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Effects of Blanching on Physicochemical Properties of Chantenay Carrots Juice and Assessing the Qualities of Formulated Carrot-MD2 Pineapple Juice Blends

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Abstract This study was carried out to determine the effects of three blanching methods on carrots and also to assess the physico-chemical and sensory properties of formulated Chantenay carrot-MD2 pineapple juice blend. Hot water, steam and microwave blanching were the methods used and the respective blanching temperatures were 98, 105 and 75 ºC for 10 minutes each. Physicochemical properties determined on the juices extracted by gravity from blanched carrots were yield, pH, total soluble sugars, total solids, ash and vitamin C. There were significant differences ($p<0.05$) in the yield, vitamin C and total solids of the blanched and unblanched carrots. Steam blanching method was chosen for the formulation of the carrot-pineapple juice blend due to its high yield and ash content of 76.65 and 0.66% respectively. The carrot juice from the steam blanching process was formulated with MD2 pineapple juice into various ratios of 50:50, 60:40, 70:30 and 100:0 with the carrot juice being the major component. A preference ranking test carried out on the formulated carrot-pineapple juices indicated that the 50 untrained panellists mostly preferred the 50:50 formulated juice. Proximate and physicochemical analyses were conducted on the 50:50 formulated carrot-pineapple juice and had the following compositions: fat (0.25%), ash (0.25%), protein (0.78%), crude fibre (2.68%), carbohydrates (23.47%), moisture (72.57%), vitamin C (12.40 mg/100 g), β-carotene (955.71 µg/100 g), pH (4.45), total soluble sugars (14.87%) and titratable acidity (1.50%). In conclusion, development of this product will enhance the utilization of carrot not solely for stews and salads but also as a juice blend with the potential to compete with the local and foreign fruit juices on the market. Consumption of the product will help address the resurgence of nutrition-related chronic diseases due to its appreciable content of β-carotene which are potent free radical scavengers in humans.

Keywords: *blanching, Chantenay carrot juice, MD-2 pineapple juice, physicochemical properties, juice blends*

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1. Introduction

Carrot (*Daucus carota*) is a herbaceous plant containing about 87% water and vitamins D, C and E. It is known to be a vegetable with excellent source of β-carotene which is a strong antioxidant. The high levels of β-carotene give carrots their distinctive orange colour. Beta-carotene is an important antioxidant which helps the body to fight against free radicals which has been implicated to initiate a lot of chronic conditions in humans. It is converted in the body to vitamin A which enhances good eye vision. Carrot also contains folic acid and other phenolic compounds which are antioxidants [1,2,3]. The consumption of carrots as food, appears to be associated with better health conditions due to its potent antioxidant content. It does not only prevent vitamin A deficiency but also cancer and other nutritionally-related chronic diseases. It has been reported that, intake of carrot juice tends to have a greater cytotoxic effect against cancer cells as well as inhibiting the activity of the enzymes that promote the conversion of precarcinogens to carcinogens. It may also enhance the immune system, protect against stroke, high blood pressure, osteoporosis, cataracts, arthritis, heart disease, bronchial asthma and urinary tract infections [4,5,6]. Carrot juice is rich in minerals like potassium, calcium, phosphorus, magnesium and some other trace minerals. In view of its many health benefits, carrot juice is called the "miracle juice". It contains other vitamins, like thiamine, riboflavin and vitamin B complex [7].

It has been reported that extraction of juice from fresh carrot is difficult and that subjecting it to heat treatment by blanching at about 80°C for several minutes softens the roots and facilitates juicing by comminution. Subsequent homogenization then yields carrot juice suitable for blending [8]. Methods of blanching are known to correlate with the nutritional composition of the product being blanched. Excessive blanching could cause loss of vital minerals whiles nutrient will be retained in the product when blanching is adequate [9]. Commonly used blanching methods in the industry are hot water and steam blanching though microwave and hot gas blanching has also been studied in recent times [10].

Carrot juice blends practically with all other juices and a large number of people suffering from various ailments have found out that the inclusion of carrot juice in their diet has greatly improved their health [8]. Pineapple (*Ananas comosus*) has been one of the most popular of the non-citrus tropical and subtropical fruits largely because of its attractive flavour and sugar-acid balance [11]. Pineapple juice is largely consumed around the world in the form of single strength and reconstituted juice as well as in a blend composition for new flavours in beverages and other products [12,13].

