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Influence of Drying Techniques on the Sensory Properties, Physicochemical and Mineral Composition of Beetroot Juice

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Abstract: *Beetroot (Beta vulgaris) juice was produced and pasteurized at 85°C in a hot water bath; 10% sugar syrup was added to the juice samples to study the influence of drying methods (oven and sun drying) on the sensory, physical, chemical properties and mineral composition of beetroot juice. The sensory properties analysed included taste, aroma, colour, mouth feel and overall acceptability. Drying methods showed no significant effect ($p<0.05$) in all the sensory attributes of sun and oven dried juice samples compared to fresh juice except sun dried sample with significantly lower taste value. Total solids, pH, viscosity and sugar content were the physical properties studied with values which ranged between 8 – 10%, 6.9 – 7.4, 0.1 – 0.3pa.S and 29.3 – 34.2%, respectively with showed no significant effect. In terms of the chemical properties such as moisture, ash, protein and carbohydrate studied, a significant influence ($p<0.05$) was not also recorded as a result of the drying methods. Mineral composition of the juice ranged from 228.4 – 874.7mg for potassium, 14.4 – 19.0mg iron, 3.3 – 4.2mg and 33.2 – 99.2mg for calcium and magnesium, respectively and all were significantly affected by drying method. Nitrate had the same value of 0.005mg in all the juice samples.*
Keywords: *Beetroot, juice, drying methods, sensory, physical, chemical, mineral properties*

I. Introduction

Beetroot (*Beta vulgaris*) as a flavouring agent is a member of the *Chenopodiaceous* family which includes silver beet, sugar beet, beet and fodder beet [1]. They are biennials although they are usually grown as annuals and believed to have originated from Germany [2]. Beetroot produces green tops and a swollen root during growing season. It is usually grown for salad and extraction of sugar from the roots. The balls are round and small with thin red-brown skin and notably sweet flavour. It can be cooked, blanched, steamed or boiled whole with some greens left intact. It is a crop of temperate region where cool weather and high humidity are available [3], as well as an ideal vegetable for health conscious people [1].

Beetroot is one of the richest dietary sources of antioxidants and naturally occurring nitrates [4]. The nitrates in beetroot improve blood flow through the body including the brain, heart and muscles. It increases a molecule in the blood vessels called nitric oxide which helps open up the vessels and allows more oxygen flow; it also lowers blood pressure and decreases the incidence of cardiovascular disease [5]. A number of studies have reported beetroot as a dietary inorganic nitrate with a potential for reducing blood pressure in humans [6 – 8]. Coles & Clifton [9] also reported that after consumption of beetroot juice on a low nitrate diet, it may lower blood pressure and therefore reduce the risk of cardiovascular event. Dietary nitrate supplementation has also been reported to reduce the oxygen cost of low intensity exercise in humans [7].

Reports have indicated that beetroot juice has immerse nutritional, medicinal and health benefits; besides its rich supply of vitamins and minerals such as phosphorus, calcium, magnesium, sulphur; it is also an excellent source of foliate, manganese, iron and many antioxidants [10]. The antioxidant property helps to prevent the formation of cancerous tumours and is therefore a powerful cancer-fighting agent. Its effectiveness against colon and stomach cancer has been established through various studies [11]. A case study of a patient who drank a quart of beetroot juice each day was reported to have effectively broken down and eliminated the cancerous tumours [11]. Vanhatalo *et al.*, [8] also reported that people who drank two cups of beetroot juice had lower blood pressure within about 60 min of drinking the juice, with a peak drop occurring 3 – 4h after ingestion. The reduction in blood pressure continued to be observed until up to 24h after the juice was consumed. The conclusion made was that one of the biggest benefits of beetroot juice is that it provides another way to combat high blood pressure without using medication [8]. Bobek & Mariassyova [12] had also observed its ability to lower LDL cholesterol levels and raise HDL cholesterol levels in the body.

