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Assessment of physicochemical characteristics and hygienic practices along the value chain of raw fruit juice vended in Dar es Salaam City, Tanzania

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Abstract: Fresh fruit juice is an essential component of human diet and there is considerable evidence of health and nutritional benefits. However, nature of the fruits used in juicing and unhygienic processes in the value chain may cause poor quality of juice. This cross-sectional study was conducted to assess physicochemical characteristics and hygienic practices along the value chain of raw fruit juice vended in Dar es Salaam, Tanzania. A total of 90 juice vendors were interviewed. Ninety juice samples were collected and analysed for physicochemical quality. The pH of juices ranged between 2.7 and 6.4, acidity 0.01% and 1.3% and, total soluble solids ranged between -1.5 and 18.04 ^{0}Brix. Most juices (67.8%) had ^{0}Brix levels below Codex recommended values classified as weak and watery. Juices were made of mango, passion, tamarind, sugar cane and mixture of these fruits sourced from open markets in the city. Water for washing of fruits and dilution of juices was from deep wells (53.3%) and taps (46.7%). About one third (37.8%) of the juice vendors didn't wash the fruits before juicing and 44.4% didn't boil water for juice dilution. Juice extraction was done by kitchen blenders, boiling in water and squeezing by simple machines. Juice pasteurization was not done. The majority of vendors (78.9%) stored juices in plastic buckets and juice was sold in glass cups, reused plastic bottles and disposable cups. Vending sites were restaurants, bus stands and along roadsides. The majority of premises (78.9%) were in unhygienic condition that likely encouraged or introduced contaminants to the juices. It is concluded that, the overall handling, preparation practices and physicochemical quality of raw fruit juices vended in Dare es Salaam City are poor. The government should educate the vendors on food safety and hygiene as well as enforcing regular monitoring of the quality of street fruit juices.

Keywords: raw fruit juice, vendors, quality, hygiene, contamination, Tanzania

Introduction

Fruit juices are well recognized for their nutritive value, mineral and vitamin contents (Wardlaw, 2004; Potter & Hotchkiss, 2006). They are important source of bioactive compounds such as phenolics (such as flavanone glycosides, hydroxycinnamic acids), vitamin C and carotenoid which is an excellent source of bio-available antioxidant phytochemicals and it improves blood lipid profiles especially for people affected with hypercholesterolemia (Franke *et al.,* 2005). Juices are the aqueous liquids expressed or otherwise extracted usually from one or more fruits or vegetables, purees of the edible portion of one or more fruits or vegetables, or any concentrates of such liquids or purees (Fraternale *et al.,* 2011). Unpasteurized juices are preferred by the consumers because of the "fresh flavour" attributes and of recently their demand have increased in many parts of Africa ((Alaka *et al.*, 2003; Okorie *et al.*, 2009; Ndife *et al.*, 2013). Unpasteurized juices are simply prepared by extracting, usually by mechanical means, the liquid and pulp of mature fruit and vegetables. The final product is an unfermented, clouded, untreated juice, ready for consumption. Diluting or blending is a common practice as many fresh juices are either too acidic or too strongly flavoured to be pleasant for consumption (Bagde & Tumane, 2011). For safety and economic reasons, fruit juices need to be of good and acceptable quality.

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Several factors need to be considered when assessing for quality of fruit juice. The composition of a fruit juice depends on the variety, origin and growing conditions of the fruit, its quality and the processing and storage procedures (Ndife *et al*., 2013). Apart from nutritive value of the juice, it should have acceptable organoleptic and physicochemical characteristics as well as free from microbial and chemical contaminants. The juice organoleptic features of interest include colour, aroma, taste/flavour, texture, degree of spreadiblity and overall acceptability by the consumers (Iwe, 2010). The juice must have the characteristic colour, flavour and taste typical of the fruit from which it comes.

