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Blanching and Juicing Effect on Flavonoids Contents in Commonly Consumed Leafy Vegetables in South West Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author BAS designed the study, wrote the protocol and wrote the first draft of the manuscript. Author KTO managed the literature searches, analyses of the study performed the spectroscopy analysis and author AKA managed the experimental process and author CBA identified the species of plant. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This study investigated the flavonoids level, and effect of blanching and juicing on commonly consumed vegetables in South West Nigeria.
Place and Duration of Study: Chemical sciences, Redeemers University, January to March, 2013.
Methodology: Ten green leafy vegetables were obtained in four major markets in South West Nigeria. Each vegetable was thoroughly mixed and rinsed then divided into three groups, which are fresh, blanched and juice groups with four replicates per group. Flavonoids content were analyzed using standard laboratory methods.

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Results: A varying order was observed in flavonoids content of fresh vegetable with highest value observed in *Hibiscus esculenta* and the lowest in *Crassocephalum ruben*. Blanching changes the flavonoids content in some vegetables with highest value in *Amaranthus viridis* and lowest in *Basela rubra*, while juicing concentrated the flavonoids in some vegetable and at the same time reducing it in some. However, highest value was observed in *Hibiscus esculenta* and lowest in *Colocasia esculenta*.
Conclusion: Variation was observed in flavonoids content of fresh vegetables while processing method; blanching and juicing either reduce or increase the flavonoids content.

Keywords: Processing; vegetable; blanching; juicing; antioxidant and flavonoid.

1. INTRODUCTION

Nutrients and other phytochemical constituents in plants tissues have attracted attention of scientists involved in Food Science and Technology partly due to their antioxidants, anti-inflammatory, antimutagenic, anticancer, antibacterial and antiviral potentials [1]. More so, considerable evidences have shown that adequate consumption of fruit and vegetable rich diets have substantial role in reducing the risk of chronic diseases [2] including cardiovascular disease, diabetes as well as other diseases related to ageing [3]. These plants based health benefits are mediated by the synthesis of certain secondary metabolites such as terpenoids, alkaloids and polyphenols [4]. The protective effect of flavonoids has been proven in-vitro and in-vivo [5]. They inhibit the oxidation of lipids and some enzymes activities including influence of the formation and transformation of peroxyl radicals [6] as well as chelation of transition metal ions [7].

Evidences abound of the protective role of dietary flavonoids against coronary heart disease and central nervous system disorder like dementia [8]. Due to the antioxidants potentials of flavonoids, consistent as well as long term consumption of wine, beverages, foods, vegetables and other flavonoids rich plants products have helped in reducing the incidences of osteoporosis, thrombogenic disorders and atherosclerosis. More so, flavonoids protect DNA against free radicals, modulate inflammation as well as platelet aggregation [9]. However, its metabolites were not without complications in people. For instance, consumption of catechin generate such metabolite that binds tightly to erythrocyte membranes and form new antigenic sites which resulted in the development of autoantibodies that may cause hemolytic anemia [10]. Flavonoids have been reported to influence the metabolism of ascorbic acid [11,12].

Vegetables present one of the most common and cheapest rich sources of flavonoids [13]. They however undergo varieties of processing methods which include sun-drying, boiling, freezing, salting, blanching and juicing [14]. These processes could improve their palatability and bioavailability relative to phytochemicals and nutrients, and preservation as well as removing microbes and other toxins [15]. In spite of the ample documentation of various processing methods and their effects, there is dearth report as regards the content and effect of processing methods on flavonoids constituents of some local vegetables commonly consumed in South Western Nigeria. Therefore, this study investigated the flavonoids level, and effect of blanching and juicing on commonly consumed vegetables in South West Nigeria.

2. MATERIALS AND METHODS

Vegetables used for this research work were sourced from major markets in Ago-iwoye, Ikenne and sagamu, in Ogun state and Ketu in Lagos state, Nigeria. The weight of the samples ranged between 1 to 5 kg; identified at the herbarium of the plant science and zoology department, Olabisi Onabanjo University.

2.1 Sample Preparation

The vegetables were destalked to remove the inedible part; afterwards samples of each specimen (two from each market) were mixed together and divided into four. Each group was further grouped into three subgroups: Fresh, juiced and blanched.

2.1.1 Blanching

This process was done by putting 200 g of vegetables in 500 ml of boiled water and it was allowed to stay for five minutes. The vegetables were removed and then drained before analysis.

2.1.2 Juicing

This was done by using master chef juice extractor (model no: mc-J2101). The juice and pulp were collected separately and the pulp was discarded [14].

