Sensory characteristics and antioxidant capacity of red raspberry extract as a preservative in fruity flavoured beverages

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Abstract Sensory evaluation is a critical process in product development and consumer research. It is a fastly growing field due to innovation of novel techniques. The objective of this study was determination of sensory properties of red raspberry extract in fruity flavoured beverages comparison to the synthetic preservatives. For this purpose, an organoleptic stability study on fruity flavoured beverages was conducted storing them at several temperatures (room temperature, 2 ± 2 °C and 40 ± 2 °C) in the dark for 3 months. Sensory quality of beverages was analysed. Difference in pH and data obtained from °Brix measurements during storage was evaluated statistically. Room temperature and 40 ± 2 °C were detected to affect sensory characteristics of beverages. Highest variations were observed at 40 ± 2 °C. Beverages stored at 2 ± 2 °C displayed most acceptable appearance in organoleptic evaluation and insignificant change occurred. It was also found that red raspberry extract provided stable sensory effects, color, flavour and taste, in beverages compared to synthetic preservatives at 2 ± 2 °C.

Keywords Sensory characteristics · Red raspberry extract · Fruity flavoured beverages · Antioxidant capacity · ?Synthetic preservatives

Introduction

Knowing consumers' favours and/or gustos and perceptions of the sensory characteristics of food and drink products is very important for food manufacturers. Sensory evaluation is a scientific method which is used for identification and analysis of the market acceptability or preferences particularly in food or drink based products (Zhang and Litchfield 1991). Sensory analysis makes to sell the best product which meets consumers intend possible. Therefore, factors affecting sensory analysis must be demonstrated and the most suitable analysis must be provided by manufacturers. Conversely, there will be a high risk of market failure if the suitable sensory analysis will not be developed (Arazi and Kilcast 2001).

Sensory evaluation leads to measurement evoked and interpret the characteristics of food and materials when they are sensed. Flavourists judge sensory characteristics of foods appearance, colour, smell, taste and mouthfeel.

Red raspberry (*Rubus idaeus* L., Rosaceae) is an edible fruit that its bright colour and characteristic flavourful taste are well known. Red raspberry is grown in all temperate regions of Europe, Asia and North America (Jin et al. 2012). Many biologically active compounds have been isolated from red raspberry such as phenolics, vitamins, organic acids and minerals (Chen et al. 2013). Numerous studies showed that *Rubus* species had been used for the treatment of different disease such as diabetes and inflammatory diseases (Rocabado et al. 2008). Preventive effects of raspberries have been demonstrated in a variety of diseases including cancer, diabetes, obesity, cardiovascular diseases, inflammation and oxidative stress (Bobinaite et al. 2012). Red raspberry generously contains several antioxidant substances such as vitamin C, ellagic acid and anthocyanins (Mullen et al. 2002). Carvalho and his research group reported that red raspberries contained more than 300 mg/kg of tocopherols (Carvalho et al. 2013).

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Fruity flavoured beverages are preserved by several methods such as freezing, irradiation, heat processing and use of chemical preservatives. Use of chemical preservative, is the most suitable and economical method for preservation of this kind of ready to serve drink beverages. However, no works have so far been done to follow the changes like colour and flavour losses during storage (Murtazat et al. 2004). BHA (butylated hydroxy anisole) is the common chemical preservative which is used in beverages and drinks. It is well known that BHA may cause a chemical taste in fruity flavoured beverages during the shelf life and this chemical taste is not acceptable for consumers. When the chemical taste occur in a beverage, the original fruit taste may lose and the shelf life of the product may shorten. All of these effects are important and critical for beverage manufacturers.

Nowadays, transparent glass bottles/jars are preferred by consumers because of being healthier compared to full covered or black materials. At the same time, seeing the color and texture of the beverage is also important for the consumers. Manufacturers want to produce the best quality natural products in the best transparent packaging materials. However, providing color and taste stable, and maintaining antioxidant content of beverages are more difficult in transparent packaging materials compared to full covered or black materials.