The physicochemical characteristics of juices considered in quality assessment include pH, titratable acidity (TA), total soluble solids (°Brix), dry matter contents, ash content, crude protein, ascorbic acid, total sugar, reducing sugar and °Brix (sugar)/acid ratio. The constituent of juice predominantly is water and also contains carbohydrate, sucrose, fructose, glucose, sorbitol and small amount of protein (Pao *et al.,* 2001). Fruit juices have a low pH (2-5) because they are comparatively rich in organic acid (Tasnim *et al.,* 2010). The total acidity of fruit juices is due to presence of a mixture of organic acids, whose composition varies depending on fruit nature and maturity. The total soluble solids (TSS) content is significantly influenced by the combined effect of stages of maturity and ripening conditions (Tasnim *et al.,* 2010).

Microbial quality is very important in foods since bacteria, fungi, viruses and protozoa are potential pathogens of humans known to cause food-borne diseases while other cause food spoilage. Most fruit juices contain sufficient nutrients that could support microbial growth (Ndife *et al*., 2013). 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 preservative (Esteve *et al.,* 2005). However, microorganisms like bacteria and fungi can enter fruits through damaged surfaces, such as punctures, wounds, cuts, and splits. This damage can occur during maturation or during harvesting and processing of fruits. The microorganisms may be the potential sources of fruit spoilage which are known to shorten shelf life (Chen *et al.,* 2010). However, the organisms that have become internalized within a fruit can be able to survive during processes to the final product until they reach the consumer (US-FDA, 2008). Such microorganisms may further cause fast spoilage of the processed products like juices or if pathogenic may be the source of food-borne diseases. Similarly, chemical contaminations especially, pesticides are commonly encountered in fruit juices which originate from pesticides sprayed fruits at final stages of production (Ferrer *et al.,* 2011). Pesticide residues have several deleterious effects to the consumers and therefore they must not be detected in ready to eat food.

Raw fruit juices are among the street foods that are vended in urban areas mostly in developing countries. In Tanzania, especially in cities like Dar es Salaam, there has been an increase in consumption of fresh extracted fruit juices because of availability of variety of fruits throughout the year (MAFSC, 2009). People have developed interest on freshly prepared fruit juices due to their fresh taste and also because of being scared of preservatives and other added ingredients in industrially processed juices. Nevertheless, there is limited information on physicochemical characteristics and hygienic practices along the value chain of unfermented fruit juice vended in Dar es Salaam city and other urban areas in Tanzania. The physicochemical characteristics and all practices involved in the whole value chain from fruit juicing to consumption determine the quality of the juice to the consumer. It was the objective of this study to determine the physicochemical quality and hygienic practices of the locally prepared and vended fruit juices in Dar es Salaam, Tanzania.

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Materials and Methods

Study area

This study was conducted in Dar es Salaam City, Tanzania (6°, 45' S - 39°, 15E) from September 2012 to August, 2013. The city has three Municipalities namely Ilala, Kinondoni and Temeke and has 10 divisions with 93 Wards and 448 streets. Dar es Salaam has a human population of 4,364,541. Dar es Salaam was chosen for this study due its large population and rapid increase of street foods including fruit juice vending activities. The selected wards for study included Mtongani, Miburani, Tandika and Sandali in Temeke Municipality; Mchikichini, Ilala, Vingunguti and Buguruni in Ilala Municipality and Mwananyamala, Hananasif, Kinondoni and Makumbusho in Kinondoni municipality.

Study design and data collection

A cross-sectional research design was conducted where sociological and laboratory data were collected. Study wards were purposively selected based on the large number of raw fruit juice vendors. Randomly selected juice vendors were enrolled into the study. Selection of participating fruit juice vendors was based on their availability in the selected streets, willingness to participate in the study and their readiness to give the required information.

Structured questionnaires were used to collect information from the juice vendors on socio-demographic characteristics, type of fruits and sources, water sources and treatment, fruit handling and juice preparation methods, storage, serving utensils and vending sites and any formal training on fruit juice preparation. In addition, observational checklist was made in accordance to the Codex Recommended General Principles (CAC/RCP 1-1969, Rev.4- 2003) of food hygiene (FAO, 2003) for food preparation settings, washing processes, general hygiene of the vendor and premises, waste management and general upkeep of the juices. On the other hand, the checklist was provided with "YES" and "NO" sections for each parameter for the researcher to fill in the observations.

