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Storage stability of functional RTS beverage contrived from headed white cabbage (*Brassica oleracea*. L) and key lime (*Citrus* × *aurantiifolia*)

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Abstract

Cabbage juice with lime extract, which are well-known for their nutraceutical potentials, was being explored as a functional ingredient in a wide array of health foods and drinks. The present work was undertaken to develop a functional RTS (ready-to-serve) beverage blend using white cabbage and key lime. Cabbage juice, lime juice, aspartame, permitted colour, sodium metabisulphite and water were mixed in different percentages of cabbage juice to lime juice to prepare the 100 mL blend. The products were bottled, pasteurised, and stored at ambient room temperature. The storage stability of the beverage blend was evaluated for quality parameters. Periodic analysis was carried out up to 12 weeks for various physicochemical parameters and sensory acceptability. The nutritional analysis of the stored RTS beverage indicated that there were significant differences among the formulations and also declining trend in ascorbic acid, total soluble solids and pH, and an increasing trend for total sugar, and titrable acidity. The sensory assessment revealed that there were no significant differences among the sensory attributes following storage. The highest overall acceptability was observed in the formulation with 18% cabbage juice and 12% lime juice, and all the formulations were microbiologically safe. Based on the quality assessment, sensory analysis and microbiological studies, the low calorie RTS functional beverage with 18% cabbage juice and 12% lime juice could be stored for 12 weeks without any significant changes and extended shelf life, which also has no deleterious effect on consumers.

Introduction

Consumer demands for healthy and nutritious food products with a fresh-like appearance have witnessed a continuous rise during recent years. Healthy beverages, particularly those that offer functional ingredients such as botanicals, minerals and antioxidants are increasing in demand (Sanguansri and Augustin, 2009; Ramachandran, 2014). Moreover, they are an excellent means for delivering nutrients and bioactive compounds such as ω-3 fatty acids, plant extracts, fibre, prebiotics and probiotics (Sanguansri and Augustin, 2009).

Cabbage (*Brassica oleracea* L. var. *capitata*) is one of the most popular cultivars of the family Brassicaceae (also known as Cruciferae) grown around the world. Cabbage is a nutrient-rich and economically-important vegetable crop with appreciable amount of vitamins C, K, A and B9-folic acid, fibre, flavonoids, proteins and minerals, and associated with secondary metabolites such as glucosinolates which have anti-carcinogenic properties (Sarikamis *et al*., 2009). Fresh cabbage juice, prepared either separately or mixed with other vegetables such as carrot and celery, is often included in many commercial weight-loss diets (Šamec *et al*., 2011).

Lime (*Citrus* × *aurantiifolia*) is a fruit crop belongs to the family Rutaceae which is an excellent source of vitamin C, and often used to accentuate the flavours of foods and beverages. *Citrus* is likely the most widely established fruit for direct human consumption in the world with pleasant flavour, sour taste and attractive colour. Lime juice contains compounds such as active phytochemical saponins, alkaloids, tannins, phenolics, flavonoids and terpenoids (Robinson, 2006).

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A combination of above two botanicals could lead to the production of delightful and delicious beverages with improved organoleptic quality and good nutritive value. Optimisation of diet by including fruits and vegetables with promising quantities of phytochemicals of nutraceutical importance could be a very cost-effective method for disease prevention. With the above facts in view, in the present work, a low-calorie cabbage-lime blend RTS functional beverage was developed, and its shelf life quality was monitored and assessed for a storage period of 12 weeks.

Materials and methods

Procurement of materials

Healthy fresh and firm white cabbage heads, dense with shiny, crisp and bright leaves, free of cracks, bruises and blemishes were purchased from a wholesale market in Batticaloa, Sri Lanka. Matured healthy key limes were purchased from a local mark*et al*so in Batticaloa, Sri Lanka. Artificial sweetener (aspartame) and permitted colourant (E142: Green S) were purchased from United Pharmacy, Colombo, and Cargills, Batticaloa, respectively.