Fruit and vegetable juices have become important in recent years due to overall increase in natural juice consumption as an alternative to carbonated soft drinks, tea and coffee beverages [14]. In recent years, a steady increase in the consumption of carrot juice has been reported in many countries [15]. Local production of fruit juices on the Ghanaian market has predominantly been pineapple juice. There is a high prevalence of fruit juices than vegetable juices on the market. Thus the need to promote vegetable juices is very important because they also provide nutritional components that the body requires for its daily activities [16]. The objective of this research work was to determine the effects of blanching on physicochemical properties of carrot juice from Chantenay variety of carrot and assess the qualities of formulated carrot-MD2 pineapple juice blends.

2. Materials and Methods

2.1. Source of Raw Materials and Reagents

Chantenay variety of carrots, MD2 pineapple variety and sugar were obtained from a local market in Kumasi in the Ashanti Region of Ghana. Reagents used for analyses were obtained from the Departments of Biochemistry and Biotechnology and Food Science and Technology, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi.

2.2. Blanching Methods

An amount of 186 g sliced carrots with an average thickness of 5.5 mm was weighed for the three heat treatments: hot water, steam and microwave blanching. Each set of carrots was then subjected to the three blanching methods for the same period of 10 minutes. An equal volume of 150 ml was used for the blending for 7 minutes. The average temperature of the hot water-blanched carrots was 98°C, while that of steam during blanching was 105°C. The temperature of 75°C of the microwave blanched carrots was determined after removal from the microwave. The total power consumption of the microwave was 800 watts and it had five regulations numbered for heating. Number one, which was the lowest regulation, was used for microwaving of the sliced carrots. Carrot juice was extracted from the blended carrots using a cheese cloth and physicochemical analyses were performed on the juice from each blanching treatment to determine the method which retained most nutrients.

2.3. Pineapple Juice Extraction and Formulation of Blends

Samples of MD2 pineapple variety were washed thoroughly with warm water and peeled after which they were sliced into pieces for blending. An amount of 500 g of sliced pineapple was blended at a time to extract the juice using a cheese cloth. The juice was then added to the carrot juice produced from the steam blanching operation which gave higher yield and ash content. As shown in Table 1, the formulated proportions of the carrot-pineapple juice blends were 50:50, 60:40, 70:30 and 100:0. The blended juices were packaged in glass bottles and refrigerated.

Table 1. The blends of Chantenay carrot juice and MD2 pineapple juice

Type of juice	Percentage Composition (%)			
Sample Code	**524**	**321**	**139**	**218**
Chantenay Carrot juice	50	60	70	100
MD2 Pineapple juice	50	40	30	0

2.4. Proximate Analyses of Carrot- Pineapple Juice Blend

The moisture, ash, crude protein, fat and crude fibre contents were determined based on official method of analysis [17]. The carbohydrate content was determined by difference.

2.5. Determination of Physicochemical Properties of Carrot Juice and Carrot-Pineapple Juice Blend

2.5.1. Titratable Acidity and pH

Hundred (100) ml of carrot-pineapple juice was filtered into a clean dry beaker. Ten (10) ml of the filtered juice was pipetted into a conical flask and diluted to about 80 ml with distilled water. About three drops of phenolphthalein indicator was added and titrated to a faint pink end point with 0.1M NaOH solution. The titre value was recorded and the procedure was carried out in triplicate for each sample. Calculation was based on citric acid [18]. The pH was measured by means of a pH Tutor Bench Meter, Singapore.

2.5.2. Total Soluble Solids and Total Solids

The total soluble solids was determined with a digital Hand-held Refractometer and the total solids was determined by subtracting the moisture content from 100%.

2.5.3. Vitamin C and β-Carotene

Vitamin C was determined based on [19] and beta-Carotene was determined using reverse phase HPLC [20].

2.6. Sensory Evaluation of Carrot-Pineapple Juice Blends and Data Analyses

Sensory evaluation was conducted on the carrot-pineapple juices using 1-5 preference ranking test with scale of 1 representing the most preferred, 2 - moderately preferred, 3 - slightly preferred, 4 least preferred and 5 representing no preference. The samples were coded and fifty (50) untrained panellists were recruited for the test. The sensory parameters or attributes evaluated were the appearance, colour, aroma and the taste. The overall mean scores of the formulated products were then calculated by summing all mean values of each attribute and dividing the total by the number of attributes considered under the sensory evaluation.

