concentration in encapsulates. Moreover, hardness could also be affected by the release of anthocyanin from the microcapsules due to its higher diffusion rate in the jelly matrix.

The negative force of the first bite between food sample and its surface represents the food property of sticking to teeth [33]. The adhesiveness values ranged between 647.06 to 739.44.

6.3.5. Color

The color parameters with different percentage of anthocyanin-loaded coconut water jelly were analyzed and presented in Fig. 6.1, Table 6.2. Significant difference ($p \leq 0.05$) was observed in the color values at different time intervals for two months when stored under room temperature. These results represented the lightness, redness and yellowness for all developed anthocyanin-loaded jellies. The color parameter, L^*, a^* and b^* value decreases with increasing the storage time period up to 60 days for all the jellies. This means that the anthocyanin microcapsules started to leach out with time within the matrix of coconut water jelly. Slow release of anthocyanin was observed from the microcapsules in the jelly. The color of anthocyanin is dependent on pH which is due to the structure of anthocyanins having an ionic nature [39] which means the structure tends to change at different pH. However, anthocyanin molecules are stable at lower pH which is accompanied by high concentration of flavylium cation [8].

Thus, the jelly developed were found suitable for incorporation of the anthocyanin microcapsules. The decrease in the color parameters indicates that the color of jelly changes to darkness from lightness. Again, the change of color to darker is associated with increasing in the percentage of anthocyanin microcapsules. a* value also reduces which indicate that the color tends to change to yellowness.

Table 6.2: Color stability of anthocyanin-loaded coconut water jelly

Days	Treatment	L*	a*	b*	C*	H*
0	J_C	35.69±0.97[b]	0.31±0.19[a]	3.38±0.90[bc]	3.48±0.35[a]	1.48±0.56[b]
	J_1	31.17±1.23[a]	2.36±0.19[b]	2.43±0.65[b]	3.43±0.83[a]	0.80±0.42[a]
	J_2	35.41±1.08[b]	5.23±0.55[c]	4.01±1.30[c]	6.69±1.42[b]	0.65±0.13[a]
	J_3	31.09±0.69[a]	3.09±0.95[b]	1.89±0.91[a]	3.78±0.23[a]	0.55±0.23[a]
30	J_C	33.10±0.22[c]	-0.14±0.05[a]	1.05±0.22[a]	1.06±0.35[a]	1.44±0.24[a]
	J_1	29.36±1.57[a]	0.37±0.13[a]	1.17±0.35[a]	1.22±0.74[a]	1.26±0.35[a]
	J_2	30.94±0.48[b]	0.67±0.08[ab]	1.02±0.49[a]	1.83±0.21[b]	0.98±0.52[a]
	J_3	29.87±0.68[a]	1.22±0.09[b]	2.26±0.55[b]	2.56±0.45[c]	1.07±0.42[a]
60	J_C	31.62±1.46[b]	-0.69±0.05[a]	1.08±0.04[a]	1.66±0.28[a]	1.57±1.00[a]
	J_1	29.14±1.86[a]	0.42±0.02[a]	1.28±0.05[a]	1.82±0.34[a]	3.02±1.25[b]
	J_2	29.69±1.53[ab]	1.72±0.04[b]	0.93±0.29[a]	3.84±0.96[b]	1.54±0.04[a]
	J_3	29.53±1.17[a]	1.36±0.33[b]	1.73±0.38[b]	4.86±0.20[c]	1.27±0.90[a]

All data are the mean ± SD of three replicates. Mean followed by different letters in the same column differs significantly ($P \leq 0.05$)

6.3.6. Total phenolic content

Table 6.3 represents the retention values of total phenolic content of anthocyanin-loaded coconut water jelly varied from 2.73 to 13.69 %. All the jelly samples showed significant increase of TPC with increase in anthocyanin percentage. As reported by Mahayothee et al., [17] and Seow et al., [35], the TPC of coconut water ranged between 5.18 to 7.08 mg GAE/100 mL and 6.26±9.09 mg GAE/100 mL respectively. Also, it is also reported that the TPC of green coconut water was significantly higher than mature coconut water. The TPC of green coconut water and mature coconut water was reported to be 5.57±2.88 mg GAE/100 mL by Seow et al., [35]. However, during preparation of jelly, thermal treatment has decomposed some of the phenolic compounds including flavonoids and anthocyanin which caused the loss of their antioxidant activity. The content of the anthocyanin microcapsules incorporated was not affected resulting from the sum of the ingredients thereby providing a higher amount of TPC in the developed coconut water jelly.

