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Research Application Summary

Physiochemical, nutritional, microbial and sensory attributes of pineapple-carrot-ginger beverage

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Abstract

A functional beverage was prepared from pineapple, carrot and ginger to form a refreshing drink. Three independent variables were used to prepare the beverage using Box-Behnken Design Response Surface Methodology (RSM): pineapple-to-carrot juice ratio (75/25-90/10), fibre size distribution (0.6-1.2 mm) and ginger concentration (2-5%). The levels of independent variables were optimized considering total soluble solids, pH, beta-carotene, and sensory attributes as responses. The optimized beverage was obtained at pineapple-to-carrot juice ratio, fibre size distribution and ginger concentration of 80/20, 0.6 mm and 3% respectively. The optimized beverage was kept at -24, -10 and 4 ^{o}C for 40 days to study the effect of storage on physicochemical, nutritional, microbial load and sensory attributes of the drink. There were significant changes in ascorbic acid, beta-carotene, total antioxidant activity, total soluble solids, titratable acidity and pH while no significant changes were observed in total phenolic content at the various storage temperatures. Regarding microbial loads, freezing significantly reduced total plate count while exponential growth occurred in the beverage stored at 4 ^{o}C. The results validate the fact that frozen storage of fresh beverage slows down quality changes in fresh fruits-veges drink and as a result improve the functionality of the beverage and hence should be considered by the fruit juice industry.

Key words: Antioxidant activity, ascorbic acid, beta carotene, beverage, phenolic, total fungal count

Résumé

Une boisson fonctionnelle a été préparée à partir de l'ananas, la carotte, et le gingembre pour former une boisson rafraîchissante. Trois variables indépendantes ont été utilisées pour préparer la boisson en utilisant le plan Box-Behnken et suivant la méthode des surfaces de réponses (MSR): le rapport de jus d'ananas à la carotte (75/25 – 90/10), la répartition de la de taille des fibres (0,6-1,2 mm), et la concentration du gingembre (2-5%). Les niveaux des variables indépendantes ont été optimisés en considérant des solides solubles totaux, le pH, la bêta-carotène et les attributs sensoriels comme des réponses. La boisson a été optimisée a été obtenu sur le rapport d'ananas à jus de carotte, de la distribution de la taille des fibres, et de la concentration du gingembre de 80/20, 0,6 mm, et 3% respectivement. La boisson optimisée a été maintenue à -24, -10 et 4°C pendant 40 jours pour étudier l'effet du stockage sur les caractéristiques physicochimiques, nutritionnelles, la charge microbienne, et les propriétés sensorielles de la boisson. Il y avait des changements importants dans l'acide ascorbique, la béta-carotène, l'activité antioxydante totale, les solides solubles totaux, l'acidité titrable, et le pH alors qu'aucun changement significatif n'a été observé dans le contenu phénolique aux différentes températures de stockage. En ce qui concerne les charges microbiennes, la congélation a réduit considérablement le nombre total par boite de pétri tandis que la croissance exponentielle a été observée dans la boisson stockée à 4°C. Ces résultats valident le fait que le stockage congelé de boisson fraîche ralentit les changements de qualité en boisson fraîche à base de fruits-légumes et par conséquent d'améliorer la fonctionnalité de la boisson et devrait donc être considéré par l'industrie des jus de fruits.

Mots clés: L'activité antioxydante, l'acide ascorbique, le bêta-carotène, la boisson, les phénoliques, le comptage fongique total

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Background and literature summary

Pineapple (*Ananas comosus* L. Merill) has for long been recognised as one of the most popular non-citrus fruits in tropical and subtropical regions of the world, largely because of its attractive flavour, refreshing sugar-acid balance (Bartolomé *et al.,* 1996), and proteolytic enzyme bromelain that helps digest food by breaking down protein (Rekha *et al.,* 2012). The fruit has for centuries been used to treat indigestion and to reduce inflammation (Gautam *et al.,* 2010) and this is largely attributed to the enzyme bromelain. Pineapple production in Africa is 4.383 million tonnes out of which Ghana contributes about 15% (FAOSTAT, 2013). Sugarloaf and smooth cayenne are the most prominent commercial pineapple cultivars in Ghana. During peak seasons, nearly 35% sugarloaf pineapples produced go to waste due to inadequate postharvest management strategies. Sugarloaf cultivar is very sweet and its natural sugars can be used to replace refined sugars in beverages.

