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The Determination of Adulteration in Orange Based Fruit Juices

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ABSTRACT

The main objective of the study was to determine adulteration in orange fruit juices in Harare, Zimbabwe. Stratified sampling method was adopted to collect the 6 different brands of 50% pure juices. The six brand samples were analysed for trace metals (magnesium, calcium, potassium, and sodium), acidity, and brix value as well as reducing sugars. The results were analysed and statistical test of correlation and linear regression was used. There were deviations from the assigned value of 50% real juice and some brand sample showed higher levels of adulteration with very low brix value (˚19.5) as well as low juice content (20.65%) indicating water additions in the juice. Other brands indicated sucrose additions because of their higher brix value than the reference standard. There is a relationship between juice content, mineral content and sugar content. It is recommended that it should be made mandatory for all juice manufacturers' large and small scale to be certified to ensure that authentic fruit juices are manufactured and honestly labeled.

Keywords: *Fruit juices, adulteration, trace metals, acidity, brix.*

1. INTRODUCTION

The analysis of food products is an area of active research in modern food science. This is easy to perceive, as the need to improve food quality is rife due to product diversification. Currently Zimbabwe's beverages sector has accelerated the growth of the manufacturing industry from January 2011 and fruit juice production is located in the main cities and towns of Harare, Kadoma, Bulawayo, Mutare, Masvingo and Gweru in supermarkets, rank stations and on the streets. According to Zimbabwe Broadcasting Cooperation (ZBC) (2011), the growth in productivity of fruit juice manufacturing in Zimbabwe has increased from 35% in 2010 to 52,3% by October 2011. The concentration of the beverages companies is high in Harare about 63% and the other cities share the remainder of 37%. A broad range of juices are appearing on the market like passion fruit, orange, lemon, lemon and lime, apple, pine apple, strawberry, leach, guava, mango and tropical, but orange juice dominates the production. Landon (2007), states that Orange juice is the most widely purchased juice for school meal programs and functions, public functions as well as for consumption nationwide.

In the citrus industry its common practice that people employ economic methods which are not legal, mainly adulteration. Adulteration of fruit juice is widespread and it became a significant issue in the 1980s and 1990s, it is done for economic reasons that is increasing profits, shortage of juice bases and because there is no policing. Ogrinc *et al* (2003) cited that, "making fraudulent profit from misrepresentation of food has been of society from historical times." Adulteration of orange juice has progressed from simple dilution with water and the substitution of cheaper ingredients such as sugar, acid and other types of fruit to sophisticated recipes utilizing citrus by-products with other appropriate ingredients to mask the adulteration process (Robards and Antolovich, 1995). A commonly practiced approach is the addition of undeclared sugar to raise the brix value followed by dilution with water to increase product volume. The brix value, a measure of soluble solids on a mass to mass basis is a tight variable by which fruit juice concentrates are marketed.

Fruit juices sold in Zimbabwe must conform to Standards Association of Zimbabwe (SAZ) regulations therefore a fruit juice is considered to be adulterated if it is not in conformity with established regulations or standards. A crush is a product of citrus, not being a citrus juice concentrate which on dilution with four times its volume of water, produces a citrus drink (Food and Food standards [15:04]). Consumers are thus deceived since added substances are not declared on the product, as a result of these malpractices the ultimate victim is a consumer who innocently takes adulterated food and this can cause serious risk to health. The undeclared substances like sugars in the fruit juices can cause adverse health problems especially to the diabetic as well as causing tooth decay to the children since they are the single largest group of fruit juice consumers (Landon, 2007). Diabetes a silent killer is on the increase in the Zimbabwe and currently more people are dying of the disease (Herald, 2012). According to the Ministry of Health and Child Welfare (2012) evidence exists that there is an increase in the prevalence diseases such as cardio-vascular diseases, hypertension, diabetes mellitus and various cancers. The constituents of most juices on the market are no longer as reflected on the labels for example 50% real juices.

In a certain study, Bodine's Company used beet and corn sugars, monosodium glutamate (MSG), ascorbic acid, malic acid, potassium sulphate, orange pulp wash, grape fruit solids and distilled flavours in foods falsely sold as pure unsweetened orange juice and their sales increased during from \$15m to over \$100m (Chandler, 1988). This case illustrates the need for consumer protection as most adulterated juices are not perceived as poor quality juices and will remain undetected by the consumer.

