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Research Application Summary

Microbiological quality and storage stability of fresh fruit and vegetable juice blends sold in Kampala, Uganda

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Abstract

Fresh fruit and vegetable juices rich in health, nutritional and minerals of benefits are consumed by all age groups in Kampala, Uganda. However, exposure to microbiological contamination, light and temperature effects may occur before and/or during processing thereby exposing consumers to potential health hazards. Therefore, this study sought to establish microbiological quality of fresh fruit and vegetable juices and their processing environment. It further sought to assess physicochemical parameters of juices stored in dark colored and clear bottles at room (24°C) and refrigerated (4°C) temperatures. Bacteriological counts of 385 samples of which 90 were solely fresh passion fruit juices were assessed for aerobic mesophiles and selected pathogens including *Staphylococcus aureus, Listeria monocytogenes, Escherichia coli* and *Salmonella* using standard plate counts. Physicochemical parameters were conducted to establish storage stability of the juices. Results showed that most preferred passion fruit juices contained 30% *Staphylococcus aureus*, 16.7% *Listeria monocytogenes*, and no *Escherichia coli* nor *Salmonella* spp. The pH ranged between 3 and 5 and Total Soluble Solids (° Brix) ranged between 1.4 and 5.2. Pineapple juices stored in dark colored bottles differed ($p<0.05$) from those kept in clear bottles. Mango juices stored in dark colored bottles at refrigerated temperatures had the lowest titratable acidity (%) of 1.65 while pineapple juice kept at room temperature in clear bottles had the highest titratable acidity (%) of 6.75. Juices stored at room temperatures differed significantly ($p<0.05$) in titratable acidity from those kept at refrigerated temperatures. Ascorbic acid content was lowest in pineapple juice (4.71 -5.97 mg/100 ml) and highest in passion fruit (53.2–61mg/ 100 ml) above the daily recommended nutrient intake levels of 45mg/100 ml. It is concluded that passion fruit juice in Kampala is a good source of ascorbic acid however stringent measures to ensure juice safety are needed.

Key words: Ascorbic acid, fresh fruit juice, public health, *Staphylococcus aureus,* vegetable juice

Résumé

Des jus de fruits et de légumes frais riches en santé, nutritionnels et minéraux d'avantages sont consommés par tous les groupes d'âge à Kampala. Toutefois, l'exposition aux problèmes de contamination microbiologique, de lumière et de température peut se produire avant et / ou pendant le traitement, exposant les consommateurs aux risques potentiels de santé. Cette étude a cherché à établir la qualité microbiologique des jus de fruits et légumes frais et leur environnement de traitement. Il a précisément cherché à évaluer les paramètres physicochimiques des jus stockés dans des bouteilles de couleur foncée et transparentes à température ambiante (24 ° C) et au frais (4 ° C). De relevés bactériologiques de 385 échantillons dont 90 exclusivement des jus des fruits de la passion, ont été évalués afin d'identifier les mésophiles aérobies et certains agents pathogènes, y compris Staphylococcus aureus, Listeria monocytogenes, Escherichia coli et Salmonella. Des paramètres physicochimiques ont été relevés pour établir la stabilité au stockage des jus. Les résultats ont montré que les jus des fruits les plus préférés contenaient 30% de Staphylococcus aureus, 16,7% de Listeria monocytogenes et pas d'Escherichia coli ni de Salmonella spp. Le pH variait entre 3 et 5 et les solides solubles totaux variaient entre 1,4 et 5,2. Les jus d'ananas stockés dans des bouteilles de couleur foncée diffèrent ($p < 0,05$) de ceux conservés dans des bouteilles claires. Les jus de mangue conservés dans des bouteilles de couleur noire au frais ont eu la plus faible acidité (%) de 1,65 alors que le jus d'ananas conservé à température ambiante dans des bouteilles claires avait l'acidité la plus élevée (%) de 6,75. Les jus stockés à température ambiante différaient significativement ($p < 0,05$) en acidité par rapport à ceux maintenus au frais. La teneur en acide ascorbique a été la plus faible pour les jus d'ananas (4,71 -5,97 mg / 100 ml) et la plus élevée pour les fruits de la passion (53,2-61 mg / 100 ml) au-dessus des doses quotidiennes recommandées de 45 mg / 100 ml. On conclut que les jus des fruits de la passion à Kampala sont de bonne source en termes d'acide ascorbique, mais des mesures strictes sont nécessaires.