2.2 Sample Analysis

2.2.1 Quantitative analysis of flavonoids

Flavonoid in the test sample was determined by the acid hydrolysis of spectrophotometric method. 0.5 g of processed plant sample was mixed with 5 ml of dilute HCl and boiled for 30min. The boiled xtract was allowed to cool and filtered. 1 ml of the filtrate was added to 5ml of ethyl acetate and 5 ml of 1% NH_3. This was then measured in spectrophotometer at 520nm wavelength for the absorbance [16].

2.2.2 Moisture content

The moisture content of 10 g of each sample was determined. This was done by taking 10 g of each sample from each replicate (4 samples) into a 200 ml crucible and then it was dried in oven at a temperature of 105ºC for 24 hour.

3. RESULTS AND DISCUSSION

Table 1 shows flavonoids content in fresh vegetables, highest flavonoids content was observed in *Hibiscus esculenta* (222.36±8.29 mg/100 g dry weight) and it is significantly higher ($p<0.05$) than other vegetables investigated. The decreased order of flavonoids content was observed for *Hibiscus esculenta, Corchorus oliterus, Amaranthus spp., Basela rubra, Piper guineesis, Colocasia esculenta, Manihot esculenta, Amaranthus viridis, Ipomoea batatas and Crassocephalum ruben respectively.* No significant ($p>0.05$) difference was observed between *Corchorus oliterus, Amaranthus spp., Basela rubra.* Also, no significant difference ($p>0.05$) was noticed among *Piper guineesis, Colocasia esculenta, Manihot esculenta, Amaranthus viridis and Ipomoea batatas. Crasssocephalum ruben* was significantly ($p<0.05$) lower than other vegetables investigated except for *Amaranthus viridis*, *Ipomoea batatas* and *Manihot esculenta*.

Shown in Table 2 are flavonoids content in blanched vegetables; *Amaranthus viridis* (870.13±115.19 mg/100 g dry weight) contains the highest flavonoids and it is significantly ($p<0.05$) higher than other vegetables studied. A decreasing trend of flavonoids content was observed for *Amaranthus viridis*, *Crassocephalum ruben*, *Amaranthus spp.*, *Manihot esculenta*, *Hibiscus esculenta*, *Corchorus oliterus*, *Colocasia esculenta*, *Ipomoea batatas*, *Piper guineesis* and *Basela rubra*. No significant differences ($p>0.05$) were observed between *Hibiscus esculenta*, *Corchorus oliterus*, *Colocasia esculenta*, *Ipomoea batatas*, *Piper guineesis* and *Basela rubra*. Lowest value was observed in *Basela rubra* though not significantly ($p>0.05$) different from *Piper guineesis*, *Ipomoea batatas* and *Corchorus oliterus*.

Table 3 revealed flavonoids content in juice extracts of vegetables; *Hibiscus esculenta* contains the highest (1050.10±113.03 mg/100 g dry wt.), while the lowest was observed in *Colocasia esculenta* (56.75±5.07 mg/100 g dry wt.), whereas no significant difference was observed in other juiced vegetables investigated. Shown in Table 4 is the percentage difference of flavonoid from fresh leafy vegetable as a result of blanching and juicing. Percentage reduction in flavonoids content was observed in blanched and juiced *Colocasia esculenta and Corchorus oliterus* when compared with their corresponding fresh leafy vegetables. On the other hand, percentage increase was recorded in *Amaranthus spp., Amaranthus viridis, Crassocephalum ruben and Manihot esculenta* as a result of the two processing methods, while others such as *Ipomoea batatas, Piper guineesis, Basela rubra and Hibiscus esculenta* increased as a result of juicing but decreased due to blanching effect.

4. DISCUSSION

Distribution of flavonoids in plants kingdom as well as plants tissues differs. Though, the structure and the concentration of flavonoids are strongly associated with varying factors ranging from biotic like genetics and predation to abiotic such as temperature, pollution, soil contents and weather condition [4]. The synthesis of flavonoids in plants is primarily meant for protection against ultraviolet radiation [4], self-defense against predation and parasitism [17] as well as repair of damaged tissues [4]. Antioxidant capacity of flavonoids in fruits and vegetables may be influenced by these aforementioned variables. During hormonal biosynthesis, flavonoids apparently modulate colour and palatability of several plant tissues [18]. This present study revealed a range of concentration of flavonoids in fresh, blanched and juice extracts of green leafy vegetables commonly consumed in South West Nigeria. The flavonoids content in fresh vegetables were observed to range between 56.75±5.07 mg/100 g dry weight in *Colocasia esculenta* to 1050.10±113.03 mg/100 g dry weight in *Hibiscus esculenta*. Variation in flavonoids content in fresh vegetable has been linked to factor such as genetic differences [18]. The protective ability of flavonoids against organic toxin from microbes [19,20] and inorganic toxic agents from the environment is a key factor in the adaptive features of plants. Flavonoids achieve this task by forming complexes with ions and other oxidizing intermediates; chelating heavy metal and inhibiting enzymes such as oxidases [21].

