Original Research Article

Influence of process time on the physicochemical, antinutrient and phytochemical properties of *Ficus capensis* Moracae vegetable drink

ABSTRACT

Aims: To determine the best process time and processing duration effects on the composition of the *Ficus capensis* drink (infusion).
Study design: Experimental design was based on completely randomized design (CRD)
Methodology: *Ficus capensis* (Moracae) leafy vegetable drink was processed by immersing the leaves in water (1:10) weight/liquid ratio. Three portions of samples were prepared and boiled separately in a stainless steel pot immersed in a water bath (temperature =100 ^{o}C) for 30, 60, and 90 min, respectively, and filtered. The samples were evaluated for proximate composition, minerals, phytochemicals, antinutrients, and physicochemical properties using standard methods.
Results: Protein, carbohydrate, and ash contents and energy value of the drink were affected differently by process times. Alkaloids, ascorbic acid, and calcium contents were lowest in samples processed by 90 min boiling. Drink processed by boiling the leaves for 60 min had the highest pro-vitamin A (12.51 mg/100ml), zinc (3.18 mg/100ml, flavonoid (18.4 g/100ml), and carotenoid (17.2 g/100ml), and 90 min processed drink had the highest vitamin B1 (0.35 mg/100ml) content. The iron contents ranged from 2.8-8.7 mg/100ml, and the values varied among different boiling times. Cyanide, phytate, and tannin contents decreased progressively as the processing times increased.
Conclusion: The nutrient contents of *Ficus capensis* (Moracae) drink were affected by process time, however, boiling the leave for 60 min was established as the best process time for the *Ficus capensis* vegetable drink processing.

Keywords: Ficus capensis drink, phytochemicals, vegetable, vitamins and minerals, process time

1. INTRODUCTION

Many Nigerian homes take leafy vegetables as an essential part of diets. Besides varieties, vegetables are valued sources of nutrients, particularly among rural communities. They contribute to nutrients (protein, mineral, vitamin, fibers among others) which are commonly in limited quantity in major staples [1]. Flavour, taste, colour, and aesthetic appeal are additional benefits to prevent making diets uninteresting. Vegetables are consumed as part of meals, snacks, and as drinks. They are rich in phytochemicals that possess antioxidant, antibacterial, antifungal, antiviral, and anticarcinogenic properties [2]. Bio-active components present in vegetables exhibit the capacity to modulate one or more metabolic processes and better health promotion. Vegetable drink like fluted pumpkin possesses health benefits [3].

Ficus capensis Moracae 'akukoro' is the specie of the *Ficus* plant from the family Moraceae and is found in the eastern part of Nigeria where it is popularly referred to as "Akukoro" by the Igbos. It is also common in terrestrial zones along rivers. *Ficus capensis* has widespread roots and produces fruits all year round with broad green leaves [4]. *Ficus* vegetable is used for preparing yam sauce, garnish stew, and soup. In communities where it is a relish, the drink is a remedy for malaria, cough, sour throat, and diarrhea for individuals with such ailments and stomach pain in babies showcasing its nutrceutical potential. Some communities claim that *Ficus capensis* drinks rapidly increased the hemoglobin levels in the treatment of anemia. *Ficus capensis* drink is traditionally consumed partly as blood tonic when prepared as an infusion. Vegetable drink is processed using heat treatment such as cooking or boiling, the processes which may have beneficial or detrimental effects on their constituents. Long-period processing with heat has detrimental effects on the compositions of vegetables and their infusion [7,8]. *Ficus capensis* drink is produced traditionally by boiling the leaves in water for an upward of 2 hours for maximal hue extraction. The processing time may alter the nutritional properties of vegetable drinks [5]. Camel *et al.* noted that the creation of consumer awareness concerning the health benefits of different food nutrients resulted in the need to evaluate food processing conditions and effects on the product quality [6]. A paucity of information exists on the processing time effect on the composition of the *Ficus capensis* drink which was the main thrust of this work.

2. MATERIAL AND METHODS

2.1 Procurement of raw materials

The fresh leaves of *Ficus capensis* Moracae 'Akukoro' were collected from farmland in Enugu Ezike in Igbo Eze North Local Government Area in Enugu State, Nigeria. The leaves were identified in the Department of Botany, University of Nigeria, Nsukka.