Data analyses was conducted on both the physicochemical and sensory parameters by analysis of variance (ANOVA) using STATSGRAPHICS CENTURION version 15.0, Virginia, USA.

3. Results and Discussion

The yield and physicochemical properties of extracted juices from blanching carrots are shown in Table 2.

Table 2. Physicochemical properties of carrot juice from the three blanching methods

Treatments Parameters	Hot water Blanched carrots	Microwave Blanched carrots	Steam Blanched carrots	Control (unblanched carrots)
Yield (%)	72.08±4.14a	66.47±0.79b	76.65±0.58c	53.32±5.0d
pH	6.14±1.10a	6.35±0.37a	6.33±0.02a	6.23±0.13a
Brix (°)	3.34±0.0a	5.14±0.42a	4.40±1.49a	5.55±0.01a
Total solids (%)	3.84±0.42a	6.15±0.40b	5.38±0.17c	6.78±0.15b
Ash (%)	0.43±0.52a	0.51±0.07a	0.66±0.04a	0.41±0.01a
Moisture (%)	96.16±0.84a	93.85±0.98b	94.62±0.17b	93.22±0.15b
Vitamin C (mg/100g)	4.23±0.28a	6.65±0.28b	5.04±0.29c	8.67±0.29d

Mean values in a row with different letters are significantly different ($p<0.05$).

3.1. Yield

The yield from the steam blanching operation was the highest with a value of 76.65% and the percentage yield of carrot juice from hot water and microwave blanching were 72.08 and 66.48% juice respectively. The yield of unblanched carrots juice of (53.32%) was the lowest. There was a significant difference ($p<0.05$) between the yields of the blanched and unblanched carrots. The high yield in steam blanching can be attributed to the fact that steam blanching achieves greater nutrient retention than water blanching. Since steam blanching minimizes the leaching of soluble solids which leaves more natural sugars in products, it improves flavour and colour retention to produce a final product with superior flavour, colour and texture. As nutrients and flavours are lost when sugars are leached from a product during blanching, yield is also lost. Yield increases of up to 5 % for steam blanched products over water blanched products are possible depending on the product and application [21].

3.2. pH

The pH of unblanched carrot juice extract was 6.23, while the values of the pH of the carrot juice extract from hot water, steam and microwave blanching methods were near 6.2. There was no significant difference ($p>0.05$) between the blanched and unblanched samples. Thus the blanching operation had virtually no effect on the pH of the carrots. The pH of carrots has been reported to be between the range of 6.1 to 6.4 by [22]. These range of values compare well with the pH values observed in this study.

3.3. Brix

The °Brix of the extracted juices from the hot water, microwave, steam blanching and control were 3.34, 5.14, 4.40 and 5.55 respectively. Although there was no significant difference ($p>0.05$) in the Brix of the blanched carrots with the control carrots, the Brix of steam and hot water blanched carrot juice extracts were lower than the microwave and control. This could be due to some loss of soluble sugars in hot water and steam during the blanching process as reported by [23].

3.4. Total Solids

Total solids measures the amount of solid components present in the carrot juice after the removal of moisture. Solids are important in juices since they add to the bulkiness of juices [16]. Among the treatments, microwave-blanched carrot juice extract had the highest amount of total solids followed by steam and hot water blanching. Unblanched carrots had total solids of 6.78% which was more than the other blanched carrots which were 3.84, 6.15 and 5.38% for hot water, microwave and steam blanching respectively. There was a significant difference ($p<0.05$) between the total solids of the carrot juices extracted from water related blanching process (hot water and steam) against microwave blanching and unblanched carrots. The low levels of total solids in steam and hot water blanched carrot juice extract could be due to the fact that steam and hot water blanching are seen to be heat treatment processes which demonstrate a cooking effect on the sliced carrots. During cooking there is the liberation of soluble constituents, gelatinization of starches and crystallization of cellulose into the water medium [23,24].