A complete chemical analysis enables the detection of an addition of sugars, acids and other undeclared ingredients. An elegant method of detecting sugar addition in particular is been the use of high performance liquid chromatography (HPLC) to determine the presence of oligosaccharides that are characteristics of the added sugars but not the fruit. To determine trace elements present there is use of the Inductively Coupled Plasma (ICP) and Atomic Absorption Spectroscopy (AAS).

2. METHODOLOGY

The aim of the research was to determine adulteration by analyzing for individual sugars, brix, acids and trace metals in orange juices from different brands. The total number of samples which were analysed were 72.

3. EXPERIMENTAL ANALYSIS

The experiment for determining trace metals and the brix which tested the total amount of sugars in samples was done at the Standards Association of Zimbabwe. The quantification of individual sugars fructose and glucose and the total titratable acidity for acid content was done at University of Zimbabwe, Biochemistry Department Laboratories. The analysis were done in triplicate. The determination of trace elements calcium, magnesium, potassium and phosphorus was done using the Inductively Coupled Plasma (ICP) (method procedure SAZ – CFTM054). Reducing sugars were analysed using Shaffer and Somogyi method (1933).The total acidity of orange juice was determined by titrating a known volume of juice with a standard solution of NaOH with phenol as an indicator, the result being expressed as citric acid. The refractometer was used to determine the total soluble solids (brix value) of the samples and according to Kimball (1999), usually degree brix corresponds to 1 gram of sucrose in 100 grams solution.

4. STATISTICAL ANALYSIS

Statistical analysis was done using Graphpad Prism 4 software package at 95% confidence interval where ($p=0.05$). Correlation and linear regression were also used.

5. RESULTS AND DISCUSSION

Table 1 shows the raw data for the results of trace metals of the 6 different brand samples of 50% orange crushes from sample A-F as well as the blank. From table1 potassium and calcium were detected in all brand samples but only brand sample F had calcium out of range. Magnesium was not detected in sample B and F. For sodium, half of the brand samples were negative.

Table 1: Summary of trace metal results using the ICP method

Parameter	Sample A	Sample B	Sample C	Sample D	Sample E	Sample F	Blank	Reference Standard
Potassium mg/100g	222.7	136.6	225.3	23.62	71.62	609.6	0.000	170
Calcium mg/100g	85.7	132.8	98.97	62.36	32.54	Out of range	0.000	80
Magnesium mg/100g	Out of range	0.000	2.218	3.801	5.225	0.000	5.784	30
Sodium mg/100g	0.000	0.629	0.000	0.035	Out of range	0.000	0.997	210

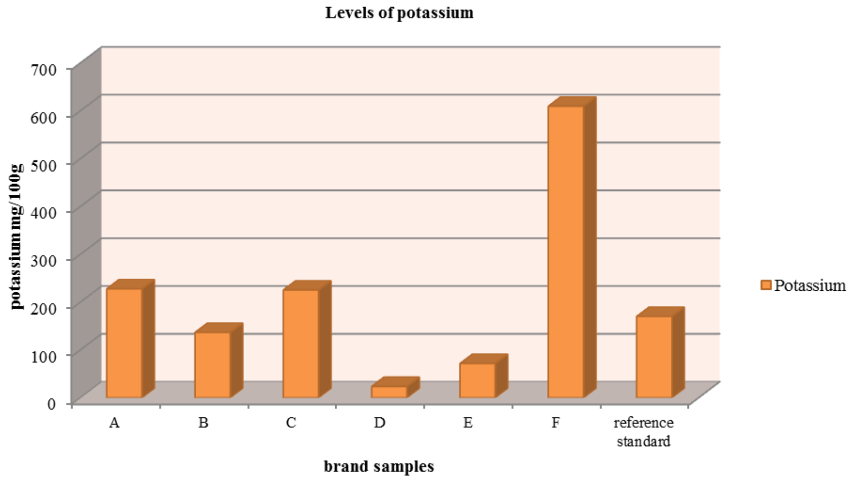

Fig 1: Potassium levels in orange juice samples

As illustrated in fig 1 brand sample F had the highest amount of potassium 609 mg/100g which was 3 times more than the standard 170 mg/100g. Brand sample D had the lowest amount of 23.62 mg/100g whilst samples A and B were slightly higher than the standard.