2.2 Preparation of sample

The destalked *Ficus capensis* leaves were sorted to remove the immature, insect-infested as well as extraneous materials. The *Ficus capensis* leaves were washed, rinsed in excess water and drained. The leaves were divided into 3 lots with each weighing 200 g. Each lot (leaves of *Ficus capensis*) was transferred separately into 3 different stainless steel pots and equal volume of water was added (1:10 w/v ratio) boiled for different time (30, 60, and 90 min) at a temperature of 100^{o}C maintain in a water bath. Stop watch was used to measure the process time.

2.3 Analyses

2.3.1 Proximate composition and energy value determination

The drink was filtered into separate bottles, labeled and kept for analysis. The proximate composition (moisture, protein, fat, fibre and ash) of the drink were determined by AOAC methods; carbohydrate was estimated by difference (100 – (% protein + % ash + % fat + % crude fibre + % moisture) [9]. The energy was calculated using Atwater's conversion factors (4 x protein, 9 x fat and 4 x carbohydrates).

2.3.2 Selected Vitamins and Mineral content determination

Selected vitamins (A, B1 and C) contents were determined by AOAC methods and minerals (calcium, iron, and zinc) content of the samples were determined spectrophotometrically with Atomic absorption Spectrophotometer as described by AOAC [9].

2.3.3. Physicochemical content determination

The drinks' specific gravity was determined with a specific gravity bottle and calculated as described by Ishiwu and Oluka [10]. A pH meter was used to determine the pH of the drinks. Titratable acidity was determined as percentage malic acid according to AACC [11] method.

2.3.4 Selected phytochemicals and antinutrient content determination

The antinutrient (phytate and tannin) contents of the drink were determined according to Pearson [12] while the cyanide content was analyzed using the methods as described by Onwuka [13]. The phytochemicals (flavonoids and alkaloids) contents were determined according to the gravimetric method of Harbone [14] while carotenoids analysis was carried out as described by Onyeka and Nwambekwe[15].

2.4 Experimental design and Data analysis

The experimental design was Completely Randomized design (CRD). All the data collected were analyzed using a one-way analysis of variance (ANOVA) and mean separation was by Least Significant Difference (LSD)[16].

3. RESULTS AND DISCUSSION

3.1. Effect of process time on the proximate composition of *Ficus capensis* drink

Table 1 shows the proximate composition of *Ficus capensis* drink processed by boiling the whole leaves for 30, 60 and 90 min. The moisture content of the drink ranged from 92.78- 93.84%. Drink processed by boiling leaves for 30 min (WBF30) recorded the highest moisture content (93.84%). Expectedly, reduction of moisture content was observed in drinks processed by longer boiling time. The decrease in moisture content with increased process time is expected and is attributable to evaporation of moisture caused by application of heat and increased total solid content. The moisture content in all the treatments was found to be within the range of 90.96% specified by Food and Agricultural Organization [17] for a drink.

Table 1: Proximate Composition of *Ficus capensis* drink processed by boiling the whole leaves at different time intervals

Constituent (%)	WBF_{30}	WBF_{60}	WBF_{90}	LSD
Protein	$2.18^{c}\pm 0.01$	$1.92^{b}\pm 0.14$	$1.81^{a}\pm 0.01$	0.05
Moisture	$93.84^{c}\pm 0.06$	$92.99^{b}\pm0.01$	$92.78^{a}\pm0.08$	0.19
Ash	$0.41^{c}\pm 0.00$	$0.36^{b}\pm 0.01$	$0.29^{a}\pm 0.01$	0.02
Carbohydrate	$3.58^{a}\pm 0.04$	$4.73^{b}\pm 0.04$	$5.11^{c}\pm 0.06$	0.14
Energy(Kcal/100ml)	$23.04^{a}\pm 0.04$	$26.60^{b}\pm0.4$	$27.68^{c}\pm0.04$	0.20

Results are mean of three replications ± SD. Values carrying different super scripts along the same row are significantly (p=<.05) different. Key: WBF_{30} = drink processed by boiling the whole leaves for 30 min; WBF_{60}= drink processed by boiling the whole leaves for 60 min; WBF_{90} = drink processed by boiling the whole leaves for 90 min.