Analysis of the current food market shows that there is a requirement in the manufacture of pure natural foods such as juices [13, 14]. This led to the trend towards the use of technology in the development of functional juices using natural and locally available plant materials as a source of biologically active substances by food industries [15]. Based on this, fruit juices from different plant materials have been produced by various scientists with the aim of transforming raw materials into edible forms and determine the health benefits and shelf life of the final products. On this premise, Emelike & Ebere [16] studied the storage conditions on the vitamin C and pH value of cashew apple juice, Banigo *et al.,* [17] reported the physicochemical and sensory evaluation of soy/carrot drinks flavoured with beetroot, while Emelike & Ebere [18] studied the storage time and temperature on the colour and sensory characteristics of cashew apple juice and Sati [19] the stabilizer substance in producing the beet juice.

Drying technique has been proven to change the chemical composition of plant foods such as fruits, vegetables and increase their storage stability and shelf life. Various plant vegetables (beetroot and *Moringa* leaves) undergo different drying techniques such as sun drying, oven and shade drying [20]. Emelike *et al.,* [21] reported the effects of these three drying techniques on the physicochemical and sensory properties of cookies prepared with *Moringa* leaves. Drying aids the *Moringa* leaves to be milled and incorporated as a functional ingredient in cookie preparation. Beetroot can as well be dried using some of these techniques to increase its shelf life, prior to milling and packaging for easy transportation. This can later be reconstituted to produce beetroot juice. Based on the health benefits and drying techniques reported, to produce beetroot juice is the aim of this research and to determine the influence of drying techniques such as sun and oven drying on the sensory, physicochemical and mineral properties of the juice.

II. Materials and Methods

2.1. Materials

Nine hundred grams (900g) of fresh mature beetroot (*Beta vulgaris*) and sugar were purchased from the Fruit Garden Market D-line, Port Harcourt. All Reagents used were obtained from the Department of Food Science and Technology Laboratory, Rivers State University of Science and Technology, Port Harcourt, Rivers State, Nigeria and were of analytical grade.

2.2. Methods

2.2.1. Processing Techniques of Beetroot Juice

Beetroot was destalked, washed, sliced into thin pieces of about 1 – 2mm thickness and divided into three equal portions. One portion was processed fresh to get fresh beetroot juice. The second portion was sun dried for seven days, while the third sample was oven dried using Omega Dako oven (Model-Ms 209) at 70^{o}C for 24h. The fresh sample was grated into mash, while the sun dried and oven dried samples were milled into powder using Philips blender (Model HR 1701/BC, U.K). The powdered beetroot samples were reconstituted and sieved with muslin cloth folded into 2, 4 and 8 layers, respectively in accordance to the method earlier reported by Emelike & Ebere [18] for cashew apple juice to obtain beetroot juice at the ratio of powder to water of 1:7 (38.63g – 270.41ml) while the ratio of 1:2 (200g – 400ml) mash to water was used to extract the fresh juice sample. The higher ratio that was used in the dried samples was because they were in a powder state and needed more water to enable reconstitution. Sugar syrup was prepared by heating; three hundred grams (300g) of granulated sugar dissolved in 150ml of water and was heated for 7 min to obtain a golden brown gel (sugar syrup). The prepared sugar syrup was then added in percentage of 10 to the juice samples, homogenized in a high speed homogenizer, transferred into sterilized bottles and pasteurized at 85^{o}C in a hot water bath (Techno test, Italy) for 10 min, cooled at room temperature and stored for analysis. The comprehensive processing techniques are depicted in Figure 1.