Juice sample collection

Samples were collected directly from the storage containers used by juice vendors. A volume of 250 ml of juice samples was collected, put into a sterile glass bottle and stored in a cool box with ice parks. For those who packed the juice in re-used plastic water bottles, the samples were collected with their original containers, and were put in the same cool box. After the field work, the samples were immediately transported to Tanzania Food and Drugs Authority (TFDA) laboratory for analysis in Kinodoni, Dar es Salaam.

Physicochemical laboratory analysis of fruit juice

Physicochemical parameters of the juice which were analysed included pH, titratable acidity, total soluble solids (°Brix), total titratable acidity and Brix/acid ratio. The pH of the samples was measured by using Jenway 3540 pH & Conductivity Meter (Bibby Scientific Ltd, Staffordshire, UK) which was first calibrated using standard buffer solutions of pH 7.0 and pH 4.0. Total soluble solids (°Brix) were determined using a RFM 340 refractometer (Bellingham and Stanley Ltd., London, U.K). Before measuring the °Brix of the samples, the refractometer was standardized by using distilled water at 0 °Brix and sucrose solution at 30 °Brix and the readings of the samples were performed (°Brix). Total titratable acidity of the samples was established using the recommended method by AOAC (1999). The solution of Sodium hydroxide (NaOH) was standardized to 0.1 Normality (N). The acidity of the sample was determined by the formula:

$$\%Acid\ (w/w) = \frac{(\text{Net ml Titrant})(\text{NTitrant})(0.064)}{(\text{Sample weight})} \times 100$$

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Where: 0.064 = the acid factor for citric acid, Net ml Titrant = titre value of NaOH and NTitrant = Normality of titrant (NaOH).

The Brix / acid ratio was obtained by dividing the total soluble solids (°Brix) by the total titratable acid (% Acid, w/w) as follows:

$$\text{Brix/Acid Ratio} = \frac{°\text{Brix}}{\%\ \text{Acid (w/w)}}$$

Data analysis

The data was analyzed by using Epi-Info version 7 statistical packages. The Chi-squire and confidence intervals were used to compare proportions. Descriptive statistics was used to compute means, standard deviations, median and range.

Ethical consideration

Research permit was provided by the Vice Chancellor Sokoine University of Agriculture and permission letters were obtained from Dar es Salaam Region Administrative Secretary and Municipal Council Directors of Ilala Kinondoni and Temeke. Prior to commencement of each interview, a verbal consent was obtained from each vendor after explaining the purpose and importance of the study. Participation in the study was on voluntary basis.

Results

Socio-demographic characteristics

The study involved 30 respondents from each of the three municipalities making a total of 90 juice vendors. Significantly, more male (60%; n=54) than female vendors participated in the study. Vendors 25-34 years old constituted the largest proportion (30%; n = 27). The age differences across the municipalities were statistically insignificant (*P*>0.05). Majority of the juice vendors had primary school education (56.7%; n=51). None of the fruit juice vendors had professional training related to safe handling and processing of fruit juices. Some vendors had been in fruit juice vending business for long period of time (range= 1-10 years). However, the overall pattern showed that, majority (30%; n=27) were transient vendors who vended fruit juices during the peak fruits seasons (Table 1).

Table 1: Socio-demographic characteristics of the respondents

Variable	Response	Number (%) of respondents			Total n (%)	P- value
		Ilala	Kinondoni	Temeke		
Sex	Female	5 (16.7)	16 (53.3)	15 (50.0)	36 (40)	0.0059
	Male	25 (83.3)	14 (46.6)	15 (50.0)	54 (60)	
Age range	15 – 24	12 (40.0)	8 (26.7)	1 (3.3)	21 (23.3)	0.0646
	25 – 34	7 (23.3)	11 (36.7)	9 (30.0)	27 (30.0)	
	35 – 44	5 (16.7)	6 (20.0)	9 (30.0)	20 (22.2)	
	45 – 54	5 (16.7)	5 (16.7)	9 (30.0)	19 (21.1)	
	≥ 55	1 (3.3)	0 (0.0)	2 (6.7)	3 (3.3)	
Education level	Non formal	3 (10.0)	2 (6.7)	3 (10.0)	8 (8.9)	
	Primary	19 (63.3)	16 (53.3)	16 (53.3)	51 (56.7)	0.8227
	Secondary	8 (26.7)	10 (33.3)	10 (33.3)	28 (31.1)	
	College	0 (0.0)	2 (6.7)	1 (3.3)	3 (3.3)	
Vending duration	< 1 year	11 (36.7)	7 (23.3)	9 (30.0)	27 (30.0)	
	1-2 years	5 (16.7)	7 (23.3)	10 (33.3)	22 (24.4)	0.2561
	3-5 years	5 (16.7)	10 (33.3)	3 (10.0)	18 (20.0)	
	6-9 years	3 (10.0)	4 (13.3)	4 (13.3)	11 (12.2)	
	≥ 10 years	6 (20.0)	2 (6.7)	4 (13.3)	12 (13.3)	