Carbohydrates and crude protein were present in the drink though in small amount. WBF90 had the highest carbohydrate content (5.11%) and WBF30 had the least carbohydrate content (3.58%) convesrly WBF30 recorded the highest protein while WBF90, the least. Longer process time caused significant ($p<0.05$) increase in the carbohydrate content and reduction in protein content. The increase observed in carbohydrate content in sample boiled beyond 30 min could be due to increased softening of the cell tissues and particle hence their inclusion into the process water and/or due to loss in moisture content or reduction of other components [18]. A decrease in the protein content as process time increase was attributable to thermal degradation of the proteins and reduced protein solubility due to coagulation. This may affect the amount of protein that leached into the liquid thereby reduction on the protein content of the drink. Ajala reported that the protein content of *Solanum nigrum* and *Solanecio biafrae* reduced to 3.68 and 2.98%, respectively after boiling for different periods and attributed it to cellular protein denaturation and release of chlorophyll bound to protein [19]. Such free chlorophyll is highly unstable and is readily converted to pheophytin which is olive green to brown in colour [20].

No crude fat and fibre contents were detected in each of the treatments. Absence of fat in the drink is an indication that leafy vegetables used as the base material for the drink production is not a good source of fat [21] and/or effect of processing on fat. Uzodinma *et al.* reported a significant reduction of fat content of tamarind seed flour processed by boiling the seeds in water and attributed the observation to heat treatment applied[22].Ash content of the drink varied from 0.29-0.41%. Fibre was undetected in the infusion probably due to no size reduction and/or due to filtration which may have removed most if not all the fibrous materials. Vegetables are consumed for their fibre content which is important in the human system when consumed through diets and could decrease bad cholesterol (LDL) levels and coronary heart disease risk among others [23]. Dietary fibre promotes beneficial effects including laxation and regulates bowel movements [24]. Size reduction as a unit operation in *Ficus capensis* drink processing is suggested as a way of improving the fibre content of the drink. *Ficus capensis* drinks produced by boiling for 30 min (WBF30) had the highest ash content (0.41%). Higher process time led to reduction of the ash content of the drink. The presence of ash connote that the drink contain minerals as ash in an index of available minerals. The progressive reduction in ash with increased process time may be due to the formation of surface coat on the stainless steel pot use for processing.

3.2 Effect of process time on vitamins and mineral contents of the drink

Table 2 present the results of vitamin C, A (calculated as retinol equivalent) and B1contents of *Ficus capensis* drink processed by boiling the whole leaves for 30, 60 and 90 min.

Table 2: Selected vitamin and micronutrient contents of *Ficus capensis* drink process at different boiling time

Constituent (mg/100ml)	**WBF_{30}**	**WBF_{60}**	**WBF_{90}**	**LSD**
Vitamin C	$17.40^{c} \pm 0.01$	$16.92^{b} \pm 0.01$	$13.54^{a} \pm 0.07$	0.15
Vitamin A(mgRE/100ml)	$7.45^{a} \pm 0.07$	$12.51^{c} \pm 0.01$	$10.46^{b} \pm 0.08$	0.19
Vitamin B_1	$0.16^{a} \pm 0.01$	$0.28^{b} \pm 0.00$	$0.35^{c} \pm 0.00$	0.20
Calcium	$27.07^{a} \pm 0.32$	$20.78^{b} \pm 0.39$	$18.66^{c} \pm 0.21$	1.00
Iron	$2.80^{a} \pm 0.01$	$8.70^{c} \pm 0.04$	$5.10^{b} \pm 0.01$	0.19
Zinc	$1.69^{a} \pm 0.03$	$3.18^{c} \pm 0.09$	$2.90^{b} \pm 0.03$	0.18

Results are mean of three replications ± SD. Values carrying different super scripts along the same row are significantly($p<0.05$) different. Key: WBF_{30} = drink processed by boiling the whole leaves for 30 min; WBF_{60}= drink processed by boiling the whole leaves for 60 min; WBF_{90} = drink processed by boiling the whole leaves for 90 mi**n**.

Vitamin C (ascorbic acid) content of the drink varied from 13.54-17.40 mg/100ml. The processed drink had an appreciable quantity of vitamin C and increase in process time decreased the vitamin C content of the drink. An appreciable quantity of vitamin C in the drink indicates that *Ficus capensis* vegetable was rich in vitamin C. Exceeding process time of 30 min resulted in 2.76-22.18% reduction in vitamin C which is attributable to oxidation caused by prolonged heating. High vitamin C losses of up to 57 and 83% for fresh green leaves of *Amaranthus hybridus* boiled for 5 and 20 min, respectively were reported by Mathooko and Imungi [25]. These results corroborate with the report of Bello and Fowoyo [8] that prolong boiling of bitter leaf and pumpkin leaf juice led to appreciable loss of vitamin C content which was more as the time of boiling increased. López-García *et al.* reported that vitamin C is heat and light sensitive; it can be readily oxidized when exposed to high temperatures over a long period [26].