Blanching, a brief exposure of vegetables to high temperature alters the constituents of plants tissues [13]. This includes substances such as oxalic acid which increased in sweet potatoes but decreased in cabbage [22]. From the reports obtained, blanched *Amaranthus viridis* contained highest flavonoids content (870.13±115.19 mg/ 100 g dry weight), while the lowest was recorded in *Basela rubra* (36.36±11.28 mg/ 100 g dry weight). As observed in this study, blanching increased flavonoids content in four of the vegetables while it decreased it in others when compared with the fresh of the corresponding vegetables except for *Ipomoea batatas* which showed no significant (p>0.05) change. Though flavonoids are altered by change in temperature however the thermal effect may vary with respect to the structural properties of the compound and matrix of the tissue.

The varying effect of blanching process observed in this study was similar to that observed by Ganiyu [23] where blanching significantly increased total phenol content in green leafy vegetables except in *Amaranthus cruentus* and *Vernonia amygdalina*. According to Gemma [24], quercetin and kaempferol contents of strawberry were stable at temperature up to 90ºC while naringin, rutin, quercetin and naringenin contents in grapefruit reduced all indicating variation in phytochemical content in plants during processing [4]. But temperature of about 70ºC allows substantial increase in flavonoid content in apple [22]. In addition, roasting at 130ºC for 33 minutes increased phenol content of cashew and peanuts [25]. Though, there are different factors that can influence thermal effects on flavonoids contents in plants tissues but the structural variation of the type of flavonoids seemed to play a prime role [4]. Thus, thermal effect occasioned by blanching may vary due to structural differences in flavonoids.

Juicing, mechanically concentrates plants tissues constituents such as vitamins, minerals and other phytochemicals. It also improves bioavailability of these constituents. In this study, juicing increased flavonoids contents in all the vegetables except in *Colocasia esculenta* and *Basela rubra*. Study has established that cutting which is a mechanical force similar to juicing increased flavonol content in fresh cut-potatoes [26]. This could be that plants tissues tend to re-organize due to mechanical force exerted during juicing as injury thereby producing more flavonoids [26,27].

Table 1. Flavonoids content of fresh leafy vegetable

Botanical names	English/ local names	Flavonoids contents (mg/100 g dry wt.)	Moisture contents
Amaranthus spp.	Joy weed/ Ebiden	112.03±15.47^{b,c}	85.20±0.41^{c,d}
Crassocephalum ruben	Ebolo	54.70±6.19^{a}	87.13±0.22^{d,e}
Amaranthus viridis	Amaranth / Tete	73.40±6.65^{a,b}	83.52±0.08^{a,b}
Ipomoea batatas	Sweet potatoes leaf / Ewe odukun	66.27±12.87^{a,b}	86.13±0.25^{c,d}
Manihotesculenta	Cassava leaf/ Ewe paki	81.16±6.80^{a,b}	85.08±1.33^{c}
Piper guineesis	Uziza	98.13±6.50^{b,c}	85.33±0.65^{c}
Colocasia esculenta	Cocoyam leaf/ ewe koko	86.56±5.03^{b}	85.52±0.58^{c}
Corchorus oliterus	Jute plant / Ewedu	138.57±30.75^{b,c}	82.98±0.60^{c}
Basela rubra	Amunututu	104.71±0.68^{c}	91.50±0.00^{f}
Hibiscus esculenta	Okra leaf / Ewe ila	222.36±8.29^{d}	85.73±0.43s^{e}

Results presented are mean ± SEM (n = 4); values in the same column with the same superscript are not significantly different from each other (P > 0.05)

Table 2. Flavonoids content of blanched leafy vegetable

Botanical names	English/ local names	Flavonoid contents (mg/100g dry wt.)	Moisture contents
Amaranthus spp.	Joy weed/ Ebiden	366.44±47.70[d]	86.10±0.49[c]
Crassocephalum ruben	Ebolo	505.04±22.40[d]	89.00±0.08[d]
Amaranthus viridis	Amaranth / Tete	870.13±115.19[e]	87.65±1.76[d]
Ipomoea batatas	Sweet potatoes leaf / Ewe odukun	61.17±8.92[a,b]	85.93±0.43[b,c]
Manihot esculenta	Cassava leaf/ Ewe paki	354.78±12.66[d]	78.13±0.61[a]
Piper guineesis	Uziza	58.63±5.47[a,b]	87.78±0.35[c,d]
Colocasia esculenta	Cocoyam leaf/ ewe koko	66.56±2.07[b]	85.88±0.69[b,c]
Corchorus oliterus	Jute plant / Ewedu	86.41±20.33[a,b,c]	87.03±0.41[c,d]
Baselarubra	Amunututu	36.36±11.28[a]	83.35±1.58[b]
Hibiscus esculenta	Okra leaf / Ewe ila	131.55±18.13[c]	83.30±0.31[b]