3.5. Ash

Ash is the inorganic residue produced after the organic matter in a foodstuff is ignited or completely oxidized [18]. The ash content of the juices from blanched carrots were: steam blanching (0.66%), hot water blanching (0.43%) and microwave blanching (0.51%). There was however no significant difference ($p>0.05$) between the ash contents of the blanched and unblanched carrots thus the blanching methods had no effect on the carrots. The ash contents of the juice samples were within the reported range of 0.40 and 0.64% for carrot juice [25]. The ash content of steam blanched carrots was slightly higher than the other treatments and was consequently selected as the blanching method for carrots to formulate the carrot-pineapple juice blend. Steam blanching helps promote nutrient retention and increases the density of the carrots compared to the other blanching methods [24].

3.6. Vitamin C

The vitamin C content of the control and juice extracts from the blanched carrots by hot water, microwave and steam blanching were 8.67, 4.23, 6.65 and 5.04 mg/100 ml respectively. The control is approximately the same as the reported amount of 9 mg/ 100g for raw carrots [26]. There was a significant difference ($p<0.05$) in the vitamin C content of the blanched samples and the control. Nutrient losses in blanching result from thermal degradation, oxidation and leaching. Hot water blanching causes leaching of water soluble vitamins and this accounted for the low value of vitamin C in the juice extract. Vitamin C is water-soluble and is a better indicator of which blanching method retains more of the nutrient. The vitamin is easily degraded by extreme temperature conditions [9]. [27] also confirmed that some vitamin C is lost in foods during processing.

Losses due to thermal degradation and oxidation are similar for steam and hot water blanching but hot water blanching results in more losses due to leaching of water-soluble vitamins [9,28]. Microwave blanching had the highest of all the methods because the temperature was relatively low and much of vitamin C was not totally destroyed. [9] confirmed that vitamin C losses in fruit and vegetables when cooked by microwave were very little and also reported that there was a significant difference in vitamin C losses in raw and hot water blanched carrot with values being 6 mg/100 ml and 4mg/100 ml respectively.

3.7. Sensory Analysis of Carrot Juice-MD 2 Pineapple Juice Blends

3.7.1. Appearance

Products 524, 321, 139 and 218 represent the 50:50, 60:40, 70:30 and 100:0 (control) formulated carrot-pineapple juices respectively. The appearance of the different formulated carrot-pineapple juice was represented by their mean values as indicated in Figure 1. The appearance of a juice as defined by [29] consists of the characteristic natural colour, presence of fibre and particles (solids). It includes visual properties such as transparency, gloss and cloudiness [30]. Product 218 was not appealing to panellists because of condensed nature of the juice and also being solely carrot juice. Product 524 was scored the lowest with a mean value of (2.26) which compared to the other formulations, was the most preferred sample. The preference of panelists was based on product uniformity and balance in taste. Differences between the means of formulated products were not statistically significant ($p > 0.05$).