Vitamin A content (calculated as retinol equivalent) ranged from 7.45-12.51 mgRe/100ml. Vitamin A (as retinol equivalent) was seen to increase as the process time increased to 60 min with the value of 12.51 mg/100ml, and then decreased by 16.39% when processed time reached 90 min. Vitamin B1 (Thiamin) content of the samples ranged from 0.16-0.35 mg/100ml. The content of vitamin B1 increased as the process time increased and the values ($P<.05$) differed among the process time. The content of vitamin B1 increased as the boiling time increased and the values differed among the process time. Thiamin is readily soluble in water and stable at cooking temperature compared to ascorbic acid especially in slightly acid solution [27]. Calcium content ranged from 18.66 to 27.07 mg/100ml. More calcium content (27.07 mg/100ml) was observed in sample processed by 30 min (WBF30) and value later decreased progressively as the process time increased. The gradual reduction of calcium value with increased process time may be attributed to the formation of coat on the surface of the pot by calcium. Decrease in solubility of calcium carbonate, encourages its precipitation and deposit on the cooking utensil. Significant ($P<.05$) differences exist in the iron contents among the treatments. The drink produced by boiling the leaves for 60 min (WBF60) contained more iron (8.7 mg/100ml) compared to 30 and 90 min. The increase in iron content from 0.26-0.35 mg/100ml may be due to leaching of soluble iron into the boiling water. Yadav and Sehgal reported that longer blanching time increased ironizable iron and available (soluble) iron from 6.47 to 7.74% and 3.53 to 4.13% between 5 to 10 min and attributed the increase to reduction of oxalic acid, phytic acid and polyphenolics by blanching process [28]. In several studies, cooking was shown to both increase and decrease the mineral content in green leafy vegetable [29,30] and the discrepancies found in the mineral content during cooking were ascribed to differences in duration of cooking. This could account to the variation of iron content observed in the study. The level of iron observed in the present study explained the traditional preference of using *Ficus capensis* drink to boost haemoglobin levels in human treatment of anaemia since iron has an important role as a constituent of hemoglobin [17]. Zinc content of the drink followed the same trend as iron. The zinc value of the drink varied from 1.69-3.18 mg/100ml. WBF60 had the highest zinc content (3.18 mg/100ml) while (WBF30) had the least. The high zinc value in the drink is of interest as zinc is one of the micronutrients that is deficient in most populations. Zinc deficiency affects on the estimate 68% of the population in Sub-Saharan Africa [31]. Consumption of the extracts would help to meet the recommended daily Allowance (RDA) of 3 mg of zinc for a certain age (infant- 7-12 months (2 mg) and toddlers- 1- 2 years (3 mg) of the population and between 79.5 and 24.3 – % of RDI of children between 4 and 18, respectively [32]. Dark-green leafy vegetables have been listed as suitable alternatives to increase zinc intake for vegetarian infant. Zinc is necessary for protein and blood formation and to maintain vitamin A concentration in plasma and also essential for growth, neurobehavioral development, reproduction, antioxidant protection, membrane stabilization, immune and sensory function [33].

3.3 Effect of process time on physicochemical properties of *Ficus capensis* vegetable drink

Titratable acidity (as percent malic acid) (Table 3) ranged from 0.02-0.06%. The titratable acidity was highest in the sample processed by 30 min (WBF30) and decreased as boiling time increased. The pH values ranged from 5.2-6.0 with WBF90 having the highest value. The drink (WBF90) with the lowest titratable acid had the highest pH as pH is inversely related to acidity. Isolated pure alkaloids and their synthetic derivatives are potent analgesic, antispasmodic and bactericidal agents [34]. The rich flavonoids content of the drinks may confer antibacterial, anti-inflammatory, anti-allergic, anti-mutagenic, antiviral, antineoplastic, anti-thrombotic, vasodilatory activity and the superoxide anions, lipid peroxy and hydroxyl radicals scavenging ability as reported by various authors[34,35]. The specific gravity of the drink was similar (0.99) in all the treatments hence were not affected by the process time.