Extraction of cabbage juice

Fresh cabbage outer covers were removed, and the remaining cabbage heads were washed under running distilled water. The thick fibrous outer leaves were collected, sliced into pieces about 2 cm thick. Then the cabbage slices were steam blanched at 80 ± 2°C for 2-3 min (Burtness, 2014). next, 200 g cabbage and 200 mL distilled water were blended with a blender (Model Smeeth) and filtered using a cheese cloth to obtain the juice. The juice was refrigerated at 4°C.

Extraction of lime juice

Key limes were washed and cleaned thoroughly. The fruits were then washed again with distilled water. The limes were cut and squeezed to extract the juice. A cheese cloth was used to filter the juice from the pulp. The juice was refrigerated at 4°C.

Blend formulations

The following formulations were prepared: C – 30% cabbage juice only; F1 – 27% cabbage juice and 3% lime juice; F2 – 24% cabbage juice and 6% lime juice; and F3 – 21% cabbage juice and 9% lime juice.

Preparation of cabbage-lime juice blend

For 100 mL RTS beverage, 70 ml water was added to 100 mL RTS beverage, and 0.032 g aspartame and three drops of E142 were added to all the formulations, and was heated at 60°C for 10 min. Then it was allowed to cool for few minutes, after that sodium metabisulphite (70 ppm) was added to the formulations.

Microbiological, physico-chemical and sensory evaluation

The prepared formulations of cabbage-lime blend RTS beverage were stored at ambient temperature (30 ± 1°C), and subjected to shelf life evaluation. Microbiological (Salfinger and Tortorello, 2015), physico-chemical (AOAC, 2002) and sensory (7-point hedonic scale) analyses were performed on all the formulations to determine the quality of the RTS beverages in two weeks interval during the storage period of 12 weeks.

Statistical analysis

Each formulation was analysed in triplicates, and the experiments were designed in Complete Randomised Design (CRD). Data for each sensory attribute was analysed using Friedman's test. Physico-chemical properties were performed using ANOVA (p = 0.05). Duncan's Multiple Range Test (DMRT) was used to determine the significance of the differences between the means of the measured parameters.

Results and discussion

Raw material characterisation

The values of TSS (5.2°Brix), titrable acidity (0.61 as % of citric acid), vitamin C (26.26 mg/100 mL), pH (5.73) and total sugar (4.1%) of cabbage juice were found to be in close agreement with the results obtained by Gyorene *et al*. (2006), Champa *et al*. (2007) and Frederick *et al*. (2016). The pH (2.68), titrable acidity (5.48 as % of citric acid), TSS (6.8) and vitamin C (37.82 mg/100 mL) of lime extract were expressed in more or less similar values to that obtained by Rangel *et al*. (2011), Jamil *et al*. (2015), and Hariharan and Mahendran (2016).

Storage stability studies

The cabbage-lime blend RTS beverage formulations were periodically analysed for various parameters on storage, and results are discussed in the following section. Changes in titrable acidity (as % citric acid) in RTS beverage during storage are illustrated in Figure 1. The overall results showed that acidity of RTS beverage significantly increased during storage. The maximum value was observed in F3 and minimum pH was in control at the end of the

storage period. Dhaliwal and Hira (2004) reported that there were minor changes in acidity i.e. from 0.39 to 0.42% in carrot-spinach and carrot-pineapple juices.

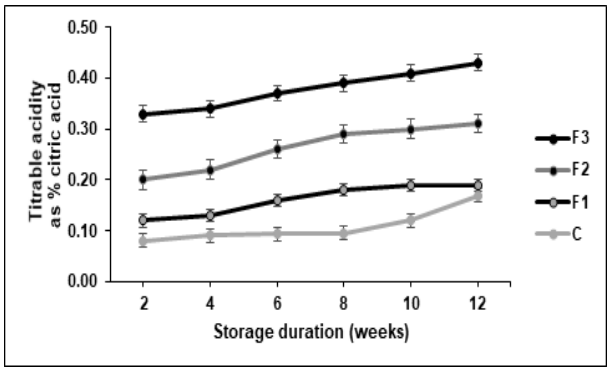

Figure 1: Changes in titrable acidity (as % citric acid) in RTS beverage during storage. The values are means of triplicates ± standard error.