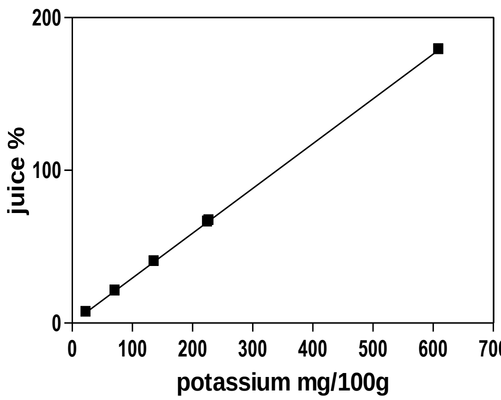

Fig 2: Relationship between potassium and juice%

Fig 2 demonstrates the relationship between potassium and juice % and it shows that there is a strong positive correlation as demonstrated by the r value which is 1.000. Therefore as the potassium content increases so does the juice content. According to Singal *et al* (2001), potassium content can only decrease when dilutions with water have been done, only those varieties with low potassium can produce juice with low potassium.

As highlighted in fig 3 below, four samples A, B, C and F had values which were above the required standard 80 mg/100g. Brand samples B and F had the highest quantities of calcium 132.8 mg/100g and 140 mg/100g respectively. Voldrich *et al* (2003), revealed that higher levels of calcium indicate that unsuitable water was used for reconstitution, therefore there was adulteration of water additions.

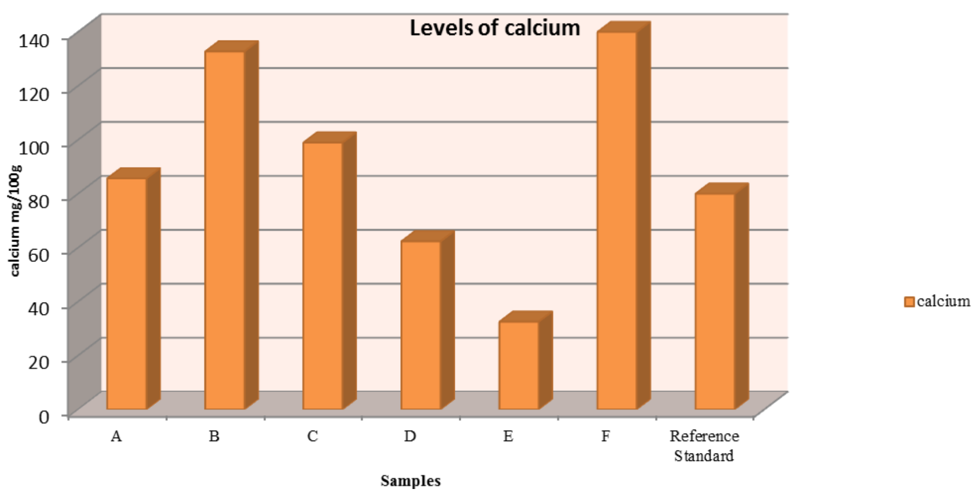

Fig 3: Calcium levels in orange juice samples

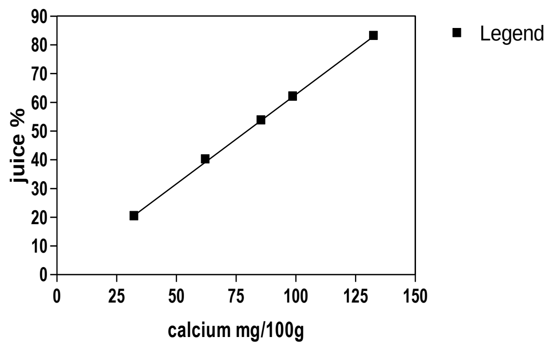

Fig 4: Relationship between calcium levels and juice content

Fig 4 shows a positive correlation that as calcium levels increases the juice content also increases as indicated by r^2=0.9997. Voldrich *et al* (2002), revealed that higher calcium content is an indicator of higher pulpwash content in juice or higher pressure squeezing.

As indicated in fig 5 magnesium was not detected in brand samples A, B and F then samples C, D and E had very small amounts of 2.218 mg/100g, 3.801 mg/100g and 5.225mg/100g respectively.