Mots clés: acide ascorbique, jus de fruits frais, santé publique, Staphylococcus aureus, jus de légumes

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Background

Fruit and vegetable juices are foods with multiple implications for body balance owing to their nutritional and biological properties (Leahu *et al.,* 2013). Nutritional and biological properties such as supplying vitamins (A, B_1, B_2, B_3, B_6, C, E, pantothenic acid and folate), minerals (Magnesium, Calcium, Phosphorus, Sodium) and phytonutrients are often supplied from fruits and vegetables (Kader *et al.,* 2014; Lamport *et al.*, 2014; Khan *et al.,* 2015). Antioxidant vitamins (A, C, E and bioflavonoids) have their strongest effect in preventing membrane lipid peroxidation and accumulation of atherogenic compounds that affect integrity of the vascular wall (Leahu *et al.,* 2013). However, fruit and vegetable juices are reported to be risk factors for infection with enteric pathogens (Heaton and Jones, 2008). Pathogens and other microorganisms find their way into the juices during processing (peeling, cutting and extraction), reducing quality as well as shelf life (Raybaudi-Massilia *et al.,* 2009). Further, they become serious health hazards to consumers, impacting negatively especially the immune-compromised individuals. There is a dearth of information on microbiological quality and storage stability of fruit juices obtained from tropical fruits (passion fruits, mangoes and pineapples) abundantly grown in Uganda. Accordingly, this study assessed microbiological quality and storage stability of fresh fruit and vegetable juices produced in Kampala, Uganda.

Literature Summary

Fruit juices are the most consumed non-alcoholic beverages for all ages throughout the world (Kader *et al.,* 2014). Consumers desire high quality foods that are nutritious with freshly prepared flavor, texture and color, with minimal or no chemical preservatives and above all safe (Cortes *et al.,* 2007; Silva *et al.,* 2015). In the absence of good manufacturing practices, juices nutritionally rich in several compounds are good medium for microbial growth and may be vehicles of food borne pathogens. Freshly squeezed juice is an important source of pathogens if the fruit is contaminated (Castillo *et al.,* 2006). The same authors reported the relocation of *Salmonella* spp, *Escherichia coli* 0157:H7 and *Listeria monocytogenes* from contaminated oranges onto all utensils used during orange crushing and into the juice. Together with the microbial load, temperature, salt and sugar concentration, pH, oxygen, light, metal catalysts, initial concentration of ascorbic acid, ratio of ascorbic acid to dehydroascorbic acid, and protection of the container affect labile nutrients such as ascorbic acid resulting in quality loss.

Study description

A cross sectional study of fresh unpasteurized juices sold in Kampala was conducted. Using a questionnaire, a preliminary survey of juices in Kampala stratified into divisions was conducted to establish the types and demographic characteristics of the juices. Three fruit juices (passion fruit, mango and pineapple) commonly consumed and grown in Uganda were studied. Number of samples collected was calculated using a formula of Kish and Leslie (1965), where $n=Z^2pq/e^2$ basing on the prevalence of Staphyloccoccal food poisoning set at maximum variability of 50% giving a total of 385 samples (90 purely fruit juice, 120 fruit and vegetable juice blends and 175 swabs from processing environment). For this part of the study, only pure fruit juices were considered.

Physicochemical analyses involved the purchase of fruits from the market and extraction in the laboratory. Three fruit juices were separately extracted using a blender (Kenwood, England) from carefully washed (passion (purple variety), mangoes (Ngowe) and pineapple (smooth cayenne) fruits. The extracted juice was divided into two portions of equal volume (approx. 500 ml for each bottle for the clear and dark bottles. Two sets of conditions were used for storage, temperature (room temperature (25°C) and refrigerated temperature (4°C), and type of glass bottle (clear and dark) for each type of juice. Microbiological analyses and physicochemical parameters were conducted right after processing using standard procedures. These were repeated for all fruit juice types every 48 hours during the period of storage.