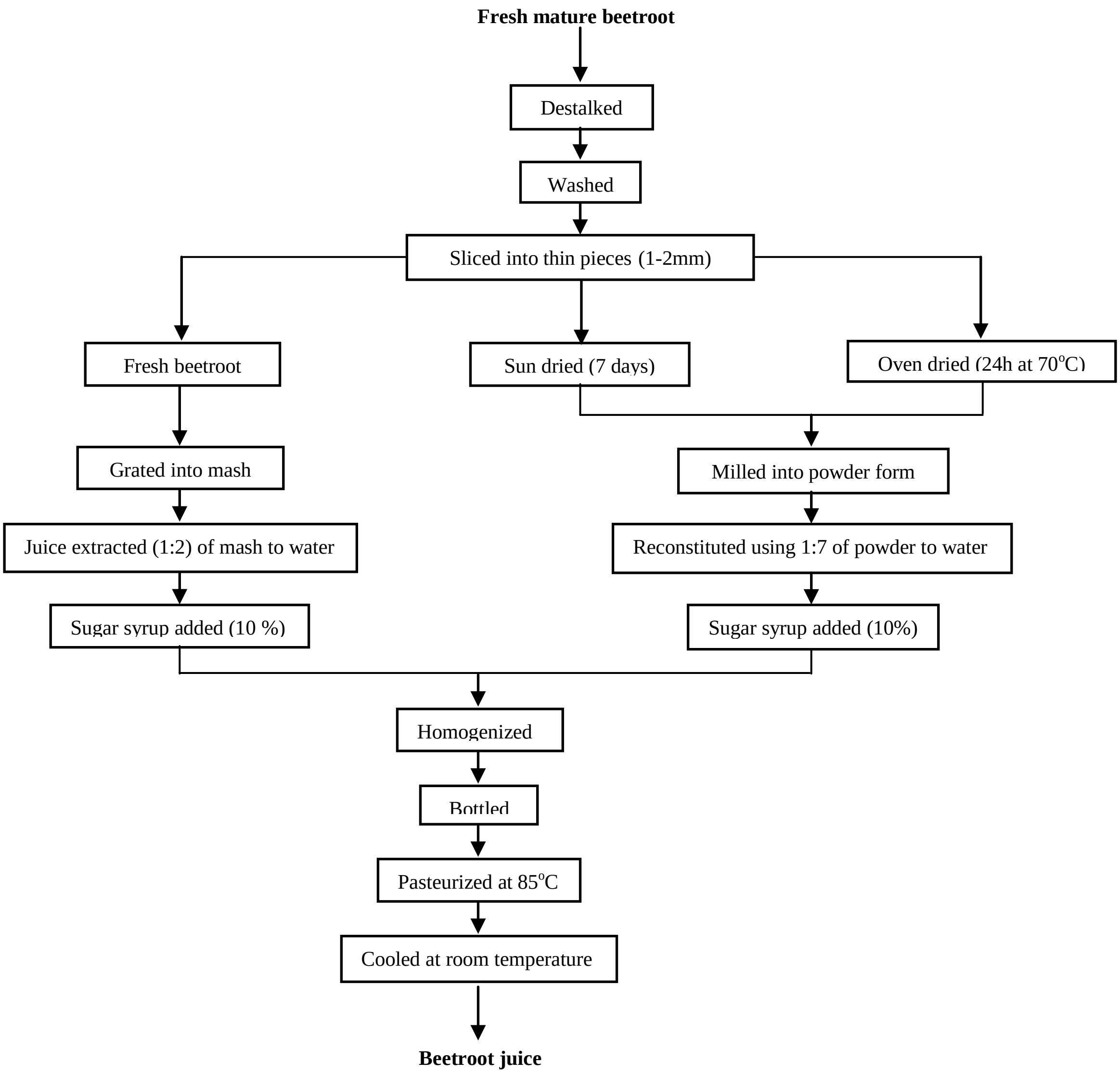

Figure 1: Flow Chart for the Production of Fresh, Sun and Oven Dried Beetroot Juice
Source: Authors' Computation

2.2.2. Sensory Evaluation

The beetroot juice samples were subjected to sensory evaluation using a twenty member panelist consisting of staff and students of the Department of Food Science and Technology, Rivers State University of Science and Technology, Port Harcourt, Nigeria. The organoleptic qualities evaluated were: Taste, flavour, colour, mouth feel and overall acceptability. The juice samples were served in clear glasses to individual panelist. The order of presentation of samples to the panel was randomized, potable water was provided to rinse the mouth between evaluations to avoid transfer of sensory attributes from one sample to the other. Each sensory attribute was scored on a 9 – point Hedonic Scale which ranged from 9 – 1 (liked extremely and disliked extremely), respectively according to the method of Iwe [22].