Table 3: Physicochemical properties of *Ficus capensis* vegetable drink processed at different boiling time

Parameter	WBF_{30}	WBF_{60}	WBF_{90}	LSD
%Titrable acidity (malic)	$0.06^{a} \pm 0.00$	$0.03^{a} \pm 0.01$	$0.02^{a} \pm 0.00$	0.00
pH	$5.2^{a} \pm 0.00$	$5.70^{b} \pm 0.00$	$6.00^{c} \pm 0.00$	0.12
Specific gravity	$0.99^{a} \pm 0.00$	$0.99^{a} \pm 0.00$	$0.99^{a} \pm 0.00$	0.00

Results are mean of three replications ± SD. Values carrying different super scripts along the same row are significantly($p < 0.05$) different. Key: WBF_{30} = drink processed by boiling the whole leaves for 30 min; WBF_{60}= drink processed by boiling the whole leaves for 60 min; WBF_{90} = drink processed by boiling the whole leaves for 90 min.

3.4 Effect of process time on selected phytochemicals and antinutrient content of *Ficus capensis* drink

The results of the selected phytochemical and antinutrient contents of *Ficus capensis* vegetable drinks as affected by process time are presented in Table 4. The result showed that the processed *Ficus capensis* drink was rich in alkaloid, flavonoid and carotenoids. The alkaloid content of the drink ranged from 2.24-3.62 g/100ml. Highest alkaloid content (3.62 g/100ml) was observed in drink produced by 30 min boiling (WBF30) which decreased as process time increased to 90 min. The flavonoid content ranged from 0.99-1.84 g/100ml. Sample produced by boiling for 60 min (WBF60) recorded the highest flavonoid content (1.84 g/100ml) while WBF90 had the least flavonoid content. The carotenoid content ranged from 1.02-1.72 g/100ml. The drink processed by boiling the leaves for 60 min had the highest (1.72 g/100ml) carotenoid. Anti-nutrients are valuable active ingredients in food and drinks when used at low levels [36]. Process time has a reduction effect on all the anti-nutritional factors analyzed. WBF30 recorded the highest phytate content (0.13 mg/100ml) which decreased with increase in process time. Tannin occurred at a level of 1.64 mg/100ml in the drink processed by boiling for 30 min which was undetected with an increase in process time to 60 and 90 min. Plant tannins, a major group of antioxidant polyphenols found in food and beverages has multifunctional properties to human health. Tannins among other antinutrients have potential antiviral, antibacterial and anti-parasitic effects [36, 37]. The cyanide content ranged from 0.21-0.75 mg/100ml and the drink processed by 30 min boiling had the highest cyanide content. The decrease in cyanide content with increased process time and subsequent absence in 60 and 90 min processed sample may be attributed to the volatility of cyanide at high temperature (100 ^{o}C) and/or prolonged time since cyanide is a volatile compound. High concentrations of hydrogen cyanide can be very poisonous to human health if consumed [38].

Table 4: Phytochemical and antinutrient contents of *Ficus capensis* drink processed at different stage of boiling

Constituent	WBF_{30}	WBF_{60}	WBF_{90}	LSD
Alkaloids (g/100ml)	$3.62^{c} \pm 0.11$	$2.57^{b} \pm 0.06$	$2.24^{a} \pm 0.00$	0.23
Flavonoids (g/100ml)	$1.03^{a} \pm 0.00$	$1.84^{b} \pm 0.06$	$0.99^{a} \pm 0.00$	0.12
Carotenoids(g/100ml)	$1.02^{b} \pm 0.07$	$1.72^{c} \pm 0.54$	$1.48^{a} \pm 0.40$	0.01
Phytate (mg/100ml)	$0.13^{a} \pm 0.00$	$0.09^{a} \pm 0.00$	nd	0.00
Tannins (mg/100ml)	1.64 ± 0.03	nd	nd	0.00
Cyanide (mg/100ml)	$0.75^{b} \pm 0.57$	$0.31^{a} \pm 0.01$	$0.21^{a} \pm 0.01$	0.12

Results are mean of three replications ± SD. Values carrying different super scripts along the same row are significantly ($p< =0.05$) different. Key: WBF_{30} = drink processed by boiling the whole leaves for 30 min; WBF_{60}= drink processed by boiling the whole leaves for 60 min; WBF_{90} = drink processed by boiling the whole leaves for 90 min. nd= none determined

4. Conclusions

This work had shown that duration of boiling affects the properties of *Ficus capensis* vegetable drinks. Tannins, phytate and cyanide contents were low in the processed drinks. Boiling the vegetable leaf for 60 min gave the highest pro-vitamin A, iron, zinc, flavonoid, carotenoid, vitamin C, calcium, and alkaloid contents suggesting 60min as the best length of time to process the drink. The rich micronutrient (iron, zinc and vitamin A) and phytochemical contents show that the drink could help in ameliorating certain deficiencies in the area where these products are consumed.

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