In this study, fruity flavoured beverage for ready to serve was formulated and packaged in transparent glass. Several red raspberry extracts were prepared in water, ethanol (96 %, v/v) and water:ethanol mixture (1:1, v/v) in order to determine extract which had the highest antioxidant capacity. Their antioxidant capacity was compared to butylated hydroxy anisole (BHA) which is a synthetic antioxidant used for beverages. Formulations containing red raspberry extracts and BHA were characterized in taste and color stability.

Materials and methods

Materials

Samples of red raspberry in dried form were purchased from a commercial Spice Bazaar (Istanbul, Turkey). Ascorbic acid, citric acid, potassium sorbate, sodium benzoate were purchased from Modern Chemistry Food Industry Trade Limited Company (Istanbul, Turkey). Pure ethanol (96 %, v/v) was provided from Analysis Chemical Laboratory Chemicals and Materials Industry Trade Limited Company (Izmir, Turkey). Berry fruit flavours, fruit concentrates and glucose syrup were trade products of Aromsa Flavours and Food Additives Industry and Trade Inc. Co. (Kocaeli, Turkey). All other chemicals and reagents were of analytical grade.

Preparation of red raspberry extracts and stock solutions

Dried red raspberry fruits (200 g) were macerated with water, ethanol and water:ethanol mixture (1:1 v/v) for 4 times, separately at room temperature. Crude extracts were concentrated under vacuum yielded 65 °Brix (the percent of soluble solids) which is important for microbiological safety.

For preparation of stock solutions, 1 portion of BHA was dissolved in 18 portion of propylene glycole (Yu et al. 1969, 1973). Ascorbic acid and α -tocopherol stock solutions were prepared as 5 mM in distilled water and 2 mM in ethanol, respectively (Re et al. 1999). Stock solutions were used as standarts in determinations of antioxidant capacity of red raspberry extracts.

Preparation of fruity flavoured beverages

First group beverages containing red raspberry extracts were prepared using 5 % red raspberry ethanol extract and 10 % fruit concentrate, 0.2 % potassium sorbate, 0.2 % sodium benzoate, 0.3 % citric acid, 15 % glucose syrup, 0.1 % berry flavour and water. Second group beverages containing BHA were prepared using 5 % BHA and 10 % fruit concentrate, 0.2 % potassium sorbate, 0.2 % sodium benzoate, 0.3 % citric acid, 15 % glucose syrup, 0.1 % berry flavour and water (Table 1). All of beverages were filled in 200 ml transparent glass bottles and pasteurized at 80 °C for 1 min. Bottles were stored at room temperature (23 ± 2 °C), 2 ± 2 °C and 40 ± 2 °C for sensory analysis modelling for different marketplace storage conditions.

Sensory analysis

Seven females and one male assessors aged between 23 and 45 who were staff of Aromsa Flavours RDC, were used in the basic tastes, threshold and odour sensitivity tests. They were trained on the sensory analysis of food flavour and mouthfeel attributes of fruity flavoured beverages at least 72 h prior to sensory analysis according to ISO guideliness (ISO 8586-

Table 1 Formulations of the first and second group beverages

First group components	Second group components	Addition concentrations (%)
Red raspberry ethanol extract	BHA	5
Fruit concentrate	Fruit concentrate	10
Potassium sorbate	Potassium sorbate	0.2
Sodium benzoate	Sodium benzoate	0.2
Citric acid	Citric acid	0.3
Glucose syrup	Glucose syrup	15
Berry flavour	Berry flavour	0.1
Water	Water	69.2
Total	Total	100

1:1993). An additional 36 h of training was dedicated to flavour lexicon identification/refinement, and calibration of assessors on fruity flavoured beverage sensory properties.

Sensory method: The quantitative descriptive analysis (QDA) was used to determine differences in sensory characteristics of samples (Stone and Sidel 1993; Lawless and Heymann 1999). Prior to the analysis, vocabulary of the sensory attribute for berry flavoured beverages was developed by a panel in a round-table session using standardised procedure (ISO/DIS 13299:1998). Ten attributes for taste were selected from previous studies on berry flavoured beverage lexicon and thoroughly defined for taste profiling (Table 2).

