Analysis of Different Brands of Fruit Juice with Emphasis on their Sugar and Trace Metal Content

Okoye, C. O. B. and Ibeto, C. N.
Department of Pure and Industrial Chemistry, Faculty of Physical Sciences, University of Nigeria, Nsukka, Enugu State, Nigeria.

Corresponding author: Okoye, C. O. B**.** Department of Pure and Industrial Chemistry, Faculty of Physical Sciences, University of Nigeria, Nsukka, Enugu State, Nigeria. **Email:** chuma_2008@yahoo.com

Abstract

Ten brands of commercial fruit juice were analysed for pH, specific gravity, total solids, reducing sugar, total sugar, and metal contents. The sugar content was determined using the Lane and Eynon method, sodium and potassium were determined by flame photometry, calcium and magnesium by complexometric titration using EDTA, while the other metals were determined by atomic absorption spectrophotometry. The juices had a pH range of 1.80-3.40, specific gravity of 1.002-1.054, total solids of 0.68-12.49%, content of reducing sugar 0.34-8.25% and content of total sugar 0.54-10.69%. Other derived values were calcium (0.01-1.25ppm), magnesium (0.06-0.43ppm), sodium (0.84-3.11ppm), potassium (0.16-7.42ppm), copper (0.28-5.06ppm), zinc (0.01-0.10ppm), chromium (0.03-0.09ppm), manganese (0.11-6.96ppm), cobalt (0.01-0.06ppm), nickel (0.03-0.15ppm), iron (0.45-50ppm), cadmium (0.16-0.38ppm) and lead (0.11-0.33ppm). The Nigerian made fruit juices had higher amount of added sugar. The pineapple juice brand had very high concentration of iron and the presence of cadmium and lead in some of the samples is a clear case of contamination. However the contamination level cannot yet present health threat to the consumer.

Keywords: Fruit juice, Added sugar, Reducing sugar, Low level contamination, Trace metals

Introduction

A lot of persons of all age groups drink fruit juice. To this extent, it is necessary to have a continuous monitoring of the quality of commercial fruit juices, as adulteration, which is the substitution of cheaper ingredients for authentic products, with the intent to defraud the buyer, occurs around the world with many commodities including fruit juices (Jeanette, 1983). A product labeled fruit juice may in fact consist of little or no actual fruit components, thus the development of standard for fruit juices is incorporated into many country's regulatory codes. These regulations include the processing method employed, and the amount of fruit contents required for various fruit juice designations.

The major component of fruit juice is water (Esminger *et al.,* 1986), and this can range from 90% in some wild berries to 70% in over ripe grapes, while less than 50% in fruits drying naturally on the plant. The non-aqueous portion contains literally hundreds of identified compounds which include natural sugars and/or sugar polymers namely glucose, fructose, starch, cellulose, hemicellulose and pectin usually representing the majority of solids. The solids are categorized as soluble, if they are readily expressed in the juice. The insoluble, solids consist primarily of the press residue and can range from 3 to 25%. Other macro components such as the fruit acids are responsible for the taste and low pH of many fruits. Principal organic acids are citric, tartaric, malic, lactic, acetic and ascorbic acids. These range from trace amounts to over 3%. Protein is usually less than 1%. Phenolic compounds ranging from antocyanin or carotenoid pigments to tannins are usually far less than 1%. Lipids are usually absent except in avocado, oil palm fruits e.t.c. The absence of lipids is reflected in the reasonably low calorie value of fruit juices. High lipid fruits are not good for fruit juice production. Vitamins and minerals are in the range of trace to 0.2% while dietary fibre can be present up to 15%.

Chemical contamination of fruit juices can occur from the environment. The unauthorized or excessive use of pesticide chemicals is the most common but an avoidable source. Even trace amounts of innocuous substances present in water or wind drift can cause contamination of fruit juices. Although the health hazard is trivial, the analytical sensitivity ensures detection. Unlabelled lethal white powders have been mistaken for food ingredients and are added to juice resulting in fatal poisoning (Morris *et al.,* 2001). The use of non-food grade equipment in the processing line is a relatively minor safety concern that still impacts juice quality. Metals such as copper, aluminium and iron, mobilized from galvanized steel (except stainless), due to attack by fruit acids; contribute to metal ions in fruit juices. The aim of this investigation is to estimate the amount of added sugar and measure the concentration, if any, of toxic metals in the fruit juice samples.

Materials and Methods

Ten different brands of fruit juice samples were purchased from Nsukka main market. Six were made in Nigeria and four were foreign made. The foreign juices were in metal cans and the Nigerian made juices were in paper and plastic packs. All the fruit juice samples were stored in the refrigerator to prevent deterioration.

Physico-chemical analysis: pH was determined using a Hanna pH meter model No. 02895.

