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Quality Assessment of Industrially Processed Fruit Juices Available in Dhaka City, Bangladesh

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ABSTRACT

This study was performed to evaluate the nutritional and microbiological quality of industrially processed packed fruit juices of mango *(Mangifera indica)* and orange *(Citrus sinensis)* from nine different manufacturing companies in Dhaka City. The highest quantity of total sugar (17.62%) and reducing sugar (9.99%) was recorded in mango juices while the lowest in orange juices (10.41% and 2.24% respectively) of different companies. In this study, protein contents were comparatively higher in mango juices than in orange juices. The pH of all samples varied from 3.50±0.10 to 4.70±0.05. Vitamin C content was comparatively higher in mango juices. The levels of metals tested namely, arsenic, lead, copper and zinc in the juices were within the limits of Bangladesh Standard and Testing Institute (BSTI) for fruit juices. The microbiological qualities of all the products were within the limits of the Gulf standards (the recommended Microbiological Standards for any fruit juice sold in the Gulf Region). Based on the above results, it is suggested that processed juices be prepared under hygienic conditions.

Keywords: Dhaka City, processed fruit juices, quality assessment

INTRODUCTION

Fruit juices are becoming an important part of the modern diet in many communities. They are nutritious beverages and can play a significant part in a healthy diet because they offer good taste and a variety of nutrients found naturally in fruits. Juices are available in their natural concentrations or in processed forms.

Juice is prepared by mechanically squeezing fresh fruits or is extracted by water. Juices are fat-free, nutrient-dense beverages rich in vitamins, minerals and naturally occurring phytonutrients that contribute to good health. For example, orange juice is rich in vitamin C, an excellent source of bio-available antioxidant phytochemicals (Franke *et al.,* 2005) and significantly improves blood lipid profiles in people affected by hyper-cholesterolemia (Kurowska *et al.*, 2000). Fruit juices promote detoxification in the human body (Deanna & Jeffrey, 2007).

The constituents of processed juices are mainly water, sugar, preservatives, colour, and fruit pulp. The most commonly used preservatives are benzoic acid, sorbic acid or sulphur dioxide. Natural colours such as anthocynins and betanin are used. Acid is

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an essential universal constituent of juice and the most commonly used acid is citric acid.

Most fruit juices contain sufficient nutrients that could support microbial growth. Several factors encourage, prevent or limit the growth of microorganisms in juices; the most important are pH, hygienic practice and storage temperature and concentration of the preservative. Storage of products at refrigerator temperature or below is not always best for the maintenance of desirable quality of some fruits. Water used for juice preparation can be a major source of microbial contaminants such as total coliforms, faecal coliforms, faecal streptococci, etc. Environmental formites may also make the fruits unsafe and these may have a role in the spread of *Salmonella, Shigella, Vibrio, Escherichia coli* and other and caause diseases as well fruit spoilage (Doyle, Beuchat & Montville, 2001). Spoilage yeasts such as *Saccharomyces cerevisiae*, *Candida lipolytica* and *Zygosaccharomyces* spp. can tolerate acidic environments. It should also be noted that changes in pH could transform a food into one which can support the growth of pathogens (FDA, 2001).

The quality of fruit juices is strictly maintained in developed countries under several laws and regulations but in many developing and underdeveloped countries, the manufacturer is not concerned about the microbiological safety and hygiene of fruit juices because of lack of enforcement of the law. Thus the transmission of certain human diseases through juice and other drinks in recent years is a serious problem.

Fruit juices are available in essentially the same form almost anywhere in the world. From polar bases to the tropics and from the largest developed countries, fruit juices are available in bottles, cans, laminated paper packs, pouches, cups and almost every other form of packaging known. In recent years these juices have been included significantly in the diet of most people, irrespective of age. Therefore, maintaining the quality of processed fruit juices is an important concern. In order to develop awareness among the people about fruit juices, this study attempts to measure nutritional and microbiological quality of industrially processed locally available fruit juices.

MATERIALS AND METHODS

Seven types of mango juices and two types of orange juices were collected from different manufactures in Dhaka City for nutritional and microbiological analysis. At least 5 samples of each category were analysed to overcome sampling bias. These samples were designated as A (orange), B (mango), C (mango), D (mango), E (mango), F (orange),G (mango), H (mango) and I (mango).