Flavour lexicon development: Kappes et al. (2006) were the first scientists who developed the flavour lexicon procedure. Flavour lexicons are used in a sensory evaluation to determine flavour profile of food products. Flavour is a combination of taste and aroma. Two principal methods exist to measure flavour in a food product. The first method uses a consumer panel composed of a large group of untrained people, or through a small highly trained group of people known as a descriptive panel. Descriptive panels use lexicons, a list of defined terms, to describe products. An array of commercial fruity flavoured beverages was used for flavour lexicon development and refinement. The assessors discussed and found out characteristics of samples and reference product for each attribute.

Protocol of evaluation: The beverages were evaluated at 10 °C which is the normal consumption temperature (Kappes et al. 2006). At the beginning of each evaluation session, the assessors were calibrated with reference solutions (Table 3). Descriptive panels used defined lexicon of terms, and were trained to rate the intensity or prevalence of each attribute that was present.

At the beginning of the each session, assessors were calibrated to prevent fatigue. For the beverage presentation, the standard procedure was identified and given to the assessors to

Table 2 Attributes for sensory descriptive analysis of fruity flavoured beverages and their definitions

Attribute (taste)	Definition of attributes
Green	New-mown berry smell and taste
Fresh	A unique fresh scent and taste of fresh fruit
Bitter	Basic taste (reference sample: caffeine solution in water, 0.5 %)
Astringent	Like strong tea, taste in the mouth after swallowing which cause wrinkling
Flowery	Similar to the sweet fragrance of violets
Ripe	Degree of fruit ripeness
Jamy	The smell and taste of jam foam while cooking
Sweet	A typical fruit sweetness
Chemical	Note characteristics for chemical compounds
Juicy	The smell and the taste of fruit juice

decrease the variability. After tasting and evaluating the each sample, a 5 min rest was given to the assessors. During the rest time, assessors rinsed their mouth with water and ate crackers to prevent carryover effects (Brannan et al. 2001). The presentation order of samples was randomized using a William's design to demonstrate presentation and carryover effects (Schlich 1993). Each beverage was measured in separate sessions in quadruplicate by each assessor.

Statistical methods

The sensory evaluation of the samples was conducted fortnightly for 3 months. Sensory evaluation was carried out on seven points hedonic scale (Larmond 1977). The results were statistically analyzed as described by Steel et al. 1996. Results obtained from descriptive panels were analyzed using Student's-t test, $P > 0.05$ was regarded as significant. A pattern of similarity between observations and variables was displayed as points on a spider graph.

Analytical measurements

There are different color space, one of them is $L^*a^*b^*$ space. $L^*a^*b^*$ space is the useful for the food industry because it is very close to human perception of color.

Color A colorimeter equipment with CIE $L^*a^*b^*$ (L =Lightness, a = +green, -red, b = +yellow, -blue) color scale (Hach Lange LICO 500, Keison Products, Chelmsford, Essex, UK), was used to measure color intensities. The colorimeter was calibrated against black and white standard tiles. The lightness (L) of the sample, yellow or blueness (b) and redness or greenness (a) were calculated automatically. Color measurements were performed on 40 ml beverage in a sample cup. All measurements were replicated three times (Chinnaswamy and Hanna 1988) at 470 nm wavelength. The maximum absorbance was seen at 470–490 nm wavelength for red raspberry flavoured beverages.

pH pH was determined according to method given by AOAC (1990). For this purpose an electronic pH meter (Sartorius, Germany) was used in the measurement. All measurements were done at 22 ± 2 °C.

°Brix °Brix was determined according to the method given by AOAC (1990). °Brix of the samples was measured by using a digital refractometer (Atago Model RX-5000, Tokyo).