Results and Discussion

Juices obtained in this study from Kampala were contaminated with microorganisms. Aerobic mesophilic counts greater than 10^5 CFU/ ml permitted by FAO/WHO were observed for all juices (Table 1). Kawempe division was found to contain juices with highest contamination. Higher numbers were observed probably due to the presence of epiphytic microflora on the surface of fruits and vegetables. Bagde and Tumane (2011) in their study on fruit juices (apple, mosambi and pineapple) in Nagpur city in India obtained a total bacterial count of 1×10^5 CFU/ml to 2×10^6 CFU/ml. Bello *et al.* (2014) in a study conducted on fruit juices (avocado, grape, orange, papaya and pineapple) in Ogun State, Nigeria obtained a total microbial load of 1×10^4 CFU/ml to 6.5×10^4 CFU/ml. Juices contained high numbers of coliforms than those permitted (10^4 CFU/ml) for fruit and vegetable juices. Coliforms are indicators of fecal contamination possibly due to unhygienic processing and contaminated water used in dilution of the juices. Microbes may find their way into the juice during cutting, slicing, preparation and processing. Presence of *Staphylococcus aureus* in any food product indicates a lot of human handling and manipulation especially for minimally processed food products. The bacteria which harbour in the nasal passage and are resident on the skin and hair of humans find their way into juice during preparation and processing especially under unhygienic processing methods.

Table 2 gives the physicochemical parameters of fruit juices assessed in the study. The pH of the fruit juices was fairly stable throughout the period of study and was within the limits of 3-5 for fresh fruit and vegetable juices. Pineapple juice had the highest level of total soluble solids while passion fruit juice had the lowest level. Total soluble solids indicate the percentage of water soluble solids in fruit juice (Gadze *et al.,* 2011). Juices stored at room temperature were significantly different ($p<0.05$) from those stored at refrigerated temperatures probably due to fermentation of juices at high temperatures converting sugars into acid. Ascorbic acid content was highest in passion fruit juice (61 mg/ 100 ml) and lowest in pineapple juice (4.71mg/100 ml). The passion fruit juice may therefore be a good source of ascorbic acid since its levels are higher than those recommended by FAO/WHO (2004). Temperature influences stability of heat sensitive nutrients like ascorbic acid. Juices should therefore be kept under refrigerated conditions to prolong their shelf life.

Table 1: Microbiological status of passion fruit juice in Kampala, Uganda

	Divisions					
	Kampala central (n=30)		Kawempe (n=30)		Nakawa (n=30)	
Counts cfu/ml	Mean	Range	Mean	Range	Mean	Range
TPC	5.80×10^6	2×10^4-TNTC	4.10×10^7	2×10^5 -1.8×10^8	8.20×10^6	2×10^5 -1×10^8
TCC	8.50×10^5	1×10^2 -9.1×10^6	6.80×10^7	6×10^3 -2.8×10^7	8.80×10^6	0 -8.5×10^5
Staphylococcus aureus	5.95×10^2	0 -2.1×10^4	8.70×10^3	0 -6.3×10^8	5.80×10^5	0 -9.8×10^6
Escherichia coli	0.00	0.00	3.90×10	0-8.9×10^8	2.97×10^6	0-1×10^6
pH	3.47±0.65		3.82±0.65		4.08±0.73	

TNTC- Too numerous to count; TPC – Total plate counts; TCC – Total colony counts

Table 2: Physicochemical parameters of fruit juices in Kampala, Uganda (Mean ± SD)