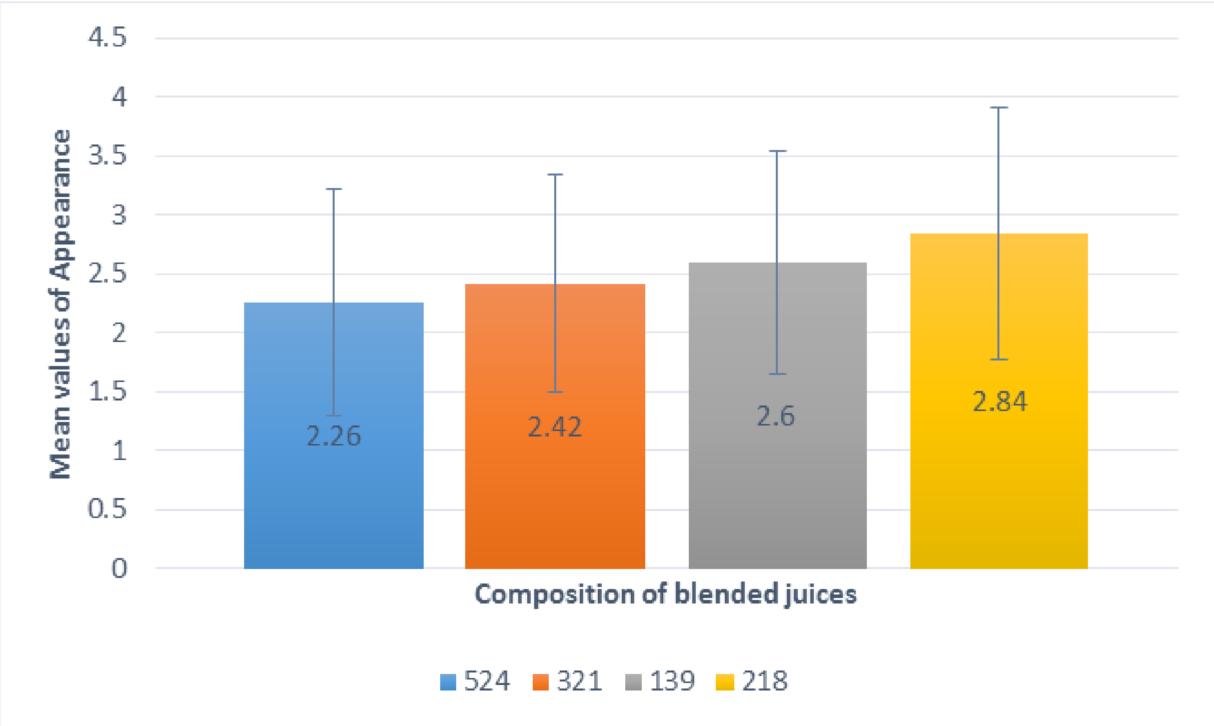

Figure 1. Mean values of appearance as a sensory attribute of carrot-pineapple juices

3.7.2. Colour

Colour is an appearance property of an object attributable to the spectral distribution of light emanating from that object [30]. In terms of colour, the mean value of product 524 (the 50:50 formulated juice) was the lowest with a value of 1.92 which is an indication of the product being the most preferred by the panellists. Even though the formulations were different, the bright and deep orange colour of the products as perceived by the panellists did not really differ significantly ($p>0.05$). From Figure 2, it could be observed that, as the amount of carrot juice increased in the blends, the colour became less appealing to the panellists. This corresponds with the mean score values shown in the graph below.

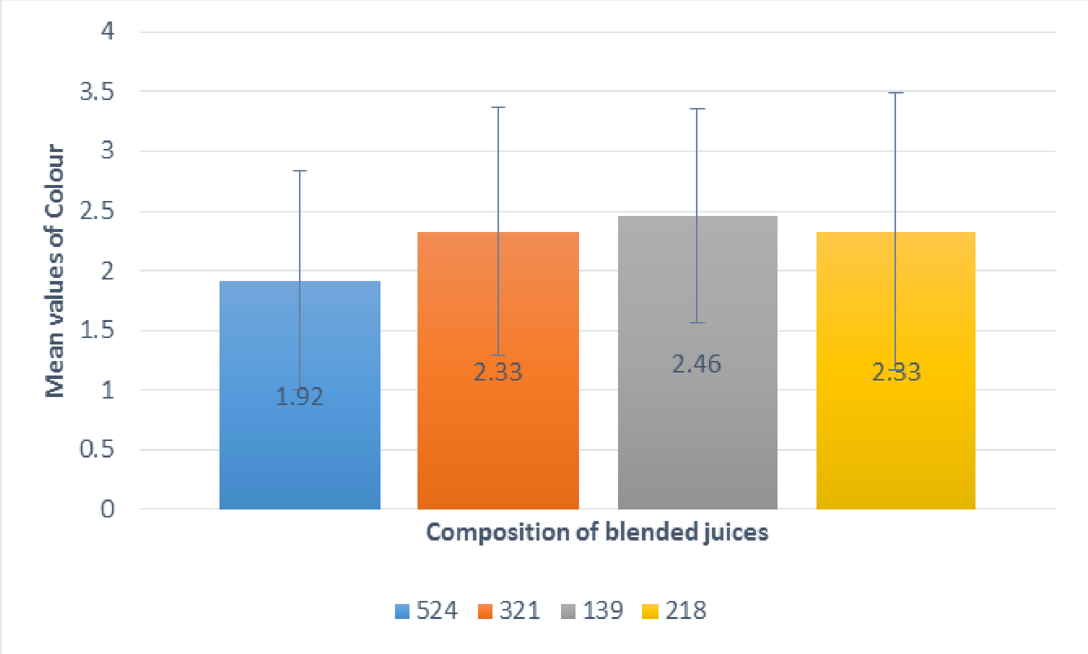

Figure 2. Mean values of colour as a sensory attribute of formulated carrot-pineapple juices

3.7.3. Taste

Mean values of taste for individual products are shown in Figure 3. The control (218) and product 524 had the same mean score of 2.82 which indicate moderate preference. Although the products had different formulations, panellists showed keen interest in consuming them. Product 524 was commented on by the panellists as having a smooth texture on the tongue. Product 321 had the highest mean score of and indicated the product was least preferred by the panellists because they commented that it had a sharp aftertaste. The means scores of product 218 and 139 also showed that they were liked by the panelists. There was no significant difference ($p>0.05$) between the mean values of the formulated products for taste.