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Sources of raw materials and methods of preparation of juices

Fruits for juice extraction were mainly sourced from local open markets in the municipalities, namely Sterio, Buguruni, Kariakoo and Tandale (Table 2). Majority of vendors from Ilala (76.7%; n=23) reported to obtain fruits from Buguruni market, while the majority in Temeke (86.7%; n=26) reported to obtain fruits from the Sterio market.

Table 2: Number (%) of respondents as regards to source of raw materials and methods of juices preparation

Variable	Response	Ilala	Kinondoni	Temeke	Total
Source of fruits	Sterio	1 (3.3)	1 (3.3)	26 (86.7)	28 (31.1)
	Buguruni	23 (76.7)	9 (30.0)	0 (0.0)	32 (35.6)
	Kariakoo	1 (3.3)	5 (16.7)	1 (3.3)	7 (7.8)
	Tandale	3 (10.0)	1 (3.3)	0 (0.0)	4 (4.4)
	Others	2 (6.7)	14 (46.7)	3 (10.0)	19 (21.1)
Source of water	Deep wells	16 (53.3)	2 (6.7)	30 (100.0)	48 (53.3)
	Tap water	14 (46.7)	28 (93.3)	0 (0.0)	42 (46.7)
Water treatment	Treated	11 (36.7)	23 (76.7)	16 (53.3)	50 (55.6)
	Not treated	19 (63.3)	7 (23.3)	14 (46.7)	40 (44.4)
Extraction methods	Blending	21 (70.0)	26 (86.7)	24 (80.0)	71 (78.9)
	Boiling	6 (20.0)	4 (13.3)	4 (13.3)	14 (15.6)
	Squeezing	3 (10.0)	0 (0.0)	2 (6.7)	5 (5.6)

The main sources of water for washing and dilution of the juices were deep wells and tap water. All juice vendors in Temeke obtained water from deep wells, while most vendors in Kinondoni (93.3%; n=28) obtained water from taps where as vendors from Ilala obtained water from either deep wells or taps. However, a substantial number of respondents (37.8%) did not wash the fruits before juicing. Up to 44.4% of the vendors admitted that they did not boil water for juice dilution especially those who were using tap water assuming that the water was clean. None of the juice vendors had attended a formal training on food processing and personal hygiene.

Table 3: Number (%) of respondents as regards to juice handling practices

Variable	Response	Number (%)
Juice storage containers during vending	Plastic buckets	71 (78.9)
	Used plastic bottles	14 (15.6)
	Ice boxes	5 (5.6)
Cold storage	Deep freezer	61 (67.8)
	Bucket with ice	16 (17.8)
	Ice boxes	13 (14.4)
Selling equipment	Glass cups	61 (67.8)
	Used plastic bottles	14 (15.6)
	Glass cups & used bottles	8 (8.9)
	Disposable cups	4 (4.4)
	Glass cups/ disposable cups	3 (3.3)
Vending sites	Restaurants	36 (40.0)
	Bus stands	20 (22.2)
	Roadsides	17 (18.9)
	Food kiosks	10 (11.1)
	Market places	7 (7.8)
Means of cleaning serving utensils	Cold water and soap	33 (36.7)
	Hot water and soap	25 (27.8)
	Cold water alone	24 (26.7)
	Hot water alone	4 (4.4)
	No washing	4 (4.4)

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The juices were extracted by three methods mainly blending by use of blenders, boiling in water and squeezing by simple manual machines. Most vendors (80%; n=72) reported to use a simple blender in extraction of juices of mango, passion and most mixed fruit (mango, passion and avocado). However, tamarind juices were extracted through boiling the fruits in water while the mixed fruit juices that involved lemon and sugar cane were extracted by manual squeezing machine.