Pineapple fruit juice is also well endowed with natural dietary fibre, which plays an essential role in human health, promoting several positive physiological and metabolic effects (Raninen *et al.,* 2011). There has been growing interest in recent times about dietary fibre because its consumption has been associated with lower incidence of cardiovascular diseases, diabetes, hypertension, obesity, and gastro-intestinal disorders (Anderson *et al.,* 2009). Due to these, there is a growing tendency to develop products enriched with fibre (Selani *et al.,* 2014). Fruit beverage is important in human diet due to its ascorbic acid, a natural antioxidant, which may inhibit the development of major clinical conditions including cardiovascular diseases, neural disorders, and cancers (Rekha *et al*., 2012). A careful blend of fruit and vegetable juices can be a convenient approach to develop functional and bioactive beverages and to provide alternatives for the utilization of under-utilized tropical fruits and vegetables. Hence, to improve the colour and nutritional composition, and bioactivity of the beverage fruit juices, they can be blended with carrot juice (Arscott and Tanumihardjo, 2010). Ginger is added to improve taste, aroma, acceptability, palatability, and nutritive value (Wadikar *et* *al.,* 2010), but also to extend the shelf life of the beverage (Bhardwaj and Pandey, 2011). It is forecasted that in 2016 consumer's preference for fresh natural product will increase due to consumers focus on health and wellness (Brandon, 2016).

Refrigeration and frozen storage have been used for centuries to slow down degradation of stored food products and extend their shelf life. Freezing of fresh fruit and vegetable juices is one of the most common ways of retaining the quality of these products (Cortés *et al.,* 2008). Several studies have shown the effects of storing fruit and their extracts at low temperatures, but few have actually examined these effects at very low temperatures (Polinati *et al.,* 2010). Therefore, the objective of this study was to investigate the effects of pineapple, carrot, and ginger concentrations and fibre size distribution on the physicochemical, nutritional and sensory attributes of the desired drink. The optimized beverage was identified and its quality during three cold storage temperatures were investigated.

Study description

Pineapple fruits were washed with chlorine water and manually peeled using a stainless steel knife, chopped into small pieces and blended with commercial type juice blender. The juice was extracted using a juicer machine (FT–0.5, China). **C**arrot and ginger roots were washed and chopped into smaller pieces and the juice extracted with Voltic Ghana drinking water in the ratio of 1:1.6 (w/w) and stored at -24 ^{o}C.

Experimental design

Box-Behnken Design (BBD) Response Surface Methodology (RSM) was used to formulate 15 combinations of the beverage. Three independent variables – pineapple-to-carrot juice ratio, juice fibre size distribution (mm), and ginger juice concentration (%) – coded as X_1, X_2, and X_3 respectively on the juice physiochemical and sensory properties were studied. The minimum and maximum values for the independent variables were 3 – 9 (75/25 v/v – 90/10 v/v) for pineapple-to-carrot juice ratios (X_1), 0.6 –1.2 mm for juice fibre size distribution (X_2), and 2 - 5% for ginger juice concentration (X_3) in the beverage. The effects of the factors were assessed and partitioned into linear, quadratic and interactive components as represented in equation (1):

$$Y = b_0 + \sum_{i=1}^{j} b_i x_j + \sum_{i=1}^{j} b_{ii} x_i^{\,2} + \sum\sum b_{ij} x_i x_j \qquad (1)$$

Where b_0 is a constant, b_i is linear coefficients, b_{ii} the quadratic coefficients and b_{ij} the interaction coefficients, x_i and x_j are the levels of the independent variables. Response surface quadratic models were developed to represent data thus collected and to graphically describe the effects of the factors on the responses.

Optimization and storage of the beverage

The data obtained for pH, total soluble solids (TSS), beta carotene and sensory attributes (colour, aroma, taste, consistency and overall acceptability) under different experimental conditions were optimized using the overall desirability techniques in Design Expert version 10.0 (Design-Expert, 2010). The optimized beverage was prepared and packaged in pre-sterilized 250 mL plastic bottles and corked tightly without pasteurization prior to storage. The packaged beverage samples were immediately stored at -24 °C, -10 °C and 4 °C and its pH, total soluble solids, titratable acidity, ascorbic acid, total phenolic, total antioxidant activity, beta-carotene, microbial loads, and sensory attributes investigated at 5-day intervals for 40 days. Each sample was prepared in triplicate and each quality determination done in duplicate.