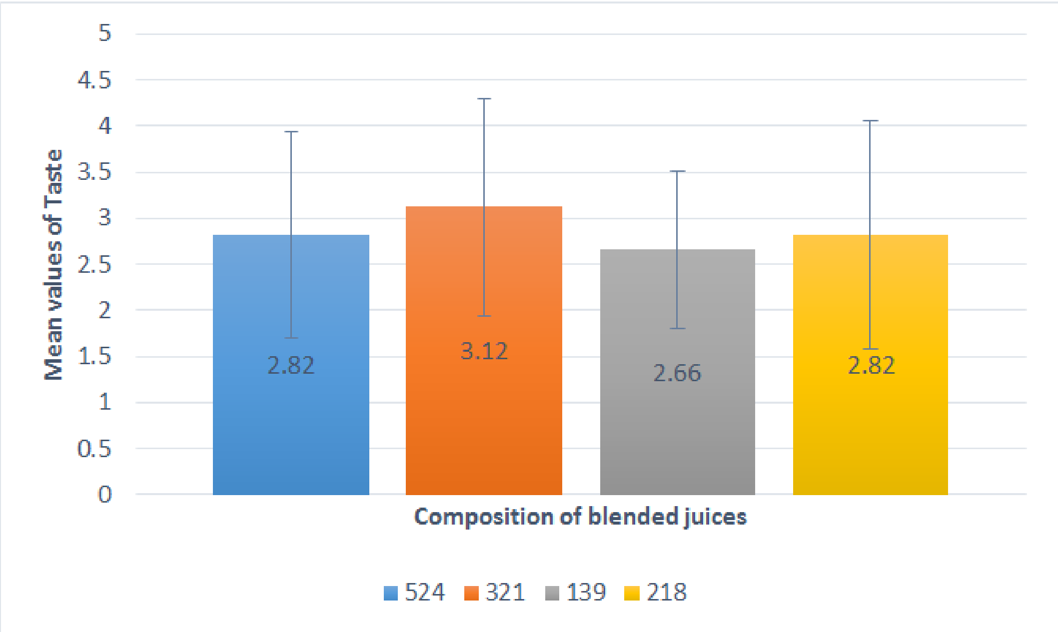

Figure 3. Mean values of taste as a sensory attribute of the carrot-pineapple juices

3.7.4. Aroma

Products 524, 321, 139 and 218 had mean values of 2.74, 2.91, 2.60 and 3.53 respectively as shown in Figure 4. The evaluation of aroma as a sensory attribute of the products by the panellists showed a significant difference ($p<0.05$) between the mean values. Due to its characteristic carrot smell, product 218 (the control) was least in term of preference of the aroma of the products. The aroma of the other formulations blended with pineapple juice was preferred by the panellists since their comments indicated that the samples had a pleasant aroma similar to that of mango juice. Panellists confirmed that the higher the percentage of pineapple in the juice blend, the better the aroma. Thus products 524 (50:50) and 139 (70:30) had appreciable aroma as stated by the panelists.