Type of fruit	Type of bottle	Temperature of storage (°C)	pH	Brix (°)	TTA(%)	Ascorbic acid (mg/100 ml)
Passion fruit	Dark colored	4°C	3.36 ±0.08	1.71 ±0.41	4.26 ±0.40	61.17 ±7.09
Passion fruit	Dark colored	24°C	4.02 ±0.06	1.54 ±0.35	3.02 ±0.27	61.03 ±6.90
Passion fruit	Clear (light)	4°C	3.36 ±0.06	1.43 ±0.30	4.56 ±0.39	55.53 ±6.73
Passion fruit	Clear (light)	24°C	3.86 ±0.03	2.26 ±0.35	1.74 ±0.13	53.19 ±0.86
Mango	Dark colored	4°C	4.12 ±0.13	4.33 ±0.19	1.65 ±0.41	7.66 ±0.62
Mango	Dark colored	24°C	3.13 ±0.03	4.50 ±0.19	6.37 ±0.35	22.53 ±13.3
Mango	Clear (light)	4°C	4.00 ±0.08	3.15 ±0.14	1.68 ±0.26	8.47 ±0.50
Mango	Clear (light)	24°C	3.03 ±0.03	3.68 ±0.26	6.07 ±0.42	16.2 ±8.46
Pineapple	Dark colored	4°C	4.02 ±0.05	3.75 ±0.04	2.58 ±0.53	4.71 ±0.49
Pineapple	Dark colored	24°C	3.11 ±0.05	5.07 ±0.07	6.28 ±0.24	5.91 ±0.86
Pineapple	Clear (light)	4°C	3.81 ±0.10	3.36 ±0.18	2.72 ±0.39	4.98 ±0.57
Pineapple	Clear (light)	24°C	2.94 ±0.001	5.16 ±0.08	6.75 ±0.47	5.97 ±0.75

TTA (%) - Titratable acidity

Conclusion

Fresh fruit and vegetable juices are contaminated with microorganisms of which, some may be pathogenic causing food borne illnesses to consumers. Passion fruit the most preferred juice sold in Kampala may be a good source of ascorbic acid for adults in Kampala and the country at large since it contains levels of ascorbic acid greater than those recommended by FDA.

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References

Bagde, N. I. and Tumane, P. M. 2011. Studies on microbial flora of fruit juices and cold drinks. *Asiatic Journal of Biotechnology Resources* 2 (4): 454–460. http://doi.org/03.2011/AJOBR-2011/02(04)/454-460

Olorunjuwon, B. O., Temitope, B. K., Muibat, F. O. and Afolabi, O. 2014. Microbiological quality of some locally-produced fruit juices in Ogun State, South western Nigeria. *Journal of Microbiology Research* 2 (1):1–8.

Castillo, A., Villarruel-López, A., Navarro-Hidalgo, V., Martínez-González, N. E. and Torres-Vitela, M. R. 2006. Salmonella and Shigella in freshly squeezed orange juice, fresh oranges, and wiping cloths collected from public markets and street booths in Guadalajara, Mexico: incidence and comparison of analytical routes. *Journal of Food Protection* 69 (11): 2595–2599. Retrieved from http://www.ncbi.

nlm.nih.gov/pubmed/17133801

Cortes, C., Esteve, M. J. and Frigola, A. 2007. Color of orange juice treated by high intensity pulsed electric fields during refrigerated storage and comparison with pasteurized juice. *Food Control* 1–8. http://doi.org/10.1016/j.foodcont.2007.03.001

Heaton, J. C. and Jones, K. 2008. Microbial contamination of fruit and vegetables and the behaviour of enteropathogens in the phyllosphere: a review. *Journal of Applied Microbiology* 104 (3): 613–626. http://doi.org/10.1111/j.1365-2672.2007.03587.x

Kader, M. M., Mamun, A. A., Islam, T. M. and Sultana, N. 2014. Bacteriological analysis of some commercially packed and fresh fruit juices available in Jessore city: a comparative look. *International Journal of Biosciences* 5 (1): 415–420.

Khan, M. M., Islam, T., Mehadi, M., Chowdhury, H. and Alim, S. R. 2015. Assessment of microbiological quality of some drinks sold in the streets of Dhaka University Campus in Bangladesh. *International Journal of Food Contamination* 2 (4): 4. http://doi.org/10.1186/s40550-015-0010-6

Lamport, D. J., Saunders, C., Butler, L. T. and Spencer, J. P. E. 2014. Fruits , vegetables, 100 % juices , and cognitive function. *Nutrition Reviews* 72 (12): 774–789. http://doi.org/10.1111/nure.12149

Leahu, A., Damian, C., Oroian, M. and Ropciuc, S. 2013. Physico-chemical parameters of fruit juices - evolution during storage. *Lucrări Ştiinţifice-Seria Zootehnie* 59: 213–217.

Silvaa, C.E.D.F., da Silvaa, I.C.C. and Abudb, A.K.D.S., 2015. Acidulants in tropical fruit pulp: physicochemical and sensory changes. *Chemical Engineering Transactions* 44:1–6.