Determination of the antioxidant capacity of red raspberry extracts

Free radical scavenging activity of the extracts was determined by 1,1-diphenyl-2-picryl-hydrazyl (DPPH) assay according to

Table 3 Reference solutions for calibrations of assessors

Descriptor	Definition	References	Preparation
Green	New-mown hay smell and the taste	Cis-3- hexenol	20 ppm (ethanol)
Parfumatic/flowery	Similar to the sweet fragrance of rose petals or violets	Ionene alpha	0.25 ppm (ethanol)
Ripe	Degree of fruit ripeness	Isoamyl acetate	10 ppm (ethanol)
Jamy	The smell of strawberry jam foam while cooking	Furaneol	50 ppm (ethanol)
Fresh	A unique fresh scent and taste of fresh fruit	Ethyl butyrate	20 ppm (ethanol)
Sweet	A typical sweetness of fruit	Vanilin	20 ppm (ethanol)
Astringent	Taste in the mouth after swallowing which cause wrinkling	Decalacton gamma	10 ppm (ethanol)

the procedure reported in an earlier study (Tepe 2008). The total phenolic content of red raspberry extracts was measured using the Folin –Ciocalteu's reagent (FCR), photometrically (Meda et al. 2005). Results were expressed as microgram of gallic acid equivalents (GEs) per mg of extract. Gallic acid monohydrate (Sigma) was used as a standard.

Determination of the total flavonoid content of red raspberry extracts was based on the method defined by Yesilyurt and his research group (Yesilyurt et al. 2008). Thus, results were expressed as microgram of quercetin equivalents (QEs) per mg of extract.

Antioxidant capacity tests were triplicated. Statistical analysis of variance was performed by ANOVA procedures. Significant differences between means were determined by Student's-t test, $P > 0.05$ was regarded as significant. IC_{50} values were calculated using the concentration-effect linear regression curve.

Results and discussion

Change in pH

pH of red raspberry flavoured beverages differed significantly and non-significantly regarding to the storage temperature and phenolic content, respectively. The mean pH values of beverages were determined in a range from 3.80 to 3.51 after 90 days of storage (Table 4). The maximum decrease in pH

Table 4 Effect of storage temperatures on pH

Treatments	pH (beverages added BHA)	pH (beverages added red raspberry ethanol extract)
T1*	3.78a**	3.80a
T2*	3.48b**	3.55c**
T3*	2.71a	3.05b

* T1, T2 and T3 symbolize refrigeration temperature (2 ± 2 °C), room temperature (23 ± 2 °C), and high temperature (40 ± 2 °C) treatment, respectively

**The same letters show that there is insignificant difference between samples, different letters show that there is a significant difference between samples

was observed in the sample which included artificial preservative (BHA) stored at high temperature (40 ± 2 °C). pH of the samples decreased due to an increase in acidity during storage. T1, T2 and T3 symbolize refrigeration temperature, room temperature and high temperature treatment, respectively.

Change in °Brix

The percent of soluble solids (°Brix) differed significantly among the treatments regarding to the storage temperature during 3 months. The initial mean soluble solid content was determined 12.00 at the 0. day. Solid content was observed to increase to 13.58 after 90 days (Table 5). This phenomena can be attributed to sucrose hydrolysis to invert sugars as reported in earlier studies by Bhatti (1975) and Ullah (1990).

DPPH free radical scavenging capacity assay

Free radical scavenging capacity assay is that hydrogen atoms or electron donation ability of the compounds are measured from the bleaching of purple coloured as the principle of DPPH. This spectrophotometric assay uses DPPH (1,1-diphenyl-2-picryl-hydrazyl) as a standard stable reagent. Absorbance of red raspberry extracts and reference standards (BHA, ascorbic acid, α -tocopherol) were measured against a blank at 517 nm (Tepe 2008) in this study.

Table 5 Effect of storage temperatures on °Brix

Treatments	°Brix (beverages added BHA)	°Brix (beverages added red raspberry ethanol extract)
T1*	12.00a**	12.00a
T2*	12.56b**	12.21b
T3*	13.58c**	13.22c

* T1, T2 and T3 symbolize refrigeration temperature (2 ± 2 °C), room temperature (23 ± 2 °C), and high temperature (40 ± 2 °C) treatment, respectively

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Table 6 DPPH radical scavenging activity (%) of red raspberry extracts, BHT, α -tocopherol, BHA, ascorbic acid