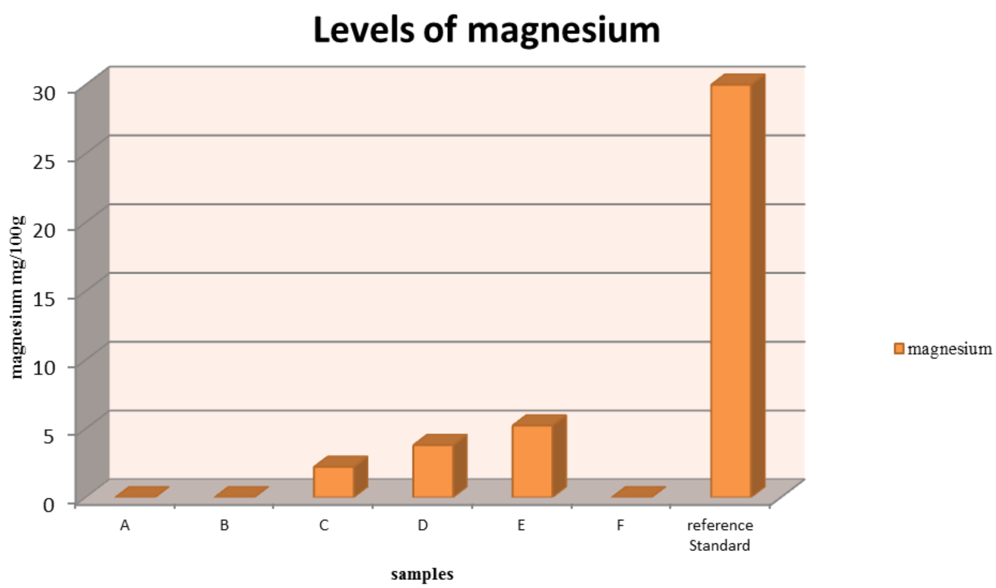

Fig 5: Levels of magnesium in orange juice samples

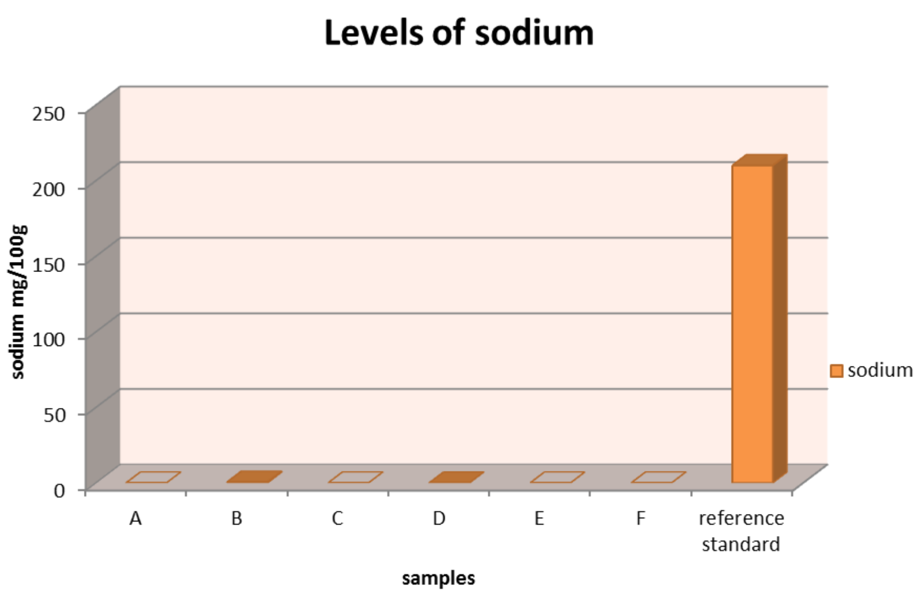

Fig 6: Levels of sodium in orange juice samples

Fig 6 shows that the sodium was not detected in any of the samples. Sodium is a good indicator of adulteration because it is normally so low in concentration; the maximum level of sodium in crushes is 210mg/100g. According to (McCance, 1994), anything more than this is an indication of adulteration.

The table 2 shows the ˚brix of the six samples with their different refractive indices as well as varying temperatures. Samples A and B had higher brix than the reference standard 28.5 and sample E had ˚19.5 which was way below the reference standard.