Results

Table 1 shows the responses of the 15 experiments performed at different levels of the independent variables according to BBD. Increasing the pineapple-to-carrot juice ratio significantly increased the pH of the beverage, while increase in the concentration of ginger significantly reduced the beverage pH (Fig. 2). As expected, increase in the pineapple-to-carrot juice ratio significantly ($p<0.001$) increased the TSS of the beverage (Fig. 2). On the other hand, increase in ginger concentration of the beverage insignificantly increased the

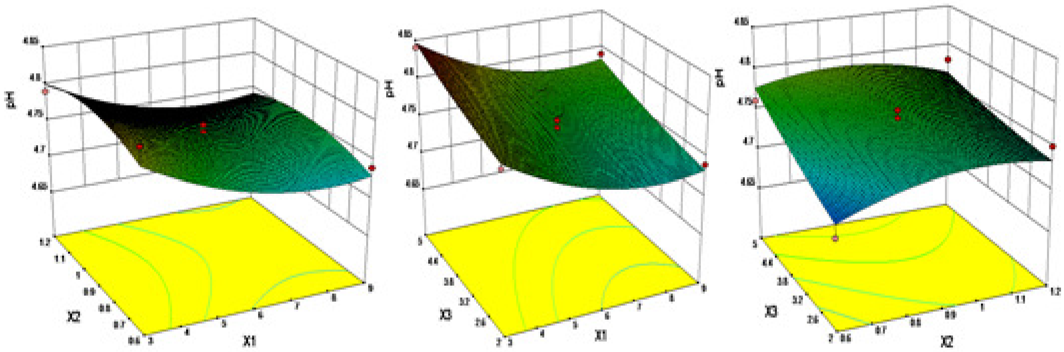

Figure 1. Effects of A) pineapple-to-carrot juice ratio and fibre size distribution B) pineapple-to-carrot juice ratio and ginger concentration and C) fibre size distribution and ginger concentration on pH

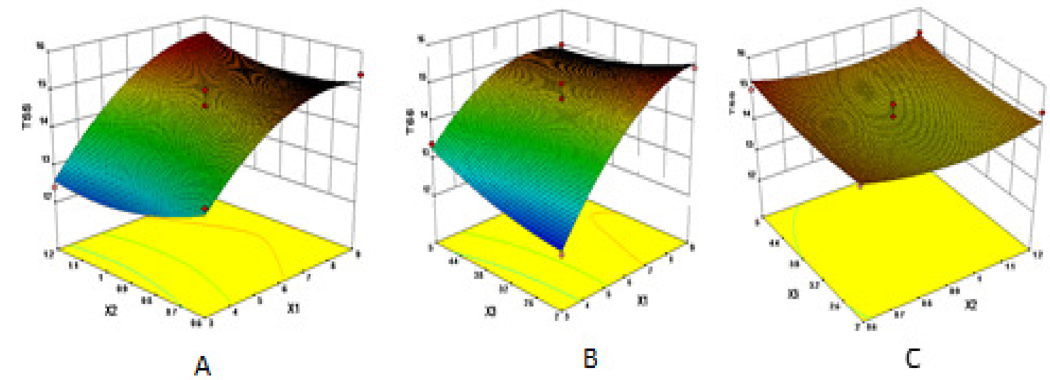

Figure 2. Effects of A) pineapple-to-carrot juice ratio and fibre size distribution B) pineapple-to-carrot juice ratio and ginger concentration and C) fibre size distribution and ginger concentration on TSS

Table 1. Results of pH, TSS, Beta-carotene and sensory scores of pineapple-carrot-ginger beverage