Table 1: Physical parameters, reducing sugar and total sugar as determined in fruit juice samples

Samples	Mean values of parameters				
	pH	Specific gravity	Total solids (%)	Reducing sugar (%)	Total sugar (%)
Lime	1.80	1.020	3.97	1.64	2.69
Mango	3.30	1.052	12.49	1.92	10.69
Orange	2.30	1.002	0.68	0.61	0.65
Guava*	3.00	1.048	9.11	3.59	5.81
Guava*	3.40	1.044	8.41	4.89	5.19
Black-Currant	2.50	1.004	0.74	0.34	0.54
Mixed-fruit*	2.40	1.052	11.61	6.51	7.05
Apple*	2.40	1.043	8.98	8.25	8.65
Apple	2.70	1.043	9.04	1.08	1.75
Pineapple	2.80	1.054	10.26	0.86	5.52

** Foreign made juices*

Table 2: Concentrations (ppm) of metals in fruit juice samples

Samples	Mean concentrations (mg/l) of parameters											
	Ca	Mg	Na	K	Cu	Zn	Cr	Mn	Co	Ni	Fe	Cd	Pb
Lime	0.58	0.23	2.04	2.01	1.07	0.01	0.06	0.11	0.03	0.08	0.93	<0.002	<0.004
Mango	0.48	0.43	1.78	5.49	<0.001	<0.006	<0.002	0.67	<0.005	<0.05	8.43	0.17	<0.004
Orange	0.01	0.09	2.58	0.26	0.28	0.04	<0.002	0.19	<0.005	0.13	3.58	<0.002	0.11
Guava*	1.25	0.20	2.18	3.74	5.06	<0.006	<0.002	0.42	<0.005	0.13	3.30	0.27	<0.004
Guava*	0.38	0.14	2.58	2.78	3.99	<0.006	<0.002	0.67	0.05	0.03	11.90	0.37	<0.004
Black Currant	0.19	0.23	3.11	0.16	0.65	0.06	0.03	0.24	<0.005	<0.05	<0.003	0.16	0.13
Mixed fruit*	0.48	0.06	0.84	2.78	0.64	0.04	<0.002	0.42	0.06	<0.05	7.78	<0.002	<0.004
Apple*	0.07	0.21	1.24	1.81	0.66	0.01	<0.002	0.19	0.01	<0.05	0.45	0.26	0.33
Apple	0.43	0.06	1.51	5.29	0.59	0.10	<0.002	0.14	<0.005	0.03	2.98	0.25	<0.004
Pine-apple	0.38	0.20	1.11	7.42	0.60	0.01	0.09	6.96	0.04	0.15	50.00	0.38	0.20

** Foreign made juices*

Table 3: Permissible levels of determined parameters in fruit juice samples

Parameters /contaminants	Maximum level/permissible levels
pH	1.4-4.0
Total sugars	7-14%
Total solids	10% minimum for fruit juices and 10% maximum for fruit drinks
Magnesium	Less than 8ppm
Copper	5ppm
Zinc	5ppm
Iron	15ppm
Lead	0.3ppm

Sources: *Standard Organization of Nigeria (1997) and FAO/WHO (1992)*

Specific gravity was determined with a 25 ml specific gravity bottle. Total solids were determined by evaporating 100 ml of fruit juice to dryness in a pre-weighed evaporating dish and weighing the contents to constant weight.

Reducing and total sugar levels were determined by the Lane and Eynon method (FAO, 1986). For the reducing sugar determination, 20 ml sample of fruit juice was clarified with 5 ml of 10% zinc acetate (BDH chemicals Ltd Poole, England), while 5 ml of 5% potassium ferrocyanide (BDH chemicals Ltd Poole, England) was used for the total sugar determination. A 50 ml volume of the clarified sample solution was inverted with 20 ml of concentrated HNO_3 (BDH chemicals Ltd Poole, England) and neutralized with 50% sodium hydroxide (LAB TECH chemicals) solution using phenolphthalein indicator (Merck, Germany) (Smith, 1993).

Volumes of the samples equivalent to 100 ml of samples were prepared for determination of metals by wet digestion using 6 ml perchloric acid (Sigma Aldrich Riedel-de-Haën GmBH) and 12 ml nitric acid (FAO, 1992). Sodium and potassium were determined by flame photometry using a Gallenkamp flame analyzer; calcium and magnesium were determined by EDTA titrimetry and the trace metals were determined by atomic absorption spectrophotometry using Alpha 4 Serial no 4200 with air acetylene flame.