Estimation of nutrient composition of fruit juices

Moisture and ash contents of fruit juices were determined using standard AOAC methods (Horwitz, 2003). Crude protein content of the samples was determined using the Kjeldahl method (Horwitz, 2003). The method consists of three basic steps: (i) digestion of the sample in sulfuric acid with a catalyst, which results in conversion of nitrogen to ammonia; (ii) distillation of the ammonia into a trapping solution; and (iii) quantification of the ammonia by titration with a standard solution. According to this method, % crude protein content of a sample = % nitrogen × 6.25.

Ascorbic acid was estimated by 2, 6-Dichlorophenolindophenol visual titration method according to AOAC. The reagents used for the estimation of vitamin C were as follows: (i) metaphosphoric acid (6%; (ii) standard ascorbic acid solution; and (iii) 2, 6-Dichlorophenolindophenol dye. For estimation of vitamin-C, the following steps were followed: standardisation of dye solution, preparation of solution and titration (AOAC, 2004). The official Lane-Eynon method described in AOAC was used to measure total sugar and reducing sugar contents in fruit juices (James, 2004).

Total Soluble Solid (TSS) is one of the more important quality factors for most fruit juices. TSS content of fruit juices was determined using an Abbe refractrometer whereby a drop of pulp solution was placed on its prism. The percentage of TSS was obtained from direct reading of the refractrometer.

Acidity was determined by dissolving a known weight of sample in distilled water and then titrated against 0.01 N NaOH using phenolphthalein as indicator (Srivastava & Sanjeev, 2003); pH was determined using digital pH meter (Inolab digital pH meter). Metals in fruit juices were measured using a graphite furnace of Atomic Absorption Spectrophotometer (GBC scientific equipment XAA1175, Australia) equipped with D2 background correction devices.

Bacterial analysis of collected juice samples

For the quantitative determination of total count of mesophilic bacteria, total coliform, faecal coliform, the standard procedure was followed (FDA, 2001). Aerobic plate count (APC) was performed by pour plate method using plate count agar (PCA), which was incubated at 35±1^{0}C for 48±2h. Lauryl tryptose broth was used for isolation of *Escherichia coli*. Gassing tube was selected for *E.coli* enumeration using most probable number (MPN) method. Enumeration of fungi was performed on Potato Dextrose Agar medium. For the isolation of *Salmonella* species, pre-enrichment was done by lactose broth followed by selective enrichment and finally confirmed using the standard method (FDA, 2001).

Statistical analyses

Data analyses were performed using Statistical Package for the Social Sciences (SPSS version 12.0). Values were expressed as percentage and mean±SD. Appropriate test statistics (ANOVA) and *t*-test were done to determine the effect of nutrition content in fruit juices.

RESULTS AND DISCUSSION

In spite of the potential benefits offered by fruit juices, concerns over their safety and quality have been raised. An estimate of the gross nutrient composition of the juices is shown in Table 1 and there appear to be some differences between the juices.

Most of the common fruits are low in protein. A considerable proportion of the protein content of fruits is insoluble and consequently remains in the pomace; therefore most fruit juices are very low in protein (Table 1). In this study, protein content in mango juices was comparatively higher than in orange juices ($P<0.001$).

It is estimated that reducing sugar and total sugar content are increased with the advanced ripening of fruits. Mango juices contained the highest ($P<0.001$) quantity of reducing sugar and total sugar while orange juices contained the lowest quantity at all times of observation (Table 1). The combined effect of stages of maturity and ripening conditions significantly affected the reducing sugar and total sugar content of the fruit juices. The highest quantity of total sugar (17.62%) and reducing sugar (9.99%) was recorded in mango juices while these were lowest in orange juices (10.41% and 2.24% respectively) of different companies.

The total acidity of fruit juices is due to the presence of a mixture of organic acids, whose composition varies depending on fruit nature and maturity. The main acids encountered in fruits are tartaric, malic, citric, succinic, lactic and acetic acids. Organic acids take the lead in importance for characteristics and nutritive value of fruit juices and confer individual originality among natural beverages. Total titrable acidity varied significantly ($P<0.001$) in different types of fruit juices (Table 1). Maximum content of total titrable acidity

Table 1. Potential nutritional value of samples of fruit juices purchased from a local market in Dhaka city