Table 2: ˚Brix values and refractive index for different brand samples

Parameter	sample A	sample B	sample C	sample D	sample E	sample F	Reference Standard
% Solids	33.5	33.3	27.9	27.4	19.5	26.2	28.5
Refractive index	1.387	1.3873	1.3774	1.3765	1.3549	1.3745	
Temperature	23.9	24.1	24.4	24.4	24.6	24.7	

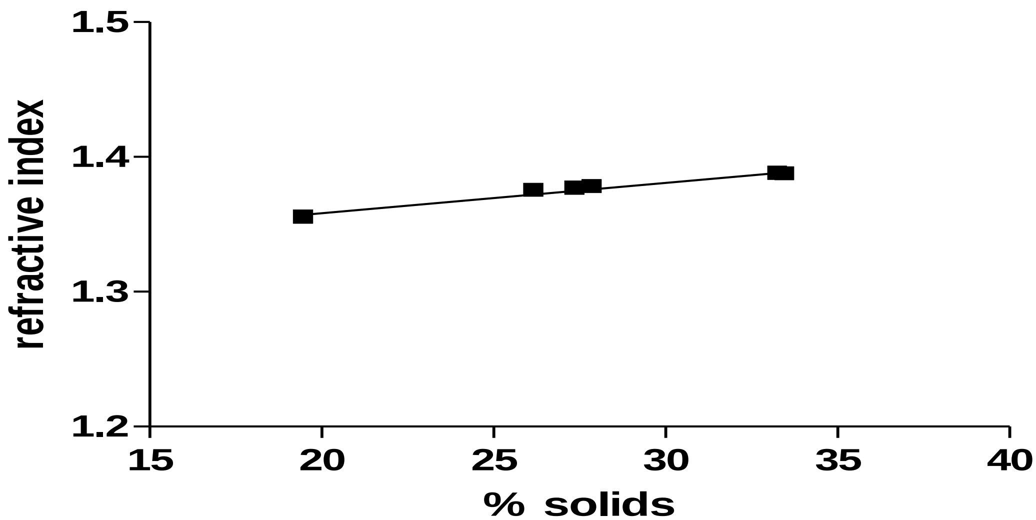

Fig 7 relationship between refractive index and % solids

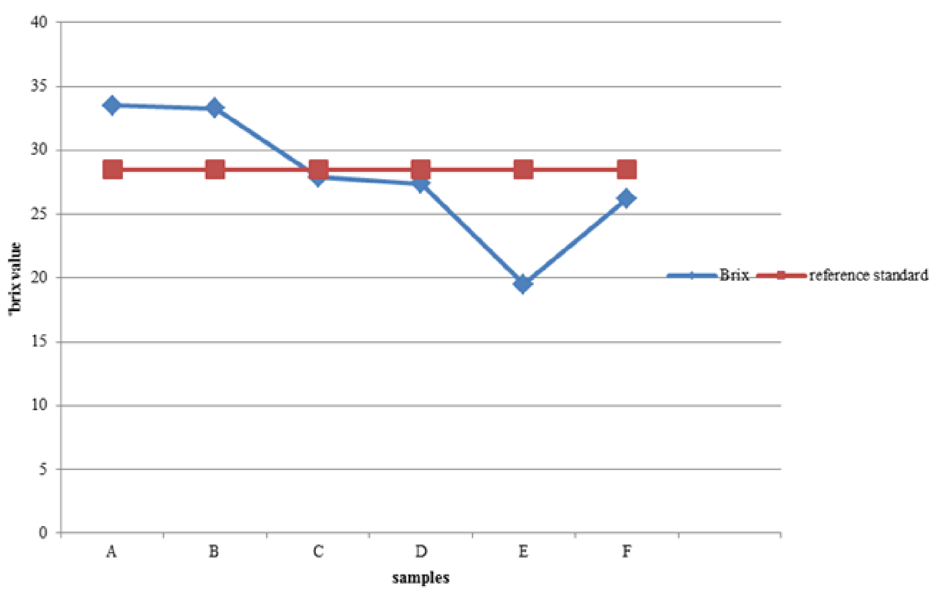

Fig 8: Results for the ˚brix values of the samples

Fig 7 shows that is a very weak positive relationship between refractive index and % solids ($r^2 = 0.9741$).