Juice preparation and handling practices

As regard to juice pasteurization, none of the juice vendors reported to pasteurize the juice after preparation. Common juice storage containers during vending included plastic buckets, used plastic bottles and cool boxes. Majority of the vendors (78.9%; n=71) stored the juices in plastic buckets. The juices were either cooled in a refrigerator or by use of ice cubes which were reported to be obtained from ice manufacturing factories. Most vendors (67.8%; n=61) used fridges to keep the juices while 17.8% (n=16) and 14.4% (n=13) kept the juice in buckets with ice cubes and cool boxes with ice cubes respectively (Table 3). The cool boxes were either directly filled with the juice or the juices were packed in plastic bottles and stored in them. In either case, ice cubes were added in the cool boxes to aid cooling during vending time.

Table 4: Number (%) of juice vendors as regards to recorded observations on practices

Parameter assessed	Category	No. (%) of juice vendors
Preparation settings that minimize contaminations	No	71 (78.9)
	Yes	19 (21.1)
Washing to minimize contaminations	Poorly done	69 (76.7)
	Fairly good	21 (23.3)
Vendor cleanliness	Poor	41 (45.6)
	Fair	49 (54.4)
Vendor had uniform	No	79 (87.8)
	Yes	11 (12.2)
Waste receiving bins present	No	20 (22.2)
	Yes (uncovered)	44 (48.9)
	Yes (covered)	26 (28.9)
Pests present in the preparation/ vending sites	No	15 (16.7)
	Yes	75 (83.3)
Type of pests	Flies	72 (96.0)
	Cockroaches/ flies	3 (4.0)
Juice protected from sources of contamination	No	68 (75.6)
	Yes	22 (24.4)
Cold storage facility effective	No	44 (48.9)
	Yes	46 (51.1)

The commonly used utensils were glass cups, reused plastic bottles and disposable cups. Majority of vendors (67.8%; n=61) reported to serve the juices with glass cups, (15.6%; n=14) reused plastic bottles and (4.4%; n=4) disposable cups (Table 3). The most common vending sites were restaurants, bus stands and along the roadsides and the main means of cleaning serving utensils included cold water and soap, hot water and soap and cold water alone.

Observed practices of vendors towards preparation and vending of juices

Most preparation settings did not meet basic standards for a food preparation premises. Majority of premises (78.9%; n=71) showed to encourage or introduce contamination to the juices. Washing of utensils were poorly done, using cold water, without detergents or sometimes vendors were reusing the water which had been used several times. About 76.7% (n=69) of the juice vendors were observed to predispose the juice and utensils to contamination through poor methods of washing (Table 4).

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With regard to waste disposal, about 22.2% (n=20) did not have waste receiving bins, hence haphazard dumping of wastes. During the survey, piles of dirty were seen in the juice preparation and vending areas. On the other hand, 48.9% (n=44) of the vendors used uncovered waste bins which were observed to encourage pests like houseflies and cockroaches in the premises. Indeed, most premises (83.3%; n=75) were observed with pests mainly house flies 96% (n=72) and 4% (n=3) with both houseflies and cockroaches.