X_1	X_2 (mm)	X_3 (%)	pH	TSS (°brix)	β-carotene (µg/ml)	Colour	Aroma	Taste	Consistency	Overall acceptability
9	0.9	5	4.79	15.0	2.299	5.90	6.57	6.48	6.71	7.1
9	0.9	2	4.74	15.4	2.134	5.48	6.71	7.00	6.71	7.14
6	0.9	3.5	4.77	14.6	2.271	5.90	6.62	6.81	6.81	7.29
3	0.9	5	4.84	13.4	3.987	7.90	7.10	6.86	6.86	7.67
6	1.2	5	4.78	15.2	2.925	6.38	6.38	6.19	6.43	6.71
3	0.9	2	4.79	12.1	4.448	8.00	7.19	7.71	7.19	7.81
3	1.2	3.5	4.79	12.4	3.861	7.86	6.90	7.00	7.00	7.67
3	0.6	3.5	4.82	13.4	4.518	8.38	7.24	7.57	7.14	7.71
6	1.2	2	4.75	15.2	2.449	6.43	6.62	6.67	6.62	7.05
9	0.6	3.5	4.74	15.4	1.812	6.29	6.81	7.14	7.05	7.29
6	0.6	5	4.76	15.0	2.889	6.29	7.14	7.19	6.76	7.43
9	1.2	3.5	4.72	15.4	2.220	5.48	6.10	6.48	6.43	6.33
6	0.9	3.5	4.75	14.0	2.540	6.05	6.52	6.67	7.10	7.24
6	0.6	2	4.69	15.0	2.541	7.10	6.86	7.05	7.05	7.38
6	0.9	3.5	4.76	15.0	2.400	6.43	7.00	7.33	7.10	7.71

X_1 represents the pineapple-to-carrot juice ratio, X_2 the juice fibre size distribution (mm) and X_3 is the ginger juice concentration (%) in the beverage, TSS is the total soluble solids

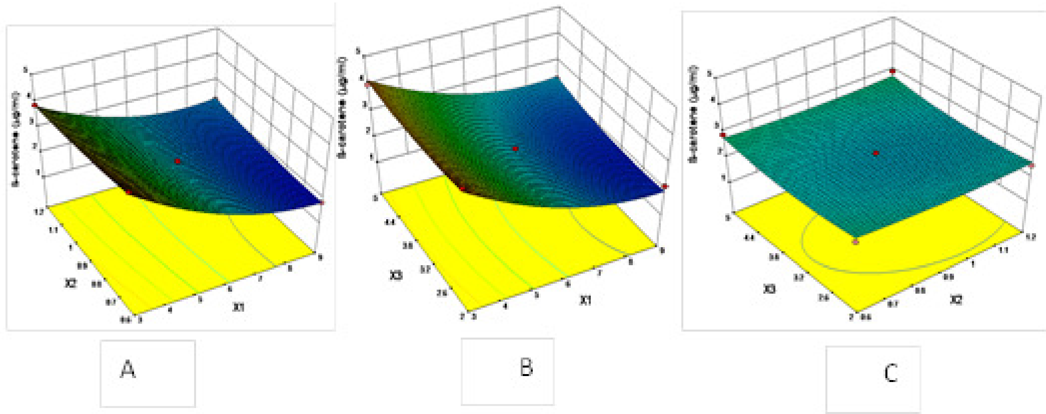

Figure 3. Effects of A) pineapple-to-carrot juice ratio and fibre size distribution B) pineapple-to-carrot juice ratio and ginger concentration and C) fibre size distribution and ginger concentration on beta carotene

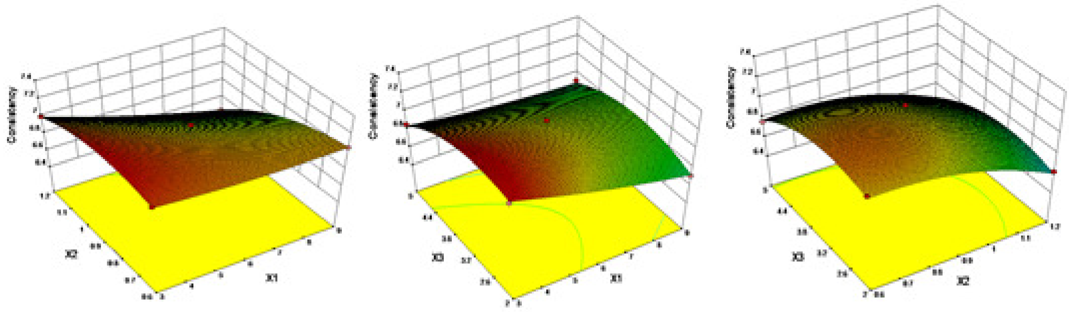

Figure 4. Effects of A) pineapple-to-carrot juice ratio and fibre size distribution B) pineapple-to-carrot juice ratio and ginger concentration and C) fibre size distribution and ginger concentration on consistency