Fig 8 clearly indicates that the brand sample E had the lowest brix value of ˚19.5 compared to the reference standard which was ˚28.5 therefore this brand sample is way below the required specification (McCance and Widdowsons, 1994). Fig 8 also shows that four samples C, D, E and F were below the required specifications of the reference standard whereas two samples where above the standard hence it can be concluded that four samples were closer to the required specifications.

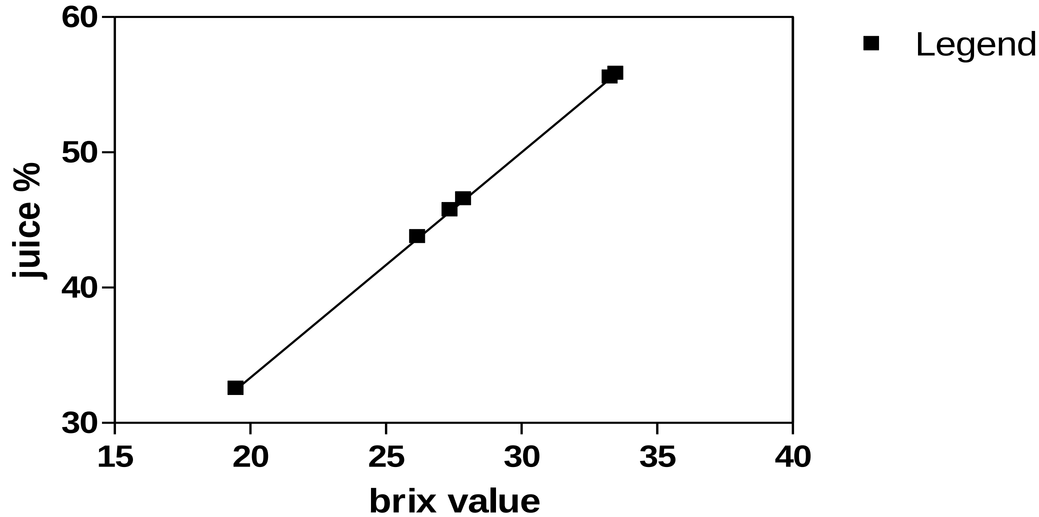

Fig 9 Relationship between brix value and juice percentage

Fig 9 above shows a positive relationship between brix and juice percentage. An increase in juice content results in an increase in the brix value.

From fig 10 it can be deduced that 3 brand samples had low juice content than the assigned value of 50% which was on the label. Sample E had 20.65% which is way below the assigned value therefore it had very low juice content. From all the brand samples not even one sample had juice percentage of 50% as indicated by the label though brand samples A, B and C had juice percentages which were closer to the assigned value, especially sample B which had 47.5%.