Table 5: Physicochemical characteristics of the juices

Type of juice	Samples (n)	Physicochemical Parameter	Mean ± S.D	Median	Range	Recommended values
Mixed fruit	45	pH	4.02 ± 0.7	4.0	3.1 – 6.4	-*
		ºBrix	8.47 ± 3.6	8.6	-1.5 – 14.5	-*
		Acidity	0.24± 0.2	0.2	0.01 – 0.9	-*
		Brix-acid ratio	89.94 ± 137.9	41.1	-3.9 – 780.0	-*
Mango	23	pH	3.95 ± 0.4	4.0	3.3 – 4.9	3.5 – 4.0
		ºBrix	8.14 ± 4.1	9.2	1.3 – 15.1	13.5
		Acidity	0.18 ± 0.1	0.2	0.1 – 0.4	0.25 – 0.5
		Brix-acid ratio	55.79 ± 42.4	39.4	11.8 – 139.6	30.0 – 50.0
Passion	8	pH	3.21 ± 0.3	3.1	2.9 – 3.9	2.5 – 3.0
		ºBrix	8.14 ± 4.1	10.2	4.4 – 14.1	12.0
		Acidity	0.40 ± 0.1	0.4	0.01 – 0.9	0.8 – 1.5
		Brix-acid ratio	29.10 ± 15.0	23.7	10.8 – 60.5	8 – 15
Tamarind	14	pH	2.84 ± 0.1	2.9	2.7 – 3.4	2.4 – 3.0
		ºBrix	8.04 ± 6.1	6.8	0.7 – 18.0	13.0
		Acidity	0.44 ± 0.3	0.3	0.2 – 1.3	0.5
		Brix-acid ratio	19.56 ± 17.2	10.8	3.5 – 65.2	27

Source for normal values: Bates et al. (2001), FAO (2005). *=recommended values not found

Physicochemical characteristics of the juice

Juice pH and acidity: The pH value of the juices ranged from 2.7 (tamarind juice) to 6.4 (mixed fruit juice) and this variations depended on the type of fruit used in making the juices. Mixed fruit and mango juices had higher pH values than passion and tamarind juices. Tamarind juices had the lowest mean pH (2.84 ± 0.1) (Table 5). The differences in their pH values were consistent with high titratable acidities. The acidity of the juices had a range from 0.01 (mixed juice) to 1.3 (tamarind juice). Both passion and tamarind juices had high acidities as compared to mixed fruit and mango juices (P<0.001). The tamarind juices were more acidic than passion juices (Figure 1). According to FAO, the juices containing more than ~1.2% acid are sour, independent of °Brix/Acid (Bates *et al*., 2001). About 98.9% (n=89) of the juice had acidity within the recommended range (≤1.2% acid).

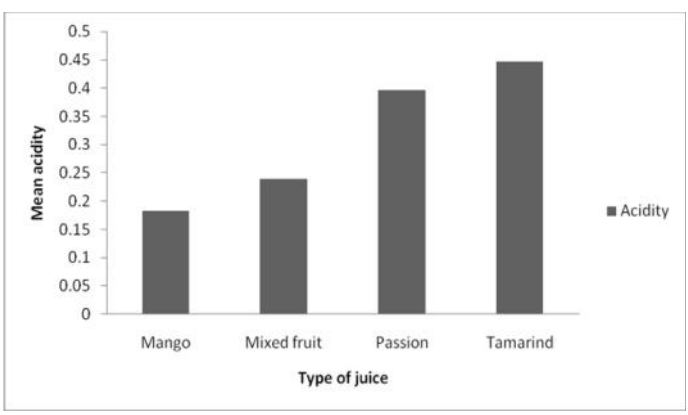

Figure 1: The relationship between types of juices and titratable acidity

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Total soluble solids (⁰Brix): The total soluble solids (⁰Brix) of the juices ranged from -1.5 (mixed fruit juice) to 18.04 (tamarind juice) ⁰Brix. Majority of the juices had ⁰Brix levels below the recommended standards (CODEX STAN 247:2005) for fruit juices and nectars (FAO, 2005) (Table 5; Figure 2). Tamarind juice had the lowest mean ⁰Brix (8.04±6.1) while mixed juice had the highest mean ⁰Brix (8.47±3.6). Neither type of juices nor location showed any significant difference in the values of ⁰Brix ($P > 0.05$). However, juice blends or beverages with less than 7 ⁰Brix are categorized as weak and watery meaning that the total soluble solids are low i.e. <7 gm/100 ml solution (Bates *et al.* 2001). Of all the samples assessed, 67.8% (n=90) were classified as weak and watery.