Results and Discussion

The results obtained are presented in Tables 1 and 2 while national and international standards for fruit juices (FAO, 1992; SON, 1997) are shown in Table 3. From the results all the samples were acidic, with pH ranging from 1.8-3.4. This falls within the range of the allowed limits by the Standard Organization of Nigeria, which is 1.4-4.0. It is suspected that the samples were very acidic due to the addition of acids during production, which is often the case. For example freshly squeezed mango juice generally has pH range from 4.5-5.0, but on acidification with citric acid during the processing, the pH will be less than 4.0 (Morris *et al.,* 2001). The mango juice brand analysed in this study had pH of 3.3.

The specific gravity of all the juices were between 1.002 - 1.054. The orange and black currant juice brands analysed had the lowest specific gravity of 1.002 and 1.004 respectively. These were expected because both are fruit drinks.

Their fruit contents or solid contents are usually below 10%. The composition of such drinks is mainly water, colouring and sugar. The total solid content of the orange and the black currant brands were 0.68% and 0.74%, which were very low in comparison with the rest of the brands, which ranged from 3.97 in the lime juice brand to 12.49% in the mango brand.

Only three of the sample brands (mango, mixed fruits and pineapple) conformed to the expected standard of a minimum of 10% total solids content. From the sugar analysis, the black currant juice brand had the lowest % total sugar (0.54%) followed by orange juice brand (0.65%). These brands were not really sweet, and it shows that there was just little or no addition of sugar. Others low in sugar were the lime and apple brands. These were Nigerian made. The amount of sugar added can be estimated from the difference between the reducing sugar and the total sugar content. The Nigerian made mango and pineapple juice brands showed the highest amount of sugar content. None of the total sugar content of the fruit juice brands exceeded the 14% maximum permissible limit by FAO/W.H.O and only three of the brands had total sugar between 7-14%.

Table 3 shows that all the samples except one of the guava brands contained lower copper than the limit set for the metal. All samples had concentrations of zinc well below the maximum level. The iron concentrations were below the limit of 15 ppm in all the samples except for the pineapple brand, which showed a concentration of 50 ppm. This could be due to many reasons such as the fact that the fruit juice brand was acidic and the fruit acids could pick up the metal from the equipment during processing or storage. As minerals are soil and species dependent, the fruit acids might also have picked up iron and other metals from the soil during growth. Iron could also have been added for fortification. Calcium, magnesium, sodium and potassium were obviously low in all the samples. This was expected as most of the properly labeled samples had 0% for calcium and magnesium while some had trace amounts of sodium. Studies have shown that the fresher the juice, the higher the quality, so standard for excellence is freshly prepared juice (Sizer and Balasubramaman, 1999).

Cadmium was more widespread, occurring in seven brands with values of 0.16 to 0.38 ppm. Lead occurred in four brands with range 0.11 to 0.33 ppm. Only the foreign made apple juice brand with the lead content of 0.33 ppm exceeded the maximum level of 0.3 ppm. The limit for cadmium was not stipulated but compared with the limit set for lead (since they are both non-nutritive elements), the foreign made guava brand and the pineapple brand may be considered high in cadmium.

Conclusion: The results clearly show that most of the Nigerian made brands had higher amount of added sugar. The pineapple drink brand had very high concentration of iron and the presence of cadmium and lead in some of the samples is a clear case of contamination either from the soil where the fruits were grown or from the vessels and equipment used in the production or storage. However, the samples analysed cannot at the levels of contamination, present health hazards to the consumers.

References

Esminger, A.H., Konlade, J.E and Robinson, J.R.K. (1986). A Nutrition Encyclopedia. 1st edition, Pegus Press, Library of Congress Catalogue. 481p.

FAO (Food and Agricultural Organization) (1986). Manual of Food Quality Control. Food Analysis: Quality, Adulteration and Test of Identity (Sugar and Honey). Paper 14/8: 110-113.

FAO (Food and Agricultural Organisation) of the United Nations W.H.O Rome (1992). Joint FAO/WHO foods standards programme for fruit juices and related products. Codex Alimentarius Commission. Vol. 6. pp 1-5.

Jeanette, G.G (1983). The analytical approach. American Chemical Society Washington D.C pp 55-56.

Morris, J.R., Grandell, P.G. and Bates, R.P. (2001). Principles and practices of small and medium scale fruit juice processing. Food and Agricultural Organization of the United Nations. pp 3-20.

Pearson, D. (1981). Pearson's Chemical Analysis of Food. 8th edition. Churchill Livington Edinburgh. 13th edition. pp 14, 143 and 253.

Sizer, C.E. and Balasubramaman, V.M. (1999). New convention processes for minimally processed foods. Food Technology. 53(10) 64-69.

Smith, G.F. (1993). The wet ashing of organic material employing hot concentration perchloric acid. The liquid free reaction. Anal Chem. Acta 5: 397-421.

SON (Standard Organization of Nigeria) (1997). Nigerian Industrial Standard. Standard for fruit juices. 2nd edition. Ikoyi, Lagos. pp 2-5.