Products (Scientific name)	*Moisture (%)*	*Ash (%)*	*Protein (%)*	*Total sugar (%)*	*Reducing sugar (%)*	*TSS (%)*	*Acidity (%)*
A(orange) (*Citrus sinensis*)	89.98±0.08	0.06±0.01	0.08±0.001	10.98±0.01	4.96±0.02	9.00±0.02	0.50±0.01
B(mango) (*Mangifera indica*)	89.22±0.04	0.05±0.02	0.17±0.01	11.00±0.20	9.99±0.31	11.00±0.23	0.50±0.02
C(mango) (*Mangifera indica*)	87.00±0.17	0.03±0.00	0.38±0.01	13.37±0.22	5.10±0.25	12.00±0.08	0.56±0.00
D(mango) (*Mangifera indica*)	86.78±0.04	0.06±0.00	0.66±0.03	10.84±0.02	4.00±0.04	12.00±0.07	0.65±0.04
E(mango) (*Mangifera indica*)	85.75±0.33	0.07±0.01	0.58±0.02	17.62±0.05	3.37±0.21	13.00±0.09	0.61±0.07
F(orange) (*Citrus sinensis*)	89.19±0.61	0.05±0.01	0.001±0.00	10.41±0.04	2.24±0.06	10.50±0.01	0.59±0.011
G(mango) (*Mangifera indica*)	89.16±0.01	0.01±0.02	0.001±0.00	12.96±0.08	7.00±0.01	13.50±0.02	0.45±0.05
H(mango) (*Mangifera indica*)	86.42±0.78	0.08±0.01	0.08±0.01	12.44±0.12	4.25±0.00	13.00±0.11	0.74±0.02
I(mango) (*Mangifera indica*)	85.80±0.02	0.05±0.02	0.001±0.00	14.49±0.50	5.29±0.08	13.50±0.25	0.66±0.01
P-value	<0 .001*	<0 .001*	<0 .001**	<0 .001**	<0.001**	<0 .001**	<0 .001*

Results are expressed as means ± SD for five observations. P-value was calculated using *One-Way ANOVA F-test among juices and **independent sample *t*-test between two types of juices.

(0.74%) was recorded in H (mango) juice while it was minimum (0.45%) in G (mango) juice.

Total soluble solids (TSS) contents are related directly to both the sugars and fruit acids as these are the main contributors. Pectins, glycosidic materials and the salts of metals (sodium, potassium, calcium etc.), when present, will also register a small but insignificant influence on the solids figure. The TSS content is significantly influenced by the combined effect of stages of maturity and ripening conditions. The TSS content of mango juices in this study was higher ($P<0.001$) than that of orange juices (Table 1).

Fruit juices have a low pH because they are comparatively rich in organic acid. The overall range of pH is 2 to 5 for common fruits with the most frequent figures being

Table 2. Vitamin C (ascorbic acid) content of different fruit juices.

Products (Scientific name)	*Ascorbic acid (mg/100)*
A(orange)(*Citrus sinensis*)	5.64±0.08
B(mango)(*Mangifera indica*)	2.25±0.11
C(mango)(*Mangifera indica*)	1.27±0.15
D(mango)(*Mangifera indica*)	7.95±0.05
E(mango)(*Mangifera indica*)	8.80±0.02
F(orange)(*Citrus sinensis*)	4.50±0.04
G(mango)(*Mangifera indica*)	4.50±0.06
H(mango)(*Mangifera indica*)	2.48±0.09
I(mango)(*Mangifera indica*)	4.70±0.07
P-value	<0.05

Results are expressed as means ± SD for five observations. P-value was calculated using independent sample *t*-test between two types of juices.

between 3 and 4. In this study, the pH of the fruit juices varied from 3.50±0.10 to 4.70±0.05. The highest pH was shown by I (mango) juice (4.70±0.05), followed by H (mango) juice (4.60±0.06), F (orange) juice (4.50±0.08), A (orange) juice (4.40±0.02), C (mango) juice (4.30±0.05), E (mango) juice (4.20±0.00), G (mango) juice (4.00±0.04), B (mango) juice (3.60±0.02) and D (mango) juice (3.50±0.10).

Ascorbic acid not only restores nutritional value lost during processing, but also contributes to the product appearance and palatability. Ascorbic acid (vitamin C) content of different fruit juices is shown in Table 2. The ascorbic acid content of commercial fruit juices is lost with respect to time and temperature during processing and storage (Biljana & Marija, 2009). Many processors add ascorbic acid to their products to make up for processing losses (Takeda U.S.A., Inc.). This could be the cause for higher content of ascorbic acid in mango juices in this study.