Changes in pH and total soluble solids (TSS) of low-calorie cabbage-lime blend RTS functional beverage during storage are expressed in Table 1. There was a significant decrease in pH during storage in all the formulations. Titrable acidity and pH are inversely proportional to each other (Hirdyani, 2015). Singh and Gaikwad (2012) demonstrated significant effect of storage period and different sample on pH of all RTS beverage samples with decrease in acidity and increase in pH in bitter gourd lemon function RTS beverage. The mean values of TSS revealed significant difference among samples and significant decrease during storage period at ambient temperature. The reduction might be due to the chemical interaction that takes place among the organic constituent of the beverage (Ghorai and Khurdiya, 1998). Similar result was reported by Sasikumar (2015) in aloe vera and aonla fruit-juice-based therapeutic RTS beverages.

Table 1: Changes in pH and total soluble solids (TSS) of low-calorie cabbage-lime blend RTS functional beverage during storage.

Quality parameters	Storage periods (weeks)	Formulations			
		C	F1	F2	F3
pH	2	4.98 ± 0.01a	3.72 ± 0.02b	3.63 ± 0.01c	3.51 ± 0.01d
	4	4.96 ± 0.02a	3.69 ± 0.03b	3.61 ± 0.02c	3.48 ± 0.02d
	6	4.95 ± 0.02a	3.65 ± 0.01b	3.58 ± 0.02c	3.46 ± 0.01d
	8	4.93 ± 0.05a	3.64 ± 0.01b	3.56 ± 0.01c	3.45 ± 0.01d
	10	4.85 ± 0.02a	3.61 ± 0.02b	3.52 ± 0.01c	3.41 ± 0.01d
	12	4.81 ± 0.01a	3.58 ± 0.01b	3.49 ± 0.01c	3.35 ± 0.04d
TSS	2	4.63 ± 0.01d	4.49 ± 0.01c	4.79 ± 0.02b	4.88 ± 0.01a
	4	4.61 ± 0.02c	4.47 ± 0.06b	4.76 ± 0.02a	4.87 ± 0.05a
	6	4.59 ± 0.01d	4.46 ± 0.01c	4.75 ± 0.01b	4.85 ± 0.02a
	8	4.58 ± 0.03c	4.43 ± 0.02b	4.73 ± 0.07a	4.79 ± 0.01a
	10	4.56 ± 0.01c	4.41 ± 0.01b	4.72 ± 0.01a	4.76 ± 0.07a
	12	4.55 ± 0.01d	4.39 ± 0.03c	4.69 ± 0.02b	4.73 ± 0.03a

The values are means of triplicates ± standard error. Means with different letters within the same column are significantly different at $p < 0.05$.

The changes in vitamin C content of low-calorie cabbage-lime juice blend RTS functional beverage are indicated in Figure 2. It is apparent that there was a significant decrease in vitamin C content of cabbage-lime blend RTS beverage with advancement of storage period, which could be due to its degradation into dehydro-ascorbic acid (Hamid *et al*., 2017). Similar findings have been reported by Chavan *et al*. (2011) in pomegranate drink and in bottle gourd juice blends with mint and lemon RTS beverage during 30 days of storage (Agarwal and Kumar, 2017).

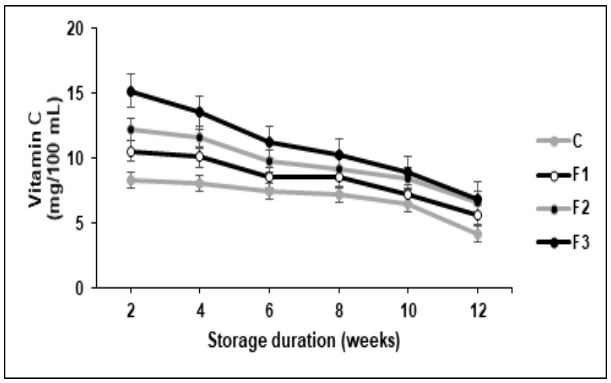

Figure 2: Changes in vitamin C (mg/100 mL) content in RTS beverage during storage. The values are means of triplicates ± standard error.