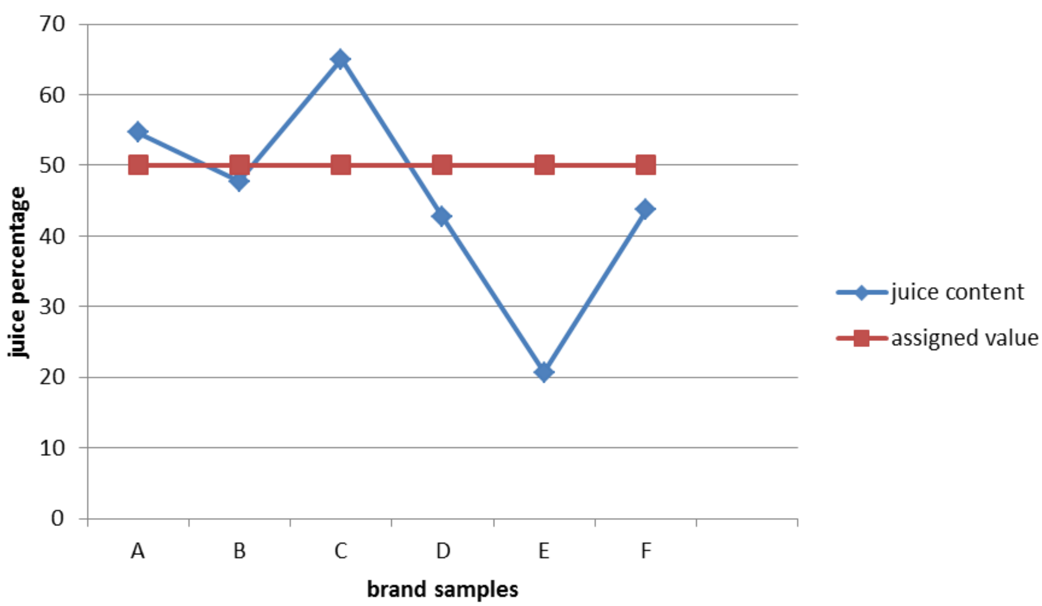

Fig 10: Juice content of different brands

6. DISCUSSION

Overally, the results showed that there was adulteration of water additions, pulpwash additions and low fruit content, but the most common being low fruit content. Statstical analysis showed that there is also a relationship between juice content, mineral content and sugar content of the 50% pure fruit juices.

6.1 Relationship between Mineral Levels and Juice Content

Metal ions measured by the ICP provide an easy and informative way of dealing with complex adulteration. The content of mineral elements such as calcium, potassium, and magnesium are the best parameters for detecting citrus juice adulterations such as that of orange (Singhal and Kulkami, 2001). Gregor (2000) cited that there are risks associated with consuming either too little or too much of any single mineral.

Fig 1 shows that there is toxicity of potassium in the fruit juices because levels for brand samples A, C and F had values which were above the standard, and F had the highest value of 609 mg/100g which leads to more toxicity of potassium for human consumption. According to McCance and Widdowson (1994), the reference standard for potassium in 50% pure orange juice is 170 mg/100g. 50% of the samples in this study had excess potassium, whereas the other 50% had potassium below the standard.

Potassium is involved in maintaining water and electrolyte balance and regulating nerve and muscle functions hence it must be maintained at its standard because low potassium levels are an indication of adulteration which is water additions. According to Singhal and Kulkami (2001) if the potassium level is below the standard this shows that there have been dilutions with water because potassium content can only decrease when dilutions with water have been done, only those varieties with low potassium can produce juice with low potassium. Toxicity of potassium causes cardiac arrest, cognitive impairment, dysphasia and weakness (Wallach, 2007).

According to McCance and Widdoson, (1994) the reference standard for calcium in 50% pure fruit juice is 80 mg/100g as shown in fig 3. Voldrich *et al* (2002), revealed that a higher content of calcium is an indicator of adulteration which might be higher pulpwash content in juice because pulpwash contains substantially more calcium than juice. Higher calcium can also be due to use of reconstitution water with higher content of calcium or unsuitable water for reconstitution. Chronic toxicity can occur due to chronic exposure to lower levels of excess calcium. Toxicity of calcium causes anorexia, aphasia, memory loss, muscle weakness, psychosis, fat intoletance, gastric ulcers, hypertension, kidney disease and liver impairment (Wallach, 2007). The hypothesis therefore showed that there is a positive relationship between calcium levels and juice content.

In fig 5, for magnesium was not detected as well as sodium in fig 6. Sodium is a valuable indicator because excess sodium can also be derived from any addition of preservative or adulterant as a sodium salt. Sodium is a good indicator of adulteration because it is normally so low in concentration in fruit juices (Ashurst, 2004). The maximum level of sodium in 50% pure orange juice is 210mg/ 100g according to McCance (1994), anything more than this is an indication of adulteration.

6.2 Brix Value

Brix is defined as the percentage of dissolved sugar in a solution on a weight for weight basis and is expressed in degrees brix (˚B) (Shachman, 2005). Relationships between brix and percentage sugars and acids can also be considered as parameters of composition of the juices and hence indices of adulteration, (Singhal, 2001). As evidenced in fig 7 brand samples E had the lowest brix value of 19.5, then samples A and B had highest ˚Brix values comparing with the reference standard of ˚28,5. According to Robards and Antolovich (1995) if the brix value is below the required specification it shows that there has been over dilution of the juice with water. Adulteration of juices with water has largely been addressed through the application of minimum solids content measured in degrees brix (Kimball, 1999). For brand samples A and B there is an indication of adulteration by addition of sucrose because of the brix values of 33.5 and 33.3 respectively. This is because ˚1brix corresponds to 1 gram of sucrose (Sachman, 2005), therefore there was more sucrose in those samples. Excess sugar can affect diabetic individual and can cause tooth decay in children. Fig 7 showed that brand sample E was mainly adulterated with water additions because it had a very low brix value as well as low fruit content. The statistical analysis also showed that there was a relationship between sugar content and juice content.