2.2.3. Physical Evaluation

2.2.3.1. Viscosity

The viscosity of the beetroot juice samples was determined with the aid of a Rotary Digital Viscometer (NDJ-85, China) using spindle number 2 at 60rpm. Thirty millimetres (30m1) of each juice sample was transferred into a 30m1 beaker, the content of each beaker was introduced directly into the rotating spindle and the values of the juice viscosity displayed on the Liquid Crystal Display (LCD) screen in pa.S and were recorded.

2.2.3.2. Ph

The pH of the juice samples was determined using a digital pH meter (model PHs-2f, USA). The pH meter was calibrated using buffer solutions of pH 4.0 and 7.0. Ten (10ml) of each juice samples was measured into a 10ml beaker. The electrode of the pH was placed into each juice sample and the pH was read on the LCD screen after sufficient time was allowed for stabilization.

2.2.3.3. Sugar

The hand held sugar refractometer, ATAGO (0-32^{o}Brix) was used for sugar determination. The prism of the refractometer was flushed with distilled water and dried. A drop of the juice was placed on the prism and closed. The sugar content percentage (soluble sugar) was red from the scale of the refractometer when held close to the eye.

2.2.4. Chemical Evaluation

The beetroot juice samples were analysed for moisture, ash, total solids and crude protein using the method outlined in AOAC [23]. Total available carbohydrate was determined using the Clegg Anthrone method as reported by Osborne & Voogt [24] with some modifications.

2.2.5. Mineral Compositions

Mineral composition of the juice samples analysed were nitrate, potassium, iron, calcium and magnesium using the Atomic Absorption Spectrophotometer, AAS (Model 372, Perkin – Elmer, Beaconsfield, U.K) by wet digestion according to AOAC [23] method.

2.2.6. Statistical Analysis

The method of Wahua [25] was used to analyse the data using one-way Analysis of Variance (ANOVA). All means were separated using Duncan New Multiple Range test and least significant difference at 5% probability level ($p>0.05$) using Statistical Package for Social Science (SPSS) version 20.0 software 2011 model.

III. Results and Discussion

3.1. Sensory Properties

Fruits and their juices have become an important part of modern diet as they play a significant role in a healthy diet, being rich sources of micronutrients and offering good refreshment. The result of the sensory evaluation of the beetroot juice samples showed that besides the sun dried sample which had significantly poorer taste ($p<0.05$) than the rest, the sensory attributes in all cases were the same in terms of flavour, colour, mouth feel and overall acceptability as presented in Table 1. The rating of the sensory attribute of flavour of the juice samples between 6.2 and above is an indication that beetroot has a great flavour. This is similar with the observation of Grubben & Denton [1] who reported beetroot as a flavouring agent. Banigo *et al.,* [17] also studied soy/carrot drinks flavoured with beetroot and reported the sensory attribute of flavour to be above 6.0 in all the samples. Since the overall acceptability scores of all the samples were around 7.0, the results showed that sun drying or oven drying can be an effective way of preserving beetroot for production of acceptable and refreshing drink for the masses and health conscious people [1]

Table 1: Sensory Attributes of Beetroot Juice

Sensory Attributes	Fresh juice sample	Sun dried juice sample	Oven dried juice sample
Taste	7.2^{a}	6.1^{b}	6.8^{a}
Flavour	6.6^{a}	6.2^{a}	6.5^{a}
Colour	7.2^{a}	7.5^{a}	7.6^{a}
Mouth feel	6.3^{a}	6.5^{a}	6.4^{a}
Overall acceptability	7.0^{a}	7.0^{a}	7.1^{a}

^{ab} Means with similar superscripts along the same row are not significantly different at 5% ($P < 0.05$) level of probability.