The changes in total sugar percentage of low-calorie cabbage-lime blend RTS functional beverage is shown in Figure 3. There was a significant increase in total sugars content of cabbage-lime blend RTS functional beverage during the entire storage period. The increased level of total sugar was probably due to conversion of starch and pectin into simple sugars (Kesharwani *et al*., 2015). Similar trend of increase in total sugars has been reported in Jamun RTS by Kesharwani *et al*. (2015).

Table 2: Sensory analysis of low-calorie cabbage-lime blend RTS functional beverage during storage.

Formulations	Colour	Taste	Aroma	Appearance	Overall acceptability
C	3.7 ± 0.01^{b}	3.4 ± 0.02^{c}	3.2 ± 0.03^{b}	3.2 ± 0.09^{c}	3.3 ± 0.03^{b}
F1	4.1 ± 0.02^{b}	4.9 ± 0.03^{ab}	4.8 ± 0.06^{b}	4.9 ± 0.04^{ab}	5.1 ± 0.07^{a}
F2	4.3 ± 0.01^{b}	5.1 ± 0.01^{ab}	4.9 ± 0.05^{a}	5.1 ± 0.02^{ab}	5.4 ± 0.01^{a}
F3	4.9 ± 0.06^{b}	5.3 ± 0.01^{ab}	5.1 ± 0.01^{b}	5.6 ± 0.02^{a}	5.8 ± 0.02^{a}

The values are means of 30 replicates ± standard error. Means with different letters within the same column are significantly different at $p < 0.05$.

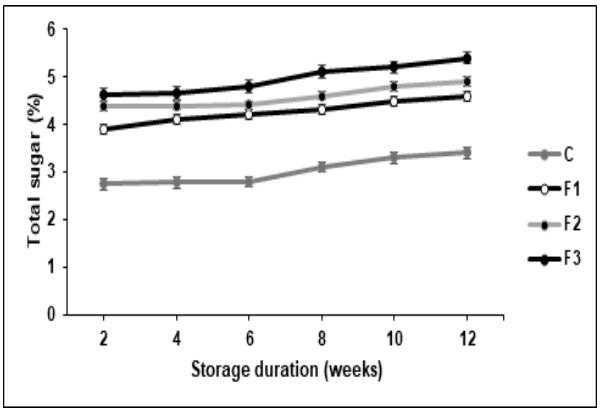

Figure 3: Changes in total sugar (%) content in RTS beverage during storage. The values are means of triplicates ± standard error.

In the present work, the organoleptic scores decreased with the increase in storage period at ambient room temperature (Table 2). The results illustrate a general decreasing trend in overall acceptability scores of RTS beverage. The blend 18% cabbage juice and 12% lime juice had the highest mean value score of 5.8. The decrease in overall acceptability scores might be due to the loss of appearance, flavour compounds and uniformity of the product. The decrease in overall acceptability scores have also been reported by Satkar *et al*. (2013) in bitter gourd RTS beverage.

Initial quality of freshly made low calorie cabbage lime blend RTS beverage formulations was microbiologically safe. This is because of the heat treatment (pasteurisation) performed and good hygienic practices. Carter *et al*. (2007) reported that the preservation by pasteurisation could be doubled by the addition of sodium metabisulphite. The sulphite inhibits yeasts, moulds and bacteria (Doughari *et al*., 2007). No microbial colonies were observed from the 0 day to eight weeks of storage period. At the end of storage, few numbers of colonies were observed in the range of 70, which were below the critical level in colony forming unit at 100 levels (Enterobacteriaceae). The results were within the standard limits of total plate count universally specified for the RTS beverage.

Conclusion

The present work revealed the various beneficial effects of cabbage and lime obtained by the manufacturing of RTS beverage. These effects include better product quality characteristics (physicochemical, sensory, microbiological) and improved storage stability. Cabbage juice could thus be used to deliver natural bioactive properties to formulate functional fruit beverages. The developed cabbage-lime based functional beverage blend could be promoted as a nutraceutical product with multiple benefits to the consumers.

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