Table 3 presents the concentration of heavy metals. Analysis of variance (P<0.001) showed a significant variability in the concentration of the studied metals. The level of arsenic found in this study was low compared to any other metal examined. The concentration of lead in these fruit juices was highest in A (orange) juice (0.200 mg/kg) and was nil in C (mango) juice. The major source of lead in canned fruit juices is the leaching of lead from the canning. Lead toxicity causes many signs and symptoms such as abdominal pains, anemia, brain damage, anoxia, convulsion and inability to concentrate etc. (Chukwujindu *et al.*, 2008). The level of zinc in this study was highest in D (mango) juice (1.640 mg/kg) and absent in A (orange) juice. Copper is an essential element for growth, although emetic in large doses. However, when present in some beverages such as fruit juices, it tends to impair shelf life and keeping quality of juices, so it is expected that fruit juice should contain low levels of copper. The level of copper found in this study was higher in G (mango) juice (1.50 mg/kg) and was lower in B (mango) juice (0.120 mg/kg). The levels of all of these metals were within the limits of BSTI standard for fruit juice (BSTI. 2002).

Standard plate count of different types of fruit juices varied from 2×10^3 - 4×10^3 cfu/ml. No coliform, fungus or *Salmonella* were detected in these juices (Table 4). The microbiological quality of all the products was within the limits of the Gulf standards for fruit juices (Gulf Standards, 2000).

Table 3. Values of arsenic, lead, zinc and copper content of different fruit juices

Products (Scientific name)	*Arsenic mg/kg*	*Lead mg/kg*	*Zinc mg/kg*	*Copper mg/kg*
A(orange) (*Citrus sinensis*)	0.010±0.001	0.200±0.01	0.000±0.00	1.000±0.09
B(mango) (*Mangifera indica*)	0.003±0.000	0.043±0.00	0.570±0.09	0.120±0.02
C(mango) (*Mangifera indica*)	0.010±0.001	0.000±0.00	0.420±0.04	0.190±0.06
D(mango) (*Mangifera indica*)	0.005±0.000	0.020±0.00	1.640±0.11	0.200±0.01
E(mango) (*Mangifera indica*)	0.002±0.000	0.042±0.01	0.230±0.02	0.260±0.03
F(orange) (*Citrus sinensis*)	0.005±0.000	0.045±0.02	0.427±0.05	0.513±0.04
G(mango) (*Mangifera indica*)	0.010±0.002	0.012±0.01	0.250±0.04	0.130±0.02
H(mango) (*Mangifera indica*)	0.002±0.000	0.013±0.00	0.150±0.01	1.500±0.08
I(mango) (*Mangifera indica*)	0.002±0.000	0.027±0.01	0.154±0.02	0.700±0.07
P-value	<0.001	<0.001	<0.001	<0.001

Results are expressed as means ± SD for five observations. P-value was calculated using One-Way ANOVA F-test among juices.

Table 4. Microbiological analysis of different fruit juices.

Products (Scientific name)	*Standard plate count Cfu/ml*	*Total* coliform *MPN/g*	*Total fungus Cfu/g*	Salmonella *g/ml*
A(orange) (*Citrus sinensis*)	4×10^3	ND	ND	ND
B(mango) (*Mangifera indica*)	3×10^3	ND	ND	ND
C(mango) (*Mangifera indica*)	3×10^3	ND	ND	ND
D(mango) (*Mangifera indica*)	4×10^3	ND	ND	ND
E(mango) (*Mangifera indica*)	2×10^3	ND	ND	ND
F(orange) (*Citrus sinensis*)	3×10^3	ND	ND	ND
G(mango) (*Mangifera indica*)	4×10^3	ND	ND	ND
H(mango) (*Mangifera indica*)	3×10^3	ND	ND	ND
I(mango) (*Mangifera indica*)	4×10^3	ND	ND	ND

ND= None Detected

Because of the poor monitoring system in developing countries like Bangladesh, it is very difficult to evaluate how the consumer can be affected by taking fruit juices. The better alternative is to monitor the proper management of raw materials and production of the plant to prevent or minimise microbial contamination of juices (Doyle, Beuchat & Montville, 2001).

CONCLUSION

This work has shown that the locally available fruit juices contain safe levels of nutritional and microbial elements for human consumption. Each juice provides a different range of nutritional components that are desirable in a diet. The levels of all metals were within the limit of the BSTI standard for fruit juice. On the basis of standard plate count, about 100% of the samples recorded an acceptable range based on the Gulf standards for fruit juices. It was also found that the presence of pathogenic organisms such as total coliform, salmonella and fungus were within the acceptable range and considered safe for consumption. The Government-authorised institute such as Bangladesh Council of Scientific and Industrial Research (BCSIR) and BSTI should undertake pre-emptive investigations to check the microbial and chemical quality of the fruit juices as well as initiate increased public awareness programmes on contaminated and adulterated juices.

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