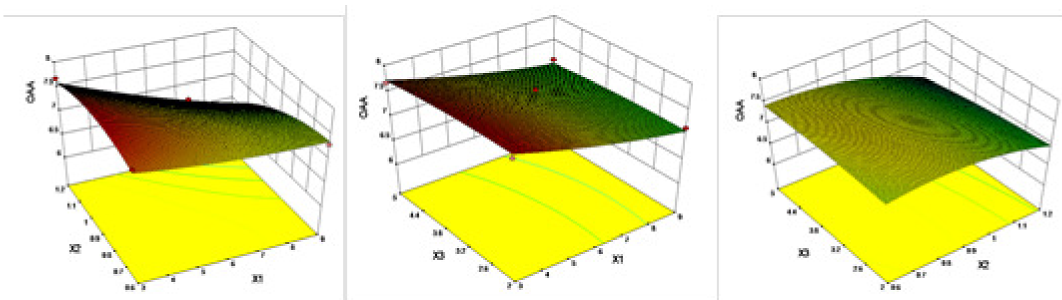

Figure 5. Effects of A) pineapple-to-carrot juice ratio and fibre size distribution B) pineapple-to-carrot juice ratio and ginger concentration and C) fibre size distribution and ginger concentration on overall acceptability

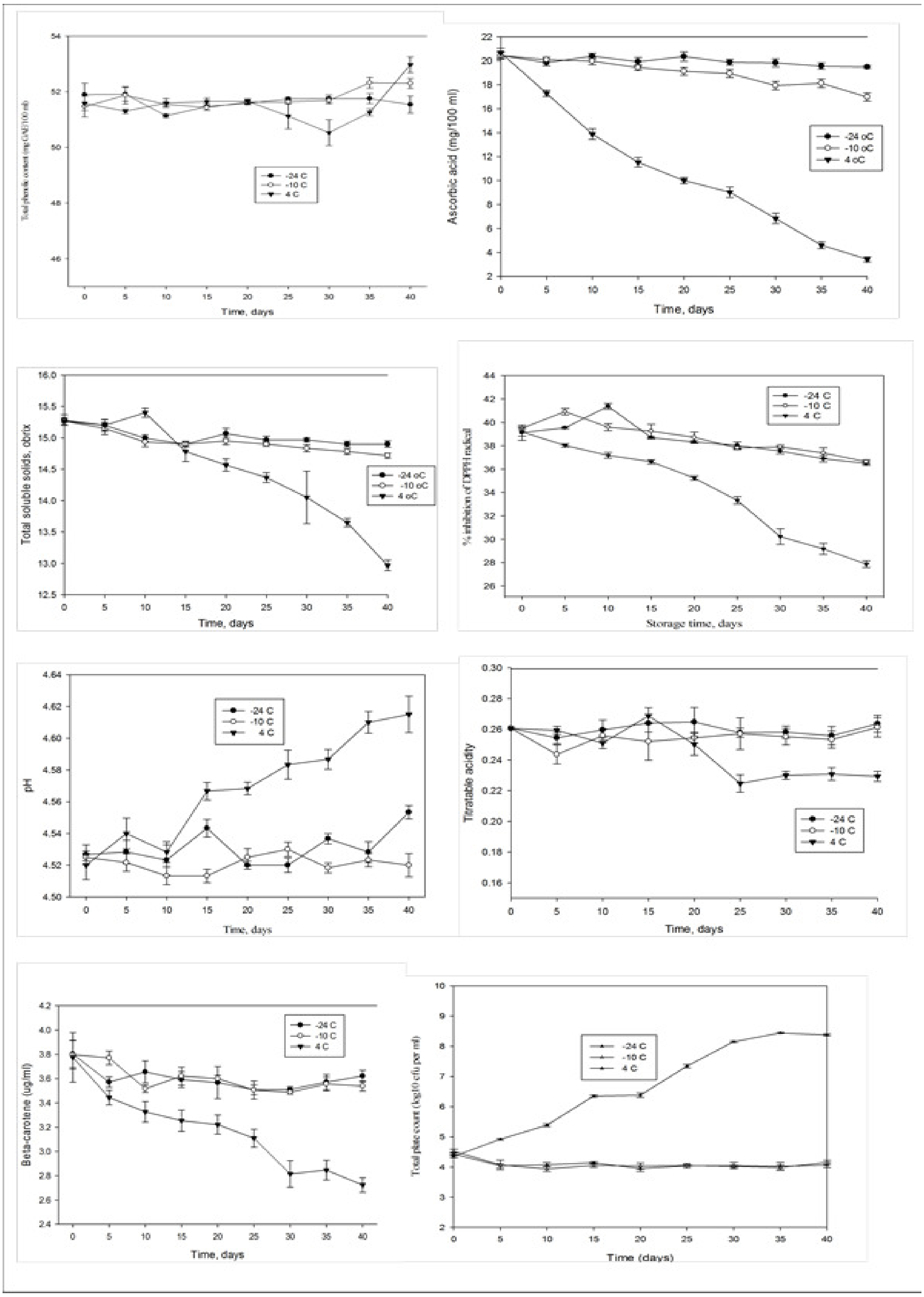

Figure 6. Effect of storage temperature and time on A) total phenolic , B) ascorbic acid, C) total soluble solids, D) antioxidant activity, E) pH, F) titratable acidity, G) beta carotene, H) total plate count, and I) total fungal count of optimized beverage

Table 2. Effect of storage on the sensory quality of pineapple-carrot-ginger beverage during storage at -24, -10 and 4 °C

Storage time (days)	Colour			Aroma			Taste			Consistency			Overall acceptability		
	-24°C	-10°C	4 °C	-24°C	-10°C	4 °C	-24°C	-10°C	4 °C	-24°C	-10°C	4 °C	-24°C	-10°C	4 °C
0	7.00	6.00	6.06	7.06	6.44	7.44	6.94	6.78	7.61	6.64	6.33	7.22	6.89	6.89	7.72
5	7.22	7.78	6.95	6.17	6.61	6.48	6.67	6.83	6.75	6.50	7.28	6.91	6.72	7.56	7.14
10	6.72	6.44	5.88	6.50	6.28	5.89	6.67	6.61	5.89	6.94	6.31	5.94	7.06	6.61	6.00
15	7.22	7.39	NA	4.89	6.00	NA	4.67	5.61	NA	6.39	6.44	NA	5.28	6.50	NA
20	7.39	7.33	NA	7.06	7.39	NA	7.28	7.17	NA	7.39	7.44	NA	7.67	7.83	NA
25	7.59	7.88	NA	7.12	7.94	NA	7.35	7.82	NA	7.65	8.18	NA	8.06	8.47	NA
30	6.12	5.88	NA	6.29	7.29	NA	6.12	5.82	NA	6.88	6.47	NA	6.82	6.18	NA
35	7.88	7.71	NA	6.88	7.29	NA	6.65	7.47	NA	7.06	7.65	NA	7.18	7.59	NA
40	7.06	7.65	NA	6.88	7.06	NA	6.76	6.65	NA	7.35	7.65	NA	7.71	7.18	NA