3.2. Physicochemical Properties

The result of the physical properties showed that the fresh juice sample had a total solid value of 9%, sun dried 8% and the oven dried juice sample 10% showing no significant difference (p>0.05) in the samples as depicted in Figure 2A. For the pH, the fresh juice sample had a pH value of 7.1; sun dried (7.0) and Oven dried juice sample with a pH value of 7.4. The result showed that drying methods did not significantly affect the pH value of all the beetroot juice samples. These values indicate that beetroot juice has a neutral pH when compared to some other fruit juices with either high or less acid value. Babajide *et al.,* [26] reported a pH range of 4.36 – 4.41 for spiced cucumber and pineapple drinks, Banigo *et al.,* [17] observed a pH range of 5.92 – 6.42 for soy/carrot/beetroot drinks and Emelike & Ebere [16] also reported fresh cashew apple juice with pH of 4.1. The difference in these reports is attributed to pineapple and cashew apples which are high acid fruits, while the different values reported by Banigo *et al.,* [17] could be as a result of the blends of soymilk and carrot fruit flavoured with beetroot. The viscosity of the juice samples were 0.2pa.S for the fresh juice, sun and oven dried samples 0.3pa.S each with no significant difference (p<0.05). In the viscosity, correlation is expected between the sugar content and the viscosity of the juice since a fluid with more sugar is thicker and has a higher viscosity [27]. The result here correlates as the oven dried juice sample with the highest total solid of 10% recorded the highest viscosity of 0.3pa.S. Banigo *et al.,* [17] also reported a correlation between total solid and viscosity of soy/carrot/beetroot drinks. Sugar content of 33.6%, 34.2 and 29.3% was observed in fresh juice sample, sun and oven dried juice samples, respectively with no significant difference in all the samples.

The result of the chemical properties showed that fresh juice sample contained 91% moisture, sun dried and oven dried beetroot juice samples had 92% and 90% moisture content, respectively as presented in Figure 2B. This falls within the range of 89 – 92% moisture content of soy/carrot/beetroot drink reported by Banigo *et al.,* [17]. Mbaeyi-Nwaoho & Nwachukwu [28] reported a range of 60 – 90.8% for yoghurt flavoured with beetroot. FAO [29] stated that the major component of fruits is water derived from the extra and intracellular fluids necessary for metabolic processes and maintenance of cell sugar. Juice consumption is one of the ways of taking water which is vital for the transportation of food, waste, digestion and regulation of body temperature. They are referred as after meal drinks or refreshing drinks during the dry season in rural and urban centres [17]. Fresh juice sample had ash content of 0.39%, sun dried 0.60% and oven dried juice sample had ash content of 0.52% and was not significantly affected when compared to the fresh juice sample. Protein value of 0.1% was observed in the fresh juice sample, sun dried 0.2%, oven dried juice sample 1.0% with no significant difference. Baniga *et al.,* [17] reported a range of 0.03 – 0.53% of crude protein for soy/carrot/beetroot drink. This is an indication that fruit juices are not good sources of protein. For the carbohydrate, fresh beetroot juice sample had carbohydrate value of 7.3%, sun dried sample 7.9%, oven dried juice sample with 9.1%. The graphical presentation of the result showed that drying methods (sun and oven drying) did not significantly influence (p<0.05) the chemical composition of the dried beetroot juice samples compared to fresh juice sample.