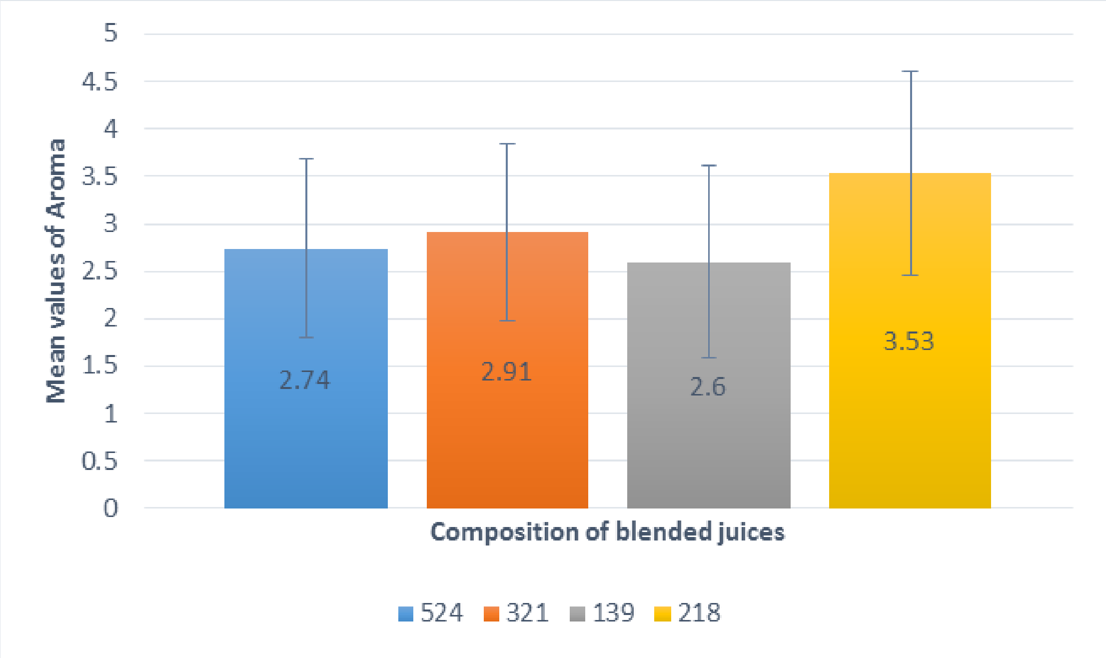

Figure 4. Mean values of aroma as a sensory attribute of the carrot-pineapple juices

3.7.5. Overall Mean Values

The overall means of the products were calculated by summation of the individual mean values of all attributes and divided by the total number of attributes considered under the preference ranking test. This mean score gave a better indication of the overall preference of the products after evaluation by the sensory panellists. Product 524 had the lowest overall mean value of 2.42 and was therefore the most preferred sample. The product with the highest mean score of 2.96 was 218 and indicated the least preferred sample. The other mean values for the formulated products are as shown in Figure 5. No significant difference ($p>0.05$) existed between the means of the formulated products.