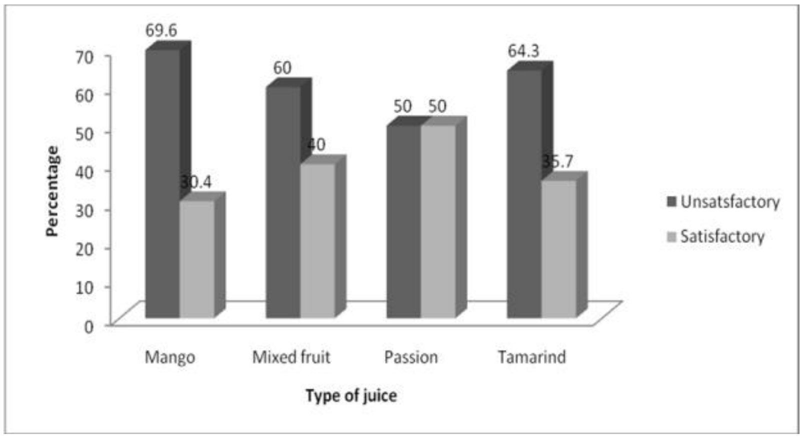

Figure 2: Percentage of juices with satisfactory or unsatisfactory values of ⁰Brix

Discussion

The current study was conducted to determine physicochemical quality and handling practices of raw fruit juices in Dar es Salaam, Tanzania. The general finding showed that, majority of the juice vendors were adult males. The most common fruit juices were from mango, passion, avocado, lemon, orange and sugarcane or their mixture. The physicochemical characteristics results showed that the pH ranged from 2.7 to 6.4 depending on the type of juices, 1.1% of juice was sour because acidity level was beyond 1.2% and 67.8% were weak and watery since had ⁰Brix of juice was less than 7. Our findings suggest that most customers in Dar es Salaam consume juice with poor quality physicochemically and possibly contaminated with microbes that put them at risk of acquiring food-borne diseases.

In the current study, fruits used in the preparation of the juices were all obtained from open markets. The fruits were delivered in these markets by trucks from fruit producing regions such as Morogoro and Tanga. In the chain of production through middlemen to the markets and to the final consumers, there are risks of contamination of the fruits in each stage. The safety of the juices prepared from these fruits depended greatly on the strict hygiene measures that were applied by the juice vendors on practices towards the fruits handling, preparation, storage and the hygiene of the vendors and premises. In the current study, the general practices of the vendors towards fruit handling, juice preparation and display for sell were observed to be poor. The general hygiene of the vendors and premises were also poor and were observed to encourage contamination of the juices in the aspects of washing of fruits and cleaning of utensils, preparation methods, storage of the juices and the general hygiene. This is contrary to Codex general requirements for food hygiene which recommend that, a place for food preparation should be kept clean at all times and should be far from any source of contamination (FAO, 1995). Similar observations were also recorded elsewhere (Muinde & Kuria, 2005; Chukwu *et al.*, 2010). Such situation is likely to be contributed by limited education on hygiene and inadequate food

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and premises inspections by health and food inspectors which would otherwise stop such food mishandling practices.

A significant proportion of vendors were storing juice under poor condition. For instance, cooling of juice by use of ice cubes was common. It should be noted that ice cubes cannot provide adequate and long lasting cooling, but instead it provides good conditions for microbial growth and proliferation. In addition, the safety of the ice cubes used to cool the juices is questionable. On the other hand, the utensils were washed using the same water several time before it was replaced. Such water probably further add contamination to the utensils and consequently to the juice. The findings are in agreement with the findings of Cardinale *et al.* (2005) in Senegal and Tambekar *et al.* (2009) in India where in both studies unhygienic practices were reported.

Generally, it is required that all fruit used for juice extraction should be subjected to effective washing, brushing and rinsing using potable water. All workers must be free from communicable diseases and should be trained not only for their task, but also to keep the vendors clean and to practice personal hygiene (CFIA, 2010). However, none of juice maker that participated to the current study had been trained on juice processing and personal hygiene. This is a challenge to all responsible authorities dealing with food and public health issues in Tanzania.

The study explored the pH, total soluble solids (⁰Brix) and acidity so as to assess the quality of the juice in terms of the maturity status of the fruits used, organoleptic values. The pH of the juices in this study ranged from 2.68 to 6.38 slightly lower than that reported by Poonam (2013) in India. Tamarind and passion juices had lower pH as compared to mixed fruit and mango juices. Passion and tamarind had lower pH values because they are rich in organic acids (Tasnim *et al.,* 2010). On the other hand, most mixed fruit juices were made of non citrus fruits such as avocado, sugarcane, mangoes and/or small portion of citrus fruit, hence had low acids and higher pH values. Generally, pH and titratable acidity of juices are used primarily to estimate consumption quality. They could be considered as indicators of fruit maturity or ripeness. The pH has influence on the flavour (sweet or sour) of the fruit and to a large extent determines the marketable quality of the fruit juices. Mangoes at fully maturity and ripening have significantly more ⁰Brix than acids hence they are generally sweet and possibly accounted for the observed high pH.