Plant	Extracts	IC ₅₀ (μ g/ml) DPPH system
Red raspberry fruits (<i>Rubus idaeus</i> L.)	Water	92.62 $\pm$ 0.47 ^a
	Ethanol	94.10 $\pm$ 0.20 ^a
	Ethanol:water mixture (50:50)	91.00 $\pm$ 0.04 ^a
Standards ^b	BHA	16.96 $\pm$ 0.34 ^a
	Ascorbic acid	4.04 $\pm$ 0.07 ^a
	α -tocopherol	9.86 $\pm$ 0.14 ^a

^a Values indicated are means $\pm$ SD of three parallel measurements ($p>0.05$)

^b Reference compounds

DPPH solution was prepared freshly. 5 ml of a 0.004 % ethanol solution of DPPH was added to standards and extracts in ethanol different concentration. After incubation time (30 min) at room temperature in the dark place, absorbance of mixtures was determined against a blank solution by Hunter color colorimeter at 517 nm (Lange, model LICO 400, Dusseldorf, Germany). Radical scavenging activity by DPPH was calculated using the following equation:

$$\text{DPPH \%} = [(A - A_R)/A] \times 100$$

Where A_R and A are absorbance of reference and extract, respectively.

Extracts and the standards concentrations giving 50 % inhibition (IC₅₀) were found from the graph plotted. Tests were repeated in triplicate. Free radical scavenging capacities of red raspberry extracts and the standards measured by DPPH assay are shown in Table 6.

Determination of total phenolic and flavonoid contents

Phenolic acids and flavonoids are present rich in fruits and vegetables, which are used source of dietary supplement due to their antioxidant activity. Total phenolic contents of red raspberry extracts were determined using Folin-Ciocalteu reagent and gallic acid as standard (Slinkard and Singleton

Table 7 Total phenolic and flavonoid contents of red raspberry extracts

Red raspberry extracts	Total phenolic content (μ g GEs/mg extract)	Total flavonoid content (μ g QEs/mg extract)
Red raspberry in water	455.55 $\pm$ 18.04	8.28 $\pm$ 0.14
Red raspberry in ethanol	844.45 $\pm$ 18.04	9.34 $\pm$ 0.02
Red raspberry in ethanol:water mixture	660.42 $\pm$ 18.04	8.97 $\pm$ 0.12

Values indicated are means $\pm$ SD of three parallel measurements ($p<0.05$)

Table 8 Effect of storage temperatures on sensory properties of beverages added BHA

Treatments	Flavour	Odour	Color	Overall acceptability
T1*	4.8a**	4.7a	4.7a	4.6a
T2*	4.3a	4.0b	4.0b	4.1a
T3*	2.8b**	2.6c**	2.5c	2.7b

* T1, T2 and T3 symbolize refrigeration temperature (2 ± 2 °C), room temperature (23 ± 2 °C), and high temperature (40 ± 2 °C) treatment, respectively

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1997; Meda et al. 2005). The concentration of phenolic compounds was calculated according to the following equation, and then obtained from the standard gallic acid graphic;

$$\text{Absorbance} = 0.0009 \text{ gallic acid } (\mu\text{g}) + 0.0573 \text{ (R}^2 = 0.998\text{)}$$

Total flavonoid contents of red raspberry extracts were measured based on the method defined by Yesilyurt et al. 2008 and results were expressed as microgram of quercetin equivalents (QEs) per mg of extract. The concentration of flavonoid compounds was calculated according to the following equation, and then obtained from the standard quercetin graphic;

$$\text{Absorbance} = 0.0146 \text{ quercetin } (\mu\text{g}) - 0.0193 \text{ (R}^2 = 0.9939\text{)}$$

Total phenolic and flavonoid contents of red raspberry extracts (water, ethanol, water:ethanol mixture) were shown in Table 7. The amount of total phenolic and flavonoid compounds were highest in the crude red raspberry extract in ethanol (844.45 ± 18.04 μ g GEs/mg extract, 9.34 ± 0.02 μ g QEs/mg extract), followed by the crude water:ethanol mixture extract of red raspberry (660.42 ± 18.04 μ g GEs/mg extract, 8.97 ± 0.12 μ g QEs/mg extract). It is highly important that there is a positive correlation between antioxidant capacity (DPPH radical scavenging capacity test results) and amount of phenolic and flavonoid compounds of the red raspberry extracts.