6.3.7. Total anthocyanin content (TANCs)

The total anthocyanin content for all the jelly samples varied from 380 to 600 µg C3G/g and is presented in Table 6.3. The data indicated that the total anthocyanin content increased with the increase in the microcapsule percentage in the anthocyanin-loaded coconut water jelly. The obtained results for total anthocyanin retention in the jelly were similar to those obtained by de Moura et al., [8] where jelly candy was developed using anthocyanin encapsulates from hibiscus extract. The total anthocyanin content found were 0.211, 0.149 and 0.156 for the jelly candy developed with: free hibiscus anthocyanin extract, particles obtained by atomization and dripping-extrusion respectively. In the present study, it could be observed that, the anthocyanin microcapsules are entrapped within the jelly matrix and tend to leach out little amount of anthocyanin with time as it is a semi-solid in nature. However, the content of jelly was not affected.

6.3.8. Antioxidant activity

The antioxidant activity of fresh coconut water was found to be 60.90 ±3.65 %. And the jelly produced using anthocyanin microcapsules ranged from 35.44 to 41.15 %. Significant different was observed in all the jelly produced ($p \leq 0.05$). The reduction of the antioxidant activity may be due to degradation of phenolic compounds, as discussed in the TPC analysis, occurring during the cooking process. All the jellies showed -OH scavenging activity with 35.44 to 41.15 % inhibition (damage to deoxyribose). The result so obtained was found similar with the result obtained by Cedeño-Pinos et al., [7] where jelly candy was developed using rosemary extract.

6.3.9. Microbial quality of coconut water jelly

The total plate and yeast count of all the jelly samples are shown in Table 6.3. According to microbial standards, mould counts should not exceed 1000 CFU/g [34]. In the present study, visible moulds were not observed on any sample after 30 days of storage except for the control sample which is coconut water jelly without anthocyanin microcapsules. However, the total plate and yeast count of the jelly samples were below 5 CFU unit. This may be due to the presence of major percentage of sugar content in the jelly matrix during preparation and may also be due to high heating temperature. Earlier studies have shown that diverse additives such as potassium sorbet and sodium benzoate decrease the microbial count and their measurements were compelling against mould amid 90 days of capacity [36]. Based on the microbial analysis, the product was considered safe for consumption up to 1 month storage period. It can also be concluded that by-product of coconut; coconut water can be used effectively for development of food products like jelly or other confectionary food products. Further studies can be employed for identification of the proper storage condition.

Table 6.3: Biochemical characterization and microbial analysis of anthocyanin-loaded coconut water jelly

Jelly	**Total phenolic content (mg GAE/g)**	**Total anthocyanin content (µg C3G/g)**	**Antioxidant activity, DPPH (%)**	**Microbial growth (cfu/g)**	
				Total plate count (cfu per g)	**Total yeast count (cfu per g)**
J_C	2.73±0.01[a]	ND	35.40±1.59[a]	3×10^{3}[b]	1×10^{3}[a]
J_1	5.74±0.02[b]	380±1.01[a]	37.30±2.66[b]	1×10^{3}[a]	1×10^{3}[a]
J_2	10.54±0.02[c]	480±1.10[b]	39.31±1.14[c]	1×10^{3}[a]	1×10^{3}[a]
J_3	13.69±0.02[d]	600±1.12[c]	41.15±1.53[d]	1×10^{3}[a]	1×10^{3}[a]

All data are the mean ± SD of three replicates. Mean followed by different letters in the same column differs significantly ($P \leq 0.05$)

6.3.10. Sensory properties

Sensory analysis was carried out under white light to evaluate the acceptance and sensory profile of the developed jelly samples. Table 6.4 represented the sensory results of developed anthocyanin-loaded coconut water jelly. For acceptance analysis, the jelly samples were previously coded with random numbers and served on a container to the evaluators. Significant difference was not observed for the sensory parameters viz. taste, appearance, aroma and adhesiveness ($p \leq 0.05$).