Results presented are mean ± SEM (n = 4); values in the same column with the same superscript are not significantly different from each other (P > 0.05)

Table 3. Flavonoids content of leafy vegetable juice extract

Botanical names	English/ local names	Flavonoids contents (mg/100g dry wt.)	Moisture contents
Amaranthus spp.	Joy weed/ Ebiden	163.47±15.12[b]	95.23±0.46[b,c,d]
Crassocephalum ruben	Ebolo	226.92±35.05[b]	96.33±0.39[c,d]
Amaranthus viridis	Amaranth / Tete	119.90±15.51[b]	93.35±0.09[b]
Ipomoea batatas	Sweet potatoes leaf / Ewe odukun	195.91±37.94[b]	95.70±1.02[c,d]
Manihot esculenta	Cassava leaf/ Ewe paki	216.32±68.43[b]	95.20±1.34[b,c,d]
Piper guineesis	Uziza	195.49±28.57[b]	95.07±0.52[b,c]
Colocasia esculenta	Cocoyam leaf/ ewe koko	56.75±5.07[a]	86.68±0.70[a]
Corchorus oliterus	Jute plant / Ewedu	113.07±12.95[b]	93.50±0.79[d,e]
Basela rubra	Amunututufunfun	254.13±24.74[b]	97.35±0.19[d,e]
Hibiscus esculenta	Okra leaf / Ewe ila	1050.10±113.03[c]	98.93±0.05[e]

Results presented are mean ± SEM (n = 4); values in the same column with the same superscript are not significantly different from each other (P > 0.05)

Table 4. Percentage difference of flavonoid from fresh leafy vegetable

Botanical names	English/ local names	Percentage difference in blanched (%)	Percentage difference in Juice (%)
Amaranthus spp.	Joy weed/ Ebiden	227.09	45.92
Crassocephalum ruben	Ebolo	823.29	314.84
Amaranthus viridis	Amaranth / Tete	1085.46	63.35
Ipomoea batatas	Sweet potatoes leaf / Ewe odukun	(7.70)	195.62
Manihot esculenta	Cassava leaf/ Ewe paki	337.14	166.54
Piper guineesis	Uziza	(40.25)	99.22
Colocasia esculenta	Cocoyam leaf/ ewe koko	(23.11)	(34.44)
Corchorus oliterus	Jute plant / Ewedu	(37.64)	(18.40)
Basela rubra	Amunututu	(65.28)	142.70
Hibiscus esculenta	Okra leaf / Ewe ila	(40.84)	372.25

Values in brackets are negatives (-)

Therefore, blanching and juicing alter the constituent and concentrations of flavonoids in green leafy vegetables in similar manner either by increasing the flavonoids content as seen in *Amaranthus spp, Crassocephalum ruben, Amaranthus viridis* and *Manihot esculenta* or decreasing as observed in *Colocasia esculenta* and *Corchorus oliterus*. These two processing methods may also affect the flavonoids content of certain green leafy vegetable in an inconsistent manner. This was observed in *Hibicus esculenta, Basela rubra, Piper guineesis* and *Ipomoea batatas.* The possible reason for the increase in flavonoids' content in juice extracts of vegetables could be in part due to the release of certain flavonoids caused by mechanical force exerted during the process [26,27] and concentration of such. Hydrogen bonding contributes to the bonds exercised by flavonoids to produce complexes with other molecules which are susceptible to thermal and mechanical effects. Furthermore, increase in temperature is inversely proportional to the availability of oxygen thereby increasing free flavonoids such as quercetin and rutin [28,29].

5. CONCLUSION

Flavonoids are valued for their pharmacological activities and nutritional benefits in both humans and other animals. The anti-inflammatory, antithrombotic and iron binding properties of flavonoids due to its antioxidant properties cannot be overemphasized. The two processing methods employed in this study revealed varying effects on the vegetable flavonoids content. In this study flavonoids contents of the majority of juice extracts increased compared with the fresh. Though, fewer blanched vegetables showed increased flavonoids contents however, these few with increased flavonoids content were much pronounced. Therefore, it is suggested based on this finding that juicing and blanching affect the concentration of flavonoids in vegetables. Thus, caution must be exercised in the intake of juiced or blanched vegetable with increased flavonoids content because of the antinutrient properties if consumed in large quantities.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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