The acidity of the samples showed that 4 samples had a higher acidity than the required range of 1.6-1.9, where sample B had the highest acidity of 3.18. Citric acid is usually added to mask the sugar addition (Voldrich *et al*., 2002).

6.3 Juice Percentage

The analysis of percentage juice has indicated to be a useful parameter for detecting adulteration (Singhal and Kulkami, 2001). The assigned value for orange juice concentration was 50% hence as illustrated in fig 10, 3 brand samples D, E and F had values below the standard 42.65%, 20.65% and 43.7% respectively. Sample E had the lowest juice content of 20.65% which is way below the assigned value. The low juice percentage indicates that little orange juice was added trying to economise the orange concentrate hence the juice was adulterated. Voldrich *et al* (2002) stated that ‘‘ lower fruit content shows that there was addition of sugars and acids whereby citric acid is usually added to mask the sugar addition.’’

7. SUMMARY

The study was based on the determination of adulteration in orange based fruit juices on the market in Zimbabwe. The research was influenced by the assortment of new juices from different companies that are not certified and many quality problems were arising in the production of juices. The main objective of the research was to determine the extent of adulteration with an emphasis on food safety to protect the health of the consumer. The study intended to benefit mainly the customer so that they purchase quality juice rather than quantity, the citrus juice concentrate producers and also the end users which are the beverages companies. The six different brand samples were analysed for trace metals, acidity, and brix value as well as reducing sugars.

8. CONCLUSION

From the results it can be concluded that there were deviations from the assigned value of 50% real juice. Brand sample E showed higher levels of adulteration with very low brix value as well as low juice content therefore this indicates water additions in the juice. Brands A and B indicated sucrose additions because of their higher brix value than the reference standard. Regression analysis showed that there is a positive correlation between sugar content and juice content and there is also a positive correlation between potassium content and juice content in fruit juices. There is also a relationship between calcium content and juice content in fruit juices.

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REFERENCES

[1] Ashurst, P. R., (2004). *Production and Packaging on non-carbonated fruit juices and fruit Beverages.* New Delhi, New York

[2] Chandler, B. V., (1988). *Adulteration of Fruit Juice Beverages,* eds. Nagy, S., Attaway, J. A., and Rhodes, M. E., Marcel Dekker: New York

[3] Chen, C. S., Shaw, P. E. and Parish, M. E. (1993) Fruit Juice Processing Technology

[4] Herald, (2010) *Diabetes on the increase*: Diabetes Association, www.herald.co.zw, Retreaved 22 April 2012.

[5] Food and Food standards Act (2005) Chapter [15:04], *Adulterated and Falsely Described Food*, Part 2

[6] Kimball. D., (1999) *Citrus Processing*, Aspen Publishers: Maryland.

[7] Landon, S., (2007) A Review Australian Fruit juice Association, *Fruit juice Nutrition and Health***, 59** (11): 533-537

[8] McCance, D and Widdowson, A., (1994). *The Composition of Foods*, 5th ed, 337-353

[9] Ogrinc.N., Košir I.J.and Spangenberg J.E., (2003) The application of NMR and MS methods for detection of adulteration of wine, fruit juices, and olive oil, *A review Analytical Biochemistry*, **376**: 424–430

[10] Robards. K. and Antolovich. M., (1995). A Review Analyst, *Methods for Assessing the Authenticity of Orange Juice*, **120**: 1-6

[11] Shachman, M., (2005), The Soft drinks Companion, *A Technical handbook for the beverage industry*, CRC Press.

[12] Shaffer P.S., and Somogyi, M., (1933) Copper-Iodometric Reagents for Sugar Determination, *Journal of Biology and Chemistry*, **100**: 695-713

[13] Singhal, R.S., and Kulkami, P. R., (2001) *Handbook of indices of food quality and Authenticity*

[14] Wallach, J.D., (2007) *Nutrient Deficiency and Toxicity Symptoms*, Longman Group: UK

[15] Voldrich. M., Skalova. P., Kvasnicka. F., Cuhra. P and Kubik, M., (2002) Authenticity of 100% Orange Juice in the Czech Market in 1996–2001, *Journal of Food Science*, **20** (2): 83-88

[16] Zimbabwe National Nutrition survey, (Jan-Feb, 2010), Preliminary findings, *House hold Food Consumption Score*