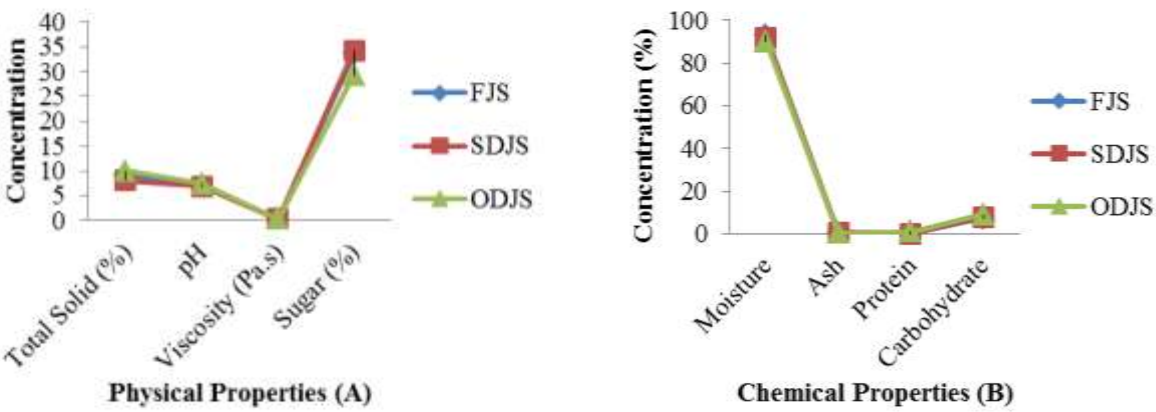

Figure 2A and B: Physicochemical Properties of the Beetroot Juice Samples

Key: FJS = Fresh juice sample, SDJS = Sun dried juice sample, ODJS = Oven dried juice sample

3.3. Mineral Compositions of the Beetroot Juice

Fruit juices are important sources of minerals and they play an important role in the diet of people in both developed and developing countries [30]. The result showed that nitrate content of the juice samples was not influenced by the methods of drying as depicted in Table 2. Oven drying method significantly increased the potassium value of the juice to 874.7mg compared to the fresh juice sample (228.4mg) with the least potassium value and showed significant difference ($p>0.05$) in all the juice samples. The fresh juice had the highest iron content (19.0mg); followed by oven dried sample with 15.5mg of iron and the sun dried 14.4mg. The sun drying method did not significantly affect the calcium content of the juice compared to the fresh juice sample. Magnesium value of the juice was increased by drying methods. Oven dried sample significantly increased to 99.2mg, sun dried sample increased to 50.3mg compared to the fresh juice with magnesium value of 33.2mg. The result indicate that drying methods significantly affects ($p<0.05$) all the mineral composition of the beetroot juice samples except nitrate values. Apart from the numerous medicinal, nutritional and health benefits of beetroot juice, the ban on the importation of fruit juices has made it imperative and profitable to engage in the extraction of juice from local raw materials and by extension, drying of the fruits with the objective of preserving the product for a longer time. Bates & Swain [31]; Achal [32] stated that preserved fruit juice commands a higher value and can be consumed more conveniently than whole fruits.

Table 2: Mineral Compositions of the Beetroot Juice

Mineral Compositions (mg)	Fresh juice sample	Sun dried juice sample	Oven dried juice sample
Nitrate	0.005^{a}	0.005^{a}	0.005^{a}
Potassium	228.4^{c}	325.0^{b}	874.7^{a}
Iron	19.0^{a}	14.4^{c}	15.5^{b}
Calcium	3.3^{c}	3.9^{c}	4.2^{b}
Magnesium	33.2^{c}	50.3^{b}	99.2^{a}

^{abc} Means with different superscripts along the same rows are significantly different at 5% ($P < 0.05$) level of probability.

IV. Conclusion

From the results, it can be concluded that drying methods applied in the production of beetroot juice showed no significant influence in terms of the sensory, physical and chemical properties of the juice compared to the fresh beetroot juice sample. For the mineral composition, drying methods significantly increased magnesium and potassium values of the juice samples, while a decrease in the value of iron was observed though oven drying preserved it more than sun drying method. There was no significant effect between the calcium content of the sun dried sample and the fresh beetroot juice sample.

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