Values are mean of determinations. NA = not applicable as the sample got spoiled to the extent that it could not be served for sensory evaluation

TSS of the beverage. The colour of the beverage significantly decreased with increase in pineapple-to-carrot ratio (Table 1). Increase in the pineapple-to-carrot juice ratio resulted in significant decrease of beta-carotene content of beverage (Fig. 3) but all the factors studied affected the consistency of the juice significantly (Fig. 4). The overall acceptability by the panelist is shown in Figure 5. The interaction effects between pineapple-to-carrot juice ratio and fiber size distribution resulted in significant ($p<0.05$) increase in beta-carotene content. The ideal combination for the beverage was a pineapple to carrot ratio of 4.136, fibre size of 0.6 mm and ginger concentration of 3%.

Figure 6 displays the effect of storage temperature and time on the total phenolic, ascorbic acid, total soluble solids, antioxidant activity, pH, titratable acidity, beta carotene, total plate count and total fungal count of the optimized beverage. Results of the sensory quality tests of the beverage at the 3 temperatures are shown in Table 2. Overall, acceptability of the beverage was good for the entire experimental period for storage temperatures of -24 ^{o}C and -10 ^{o}C. However, after 10 days, samples stored at 4 ^{o}C were already unacceptable. Results thus demonstrate that low temperature storage preserved the quality of the beverage and must be considered by the food industry for fresh juice storage.

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