Table 9 Effect of storage temperatures on sensory properties of beverages added red raspberry ethanol extract

Treatments	Flavour	Odour	Color	Overall acceptability
T1*	5.0a**	5.0a	5.0a	5.0a
T2*	4.6a	4.2b	4.3b	4.5a
T3*	3.2b**	3.0c**	3.1c	3.4b

* T1, T2 and T3 symbolize refrigeration temperature (2 ± 2 °C), room temperature (23 ± 2 °C), and high temperature (40 ± 2 °C) treatment, respectively

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Table 10 Instrumental color measurements of fruity beverages added BHA

Treatments	Storage time	L*	a*	b*
T1**	Day 1	55.72a ***	26.18a	12.04a
	Day 14	56.21a	25.64a	11.86a
	Day 30	56.56a	24.87b	11.92a
	Day 60	56.96a	23.41b	11.90a
	Day 90	57.12b ***	22.12c	11.88a
	Day 1	55.72a	26.18a	12.04a
T2**	Day 14	56.12a	25.25b	12.01a
	Day 30	58.01b	24.61c	11.90a
	Day 60	58.64b	21.12d	11.85a
	Day 90	59.32c ***	20.40d ***	11.72a
	Day 1	55.72a	26.18a	12.04a
	Day 14	57.14b	24.32b	11.84a
T3**	Day 30	58.96bc ***	21.25c	11.12ab ***
	Day 60	61.25c	19.92d	10.52b
	Day 90	64.24d	18.21d	10.04b

* T1, T2 and T3 symbolize refrigeration temperature (2 ± 2 °C), room temperature (23 ± 2 °C), and high temperature (40 ± 2 °C) treatment, respectively

**The same letters show that there is insignificant difference between samples, different letters show that there is a significant difference between samples

Table 11 Instrumental color measurements of fruity beverages added red raspberry ethanol extract

Treatments	Storage time	L*	a*	b*
T1**	Day 1	55.72a ***	26.18a	12.04a
	Day 14	54.96a	25.32a	12.11a
	Day 30	54.65a	24.54b	11.85a
	Day 60	53.88b ***	24.24b	11.96a
	Day 90	53.26b	23.15c	12.01a
	Day 1	55.72a	26.18a	12.04a
T2**	Day 14	54.25a	25.22a	11.65a
	Day 30	53.72b	24.02b	11.87a
	Day 60	53.12b	23.55b	12.01a
	Day 90	51.98c ***	22.34c	11.76a
	Day 1	55.72a	26.18a	12.04a
	Day 14	54.12b	25.45b	12.01a
T3**	Day 30	53.25b	22.88c	11.85a
	Day 60	52.68c	21.16c	11.42b
	Day 90	51.32c	20.03d	10.25c

* T1, T2 and T3 symbolize refrigeration temperature (2 ± 2 °C), room temperature (23 ± 2 °C), and high temperature (40 ± 2 °C) treatment, respectively

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Table 12 Mean sensory ratings of fruity flavoured beverages added BHA

Sensory attributes	T1*	T2*	T3*
Green	3.5bc	3.0b	2.5a
Fresh	4.0b **	3.0b	2.0c
Bitter	1.5cd	3.5a **	4.2b
Astringent	2.0c	2.6a	3.5bc
Flowery	2.0c	2.2b	1.5cd
Ripe	1.6cd **	1.8bc **	1.5cd
Jamy	1.0d	2.5b	4.0b
Sweet	4.0b	4.0b	4.2b
Chemical	1.0d	1.4c **	3.0b
Juicy	4.0b	3.2b	2.8a

* T1, T2 and T3 symbolize refrigeration temperature (2 ± 2 °C), room temperature (23 ± 2 °C), and high temperature (40 ± 2 °C) treatment, respectively

**The same letters show that there is insignificant difference between samples, different letters show that there is a significant difference between samples

Sensory characteristics

Fruity flavoured beverages containing red raspberry ethanol extract and synthetic preservative as a reference were stored at refrigeration temperature (2 ± 2 °C). Samples were ranked the best for color, odour and taste stability comparing refrigeration temperature to room (23 ± 2 °C), and high temperatures (40 ± 2 °C). Color difference in red raspberry ethanol extract added fruity flavoured beverages occurred because of the browning reaction between reducing sugars and amino acids accelerated by high temperature (Gonzalez and Leeson 2000). Colors of