Lower pH of fruit and ultimately the raw juice have inhibitory effects to microbial contamination (Castillo *et al.,* 2000; Rodrigues *et al.,* 2000). However, during the processing, a large part of the quality characteristics of the fresh fruits undergo remarkable changes which could reduce the nutritional value of the products (Wenkam, 1990; Landon, 2007). Moreover, the fresh juice may be stored for a long time in unfavourable conditions that lead to undesirable quality changes. A study by Wissanee & Renu (2007) found that the acidity of fruit juice increases with increased storage time to indicate fermentation process. Decrease in pH-values and increase in total titratable acidity during the storage period may be due to activity of some acid-producing bacteria such as *Alicyclobacillus acidoterrestris* (Kang *et al.,* 2003).

The acidity values of the juices observed during the current study ranged between 0.01 and 1.3%. According to FAO (2005), juices with more than ~1.2% acid are sour, independent of °Brix/Acid (Bates *et al.,* 2001). Fortunately, 99% (n=89) of the juices were within recommendations. This may indicate that the fruits used in the preparation of the juices in this study were at the state of fully maturity and ripening. The acidity values reported in this study were in agreement with those reported elsewhere (Wissanee & Renu, 2007; Oranusi *et al.,* 2012; Rizzon & Miele, 2012; Ndife *et al.*, 2013). However, the variations may be due to the type of fruits, their ripening stage and the season of the year, inappropriate storage of fruit and over dilution of fruit juices. Moreover Anvoh *et al.* (2009) reported that fruit acids influence colour, flavour and gustative characteristics of the juice products.

The total soluble solids of the juices were found to have a wide range of variation that ranged between -1.54 and 18.04 °Brix. The total soluble solids of juices originate from the fruit

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since as the flesh of fruit forms it deposits nutrients as starch that, as the fruit ripens, transform to sugars which indicate degrees Brix dictate the sweetness of the juice. However, according to FAO (2005), juice blends or beverages with less than 7°Brix are deemed weak and watery (Bates *et al.,* 2001). About two-thirds of the juices in the current study were found to be weak and watery. Low values of °Brix observed in this study may be due to over dilution of the juices by unfaithful traders to increase the volume which ultimately reduces the specific gravity. On the other hand, the decreased ⁰Brix levels could be attributed by the onset of fermentation due to improper storage temperatures of some of the juices, however levels can also decrease depending on maturity and ripening conditions of fruits. Sometimes, the variation of ⁰Brix levels of fruit juice depends on different source of juice types. ⁰Brix to acid ratio is crucial since it constitutes a measure of the balance between sugars and acids. As a consequence the ⁰Brix acid ratio serves as an indication of the palatability of the juice. Large values indicate a sweeter taste, but very high values may be indicative of an insipid tasting juice. Similarly, low values also lead to lack of taste. ⁰Brix may also determine the nutritional status, and postharvest storage potential of fresh produce.

Based on the findings, it is concluded that the general hygiene of vendors, premises and handling practices as regards to juice preparation, extraction methods and washing of utensils in Dar es Salaam are very poor. The majority of the unpasteurized fruit juice had total soluble solids levels below the recommended Codex specifications. Because of the poor monitoring system in developing countries like Tanzania, it is very difficult to evaluate how the consumer is affected by taking fruit juices of low physicochemical quality characteristics. Since unhygienic environments have been observed in the fruit vending activities, it is therefore recommended that the government should educate both vendors and consumers on principles of good hygienic practices of food handling to ensure wholesomeness, soundness and safety of the food to the consumers. It is equally important that the national regulatory authorities should ensure that fruit juices are safe by periodically monitoring its quality and inspecting production facilities to ensure they conform to specified standards.

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