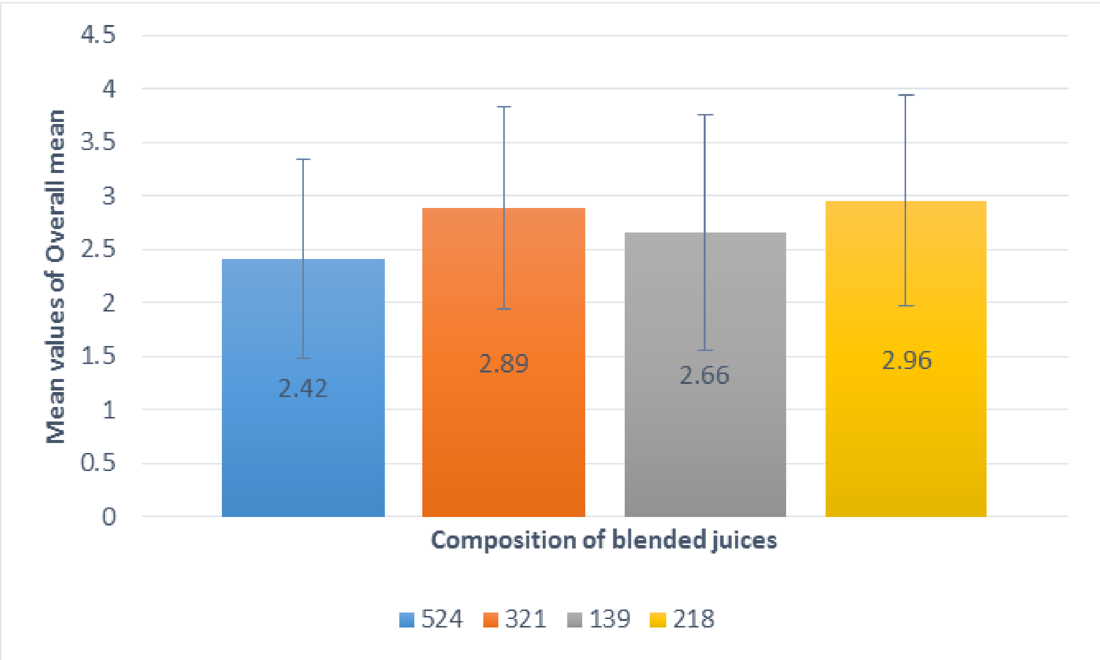

Figure 5. Overall mean score of all the sensory properties of the juice blends

3.8. Proximate Composition and Physicochemical Properties of the most Preferred Carrot-Pineapple Juice Blend

The most preferred carrot-pineapple juice blend (50:50) was analyzed for its nutritional composition and Table 3 and Table 4 show the proximate composition and physicochemical properties respectively. The protein content of 0.78% was higher than the amount of 0.40 % stated for pineapple juice and was within the range of 0.70-1.20 % stated for carrot juice. The ash content of 0.25% was a bit lower than the stated range of 0.32 to 0.5% for raw pineapple and 0.66 to 1.02 % for carrot juice, but compares well with the ash content of 0.22 % of pineapple juice [25,31]. The carbohydrate and fibre contents were 23.52 and 2.68% respectively. The fibre content lies within the crude fibre content of 2-3% reported for edible portion of the pineapple fruit. Pineapple contains considerable carbohydrates and crude fibre. Dietary fibre is known to be very effective in curing constipation and simulating regular bowel movement [32].

The relatively low vitamin C content of 12.35 mg/100 g can be due to the fact that carrots are low in Vitamin C and has been reported to be 7 and 6 mg/100 g by [25]. Even though MD 2 pineapple is rich in Vitamin C with a reported range of values of 49.59-54.17 mg/100g, the blending of juices reduced the amount of Vitamin C [33].

Carrot is rich in β-carotene and the values cited for research work on carrot samples has been stated to be between 7230 and 14590 µg/100 g. The value of 955.71 µg/100 g obtained in this work was far lower than the state range but was much higher than the values reported for pineapple fruit as 10 and 60 µg/100 g [34,35]. As an antioxidant, beta-carotene has proven to be protective against many types of cancer, but especially cancer of the lungs. Studies also indicate that it may help to protect the eyes from the damage that can lead to cataracts. Beta carotene has the ability to destroy free radicals which have been found to induce oxidative stress in the human body [36]. With the carrot-pineapple juice blend in this study having an appreciable amount of beta-carotene, it has the potential to provide nutritional and health benefits to the human body after consumption. The carrot-pineapple juice had a low pH (4.45) and thus will have better keeping quality since a low pH will help curtail microbial growth [37].

^{o}Brix is generally used as indicator for soluble solid content (%) [38]. Total soluble solids of pineapple is reported to be 13.30 %. The total sugar content of pearl pineapple of Brazil had a total sugar content of 14.5%. TSS varies from 10 to 14% brix depending upon the stage of maturity and season [39]. Ghanaian pineapples contain higher amount of reducing sugar 16.5% [32]. The total soluble solids of 14.87% recorded for the juice blend produced in this study compares well with the above stated values.

Table 3. Proximate composition of 50:50 formulated carrot-pineapple juice

Component	Value
Fat (%)	0.25±0.01
Ash (%)	0.25±0.11
Protein (%)	0.78±0.03
Crude Fibre (%)	2.68±0.08
Carbohydrates (%)	23.52±0.28
Moisture (%)	72.57±0.45

Table 4. Physicochemical properties of 50:50 formulated carrot-pineapple juice

Property	Value
Vitamin C (mg/100g)	12.35±0.07
β-Carotene (µg/100g)	955.71±0.0
pH	4.45±0.07
^{o} Brix	14.87±0.25
Titratable Acidity (%)	1.50±0.07

4. Conclusion

Steam blanching operation was found to be the best method of blanching Chantenay carrots since the treatment comparatively gave a juice extract with higher yield of 76.65% and an ash content of 0.66%. The carrot pineapple juice formulated in the ratio of 50:50 was the most preferred product by the sensory panellists. Proximate composition on the 50:50 formulated carrot-pineapple juice had the following constituents: protein (0.78%), fat (0.25%), carbohydrate (23.52%), crude fibre (2.68%), ash (0.25%) and moisture (72.57%). Physicochemical properties regarding beta-carotene, vitamin C, pH, total soluble solids, and titratable acidity were 955.71 µg/100 g, 12.35 mg/100 g, 4.45, 14.87% and 1.5 respectively.

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