Table 13 The mean sensory ratings of fruity flavoured beverages added red raspberry ethanol extract

Sensory attributes	T1*	T2*	T3*
Green	3.6b **	3.2a **	2.5a
Fresh	4.4b	3.5a	2.0c
Bitter	1.5c **	2.8a	3.0b
Astringent	1.8c	2.6a	2.8b
Flowery	2.0c	2.0b	1.8c
Ripeness	1.6c	1.8b	1.6c
Jamy	1.0d **	2.5b	3.0b
Sweetness	4.2b	4.0b	4.2b
Chemical	0.8d	1.4c	1.8b
Juicy	4.2b	3.8b	3.5a

* T1, T2 and T3 symbolize refrigeration temperature (2 ± 2 °C), room temperature (23 ± 2 °C), and high temperature (40 ± 2 °C) treatment, respectively

**The same letters show that there is insignificant difference between samples, different letters show that there is a significant difference between samples

Fig. 1 Sensory profiles of fruity flavoured beverages added BHA of different storage temperatures (23 ± 2 °C, 2 ± 2 °C and 40 ± 2 °C)

synthetic preservative added beverages faded during the storage period. The loss of odour and taste may be due to the degradation of ascorbic acid and reactions of furfural (Shimoda and Osijama 1981; Perez and Sanz 2001) at high storage temperature (Daep 1973). Storage at refrigeration temperature resulted in less odour and taste loss in the samples (Tables 8 and 9).

Color values L^* , a^* and b^* of different treatments and formulations during storage are shown in Tables 10 and 11. Changes in lightness, a^* and b^* of for formulations during storage were not negligible ($p < 0.05$). A wide range of lightness, a^* and b^* values was found at high temperature (T3) during the storage period.

Flavour lexicon

In sensory evaluation, quantitative descriptive analysis (QDA) is a very popular method in use. It is based on discrimination and description of both the qualitative and

quantitative sensory of a product attributed by trained panels. The mean sensory ratings for the samples are presented in Tables 12 and 13. The results show that among 10 attributes, 4 of them were statistically significant. Significant differences were observed among the intensity of bitter ($F=3.72$; $p < 0.05$), fresh ($F=6.54$; $p < 0.05$), jamy ($F=5.46$; $p < 0.05$) and chemical taste ($F=8.52$; $p < 0.05$). In order to observe those differences in the beverages, the sensory profiles of samples were displayed as spider diagrams in Figs. 1 and 2.

Those results indicated that sensory properties of fruity flavoured beverages were dependent on storage temperature and formulation of the beverages. Increase in temperature resulted in major changes in beverages. Jamy note was highly sensed by assessor in both beverages in T3 condition. However, chemical, bitter and astringent notes were more sensed beverages added BHA. Green, juicy and fresh notes were more sensed beverages added red raspberry ethanol extract in both storage temperatures by the assessors.

Fig. 2 Sensory profiles of fruity flavoured beverages added red raspberry ethanol extract of different storage temperatures (23 ± 2 °C, 2 ± 2 °C and 40 ± 2 °C)

Conclusion

In this study, use of red raspberry fruit extracts was investigated in fruity flavoured beverages instead of BHA as a synthetic antioxidant. Red raspberry ethanol extract was determined to have the highest antioxidant capacity among the other red raspberry extracts of different solvents according to antioxidant capacity studies. Thus, it was decided to use in beverages. At 2 ± 2 °C was observed as the most suitable storage temperature for beverages. Beverage formulation containing red raspberry ethanol extract also displayed the highest storage stability. In sensory analysis for comparison of red raspberry ethanol extract to BHA in beverages, assessors attributed bitter taste caused by BHA in time. However, red raspberry ethanol extract did not give the same unwanted taste. No changes were also detected in taste in beverages containing red raspberry ethanol extract. As a result, it was concluded that red raspberry ethanol extract was more preferable and suitable antioxidant component for fruity flavoured beverages compared to BHA.

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