The data indicated that the score for taste and texture increased from 7.57 to 8.07 and 7.64 to 7.93 respectively, which means the anthocyanin-loaded jelly was more favourable by the panellists than the control jelly in terms of taste and texture. The loss of aroma was reported from 7.64 (J_2) to 7.07 (J_3). This result was found similar to 8.23 to 8.19 in karonda jelly reported by Singh (2010), 7.55 to 6.15 in guava-carrot jelly reported by Singh and Chandra [37] and 7.70 to 5.20 in sapota and beetroot blended jelly reported by Deokar et al., [11]. The aroma for all the developed jelly were less as compared to the coconut water. This may be due to the undesirable changes induced during thermal treatment of jelly preparation process as temperature plays major role in food preparation leading to development of off flavour. The data indicated that the score for adhesiveness of the samples decreases from 7.85 to 7.47. The control sample (coconut water jelly) without anthocyanin microcapsules were mostly liked by the panellists. Decrease in consistency was also reported during study of storage of karonda jelly [38]. The data indicated that the overall acceptability score gradually increased with anthocyanin percentage. However, the overall acceptability score for the highest anthocyanin content was the lowest. The decreased in overall acceptability score may be because of undesirable change occurred as high percentage of anthocyanin content in it. Overall, coconut water jelly loaded with anthocyanin could be used as a functional ingredient without negotiating any consumer acceptance. The jelly prepared with 2 % anthocyanin received the highest overall acceptability.

Table 6.4: Sensory analysis of anthocyanin-loaded coconut water jelly

Jelly samples	**Taste**	**Texture**	**Appearance**	**Aroma**	**Adhesiveness**	**Overall acceptability**
J_C	7.57 ± 0.85^{a}	7.64 ± 0.74^{b}	7.57 ± 0.76^{a}	7.29 ± 1.14^{a}	7.85 ± 0.82^{a}	7.57 ± 0.76^{ab}
J_1	8.07 ± 0.83^{a}	7.86 ± 0.66^{b}	7.43 ± 0.85^{a}	7.57 ± 0.85^{a}	7.23 ± 0.59^{a}	7.79 ± 0.66^{ab}
J_2	8.07 ± 1.00^{a}	7.93 ± 0.92^{b}	7.82 ± 0.79^{a}	7.64 ± 0.63^{a}	7.17 ± 0.72^{a}	8.00 ± 0.78^{b}
J_3	7.43 ± 0.76^{a}	7.00 ± 0.96^{a}	7.50 ± 1.16^{a}	7.07 ± 0.62^{a}	7.47 ± 0.68^{a}	7.36 ± 0.74^{a}

All data are the mean ± SD of three replicates. Mean followed by different letters in the same column differs significantly ($P \leq 0.05$)

6.4. Conclusions

Considering the popularity and the demand for functional foods, anthocyanin microcapsules which was developed from plant source as a bioingredient, was successfully incorporated in the coconut water jelly, contributing with considerable amount of anthocyanin-rich phytocompounds. From the characterization, the jelly produced with the highest percentage of anthocyanin microcapsules showed higher retention of TPC, TANCs and provided the best antioxidant activity. The microbial analysis showed that visible moulds were not observed for the sample within the storage period of 30 days. It can be concluded that the jelly thus developed with loaded anthocyanin can be a source stable nutraceutical. The application has also shown to be feasible technically, providing the product with color and functionality.

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