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Effect of cooking methods on proximate composition, gross energy and dietary fibre of some green leafy vegetables

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ABSTRACT

The human population in tropical Africa denpends largely upon a large number of edible leaves to meet up with shortage in essential nutrients such as protein, mineral, and vitamins. Seven tropical vegetable species (Talium triangulae, Amaranthus hybridus, colocaisa esculenta, Telfairia occidentails, Solanum nigrum, Carssocephalum crepidiodes, and cindosculus aconitifolis) that are used as soup condiments in Nigeria either in the processed or unprocessed forms, were subjected to tow cooking methods (cooking without blanching and cooking after blanching). The effect of these cooking methods on the proximate composition and dietary fibre of these vegetable species were subsequently determined. The result of the study revealed that blanching and cooking caused significant ($p<0.05$) reduction in the proteins, carbohydrate and gross energy values of the vegetables, while it led to significant ($p<0.05$) increase in moisture, fat, and crude fibre contents of the vegetables. Cooking has a resultant increase on the ash content of the vegetables. Generally cooking caused significant ($p<0.05$) reduction in dietary fibre and cell wall carbohydrate but a corresponding increase occurred in the soluble fibre content of the leafy vegetables.

INTRODUCTION

Green leafy vegetables occupy an important place among the food crops as these provide adequate amounts of many vitamins, and minerals for humans (1). They are valuable sources of nutrients especially in rural areas of Nigeria where they contribute substantially to nutrients, vitamins, dietary, fibre, energy and certain hormone precursors, which are usually in short supply in daily diets (2, 3, 4). Besides, they add flavour, variety, taste, color and aesthetic appeal to what would otherwise be a monotonous diet (5). Most tropical countries including Nigeria are blessed with a diversity of vegetable species which play a basic role in nutrition and healthy body development (6, 7). In Nigeria, they are used as ingredient in soups and therefore serve as complements to most cereal and tuber staples and help in alleviating hunger and food security by contributing bulk of the nutritional components in the diets of people where animal products are scarce (3, and 5).

Several works and reports have been published in literatures that processing techniques (Drying, Blanching, Abrasion with or without salt, Boiling) quantitatively and/or quantitatively modifies the nutritive value of some commonly consumed plants food (vegetables inclusive) in Nigeria (5, 8, 9, 10 11, 12,). In Nigeria, unlike the western worlds where green leafy vegetables are usually consumed in their unprocessed forms, green leafy vegetables are usually used in soup preparation in their processed and unprocessed forms, however there is limited information with regards to the effect of cooking methods on the nutrients and dietary fibre values of green leafy vegetables soups. Therefore, the purpose of this study is to conduct investigation on the effect of cooking methods on the proximate composition, energy values, and dietary fibre components of some selected Nigeria green leafy vegetables.

MATERIALS AND METHODS

SOURCES

The indigenous green leafy vegetables and other ingredients that were in soup preparation were purchased from the local market in Ilaro, Ogun State, Nigeria. These vegetables were Amarranthus hybridus (Tete), Talium triangulae (Gbure), Colocasia esculentum (Cocoyam leaves), Solanum nigrum (Igbo), Telifera occidentalis (Ugwu/ewe riko). Crassocephalum crepidioides (Ebolo), Cnidoscolus acontifolus (ipaya).

PREPARATION

Each vegetable sample was destalked, cut into slices, and washed. Enough quantity of each vegetable was taken and kept as the control. Each vegetable was divided into two portions; one portion was subjected to blanching in hot water at 1000C for 5 – 6 Mins, allowed to cool and further divided into two. A portion was reserved as the blanched samples. The remaining blanched vegetables and the unblanched vegetables were used to prepare vegetables soup using standard ingredients [table 1] as described by Eboh,2000 (13), which was modified by not using any of the animal protein sources to prepare the vegetables soups. A common sauce was prepared for the vegetable soups. Out of which 500ml was taken, into which 250g of the blanched or unblanched vegetables were added and cooked for further 5mins. The soups were allowed to cool and stored using air tight plastic containers in a refrigerator pending chemical analysis.

Table 1: Recipe for Vegetable Soups

Ingredients	Amount
Dried Fish [kg]	1.0
Meat [kg]	1.0
Ground Crayfish	90.0
Onions [g]	2
Magi [g]	15
Pepper [g]	15
Salt [g]	10
Palm Oil [g]	35
Vegetables [g]	250
Water [ml]	1000

Adapted from Eboh, 2000

CHEMICAL ANALYSIS

The refrigerated samples of raw [R], blanched [B], unblanched cooked [UBC] and blanched cooked [BC] vegetables were analyzed for their proximate composition using the recommended methods of the Association of Official Analytical Chemist (14). Energy content was determined by using Atwater factor of 4,9,4 to multiply the % crude protein, % crude fat and % carbohydrate respectively (15). Cell walls carbohydrate cellulose, hemicelluloses and lignin content of the samples were determined according to Fonnesbeck, 1976 (16) procedures. Dietary fibre analysis was performed by a modification of the enzymatic-gravimetric AOAC method (17).

STATISTICAL ANALYSIS

All the analysis were done using triplicate samples. Experimental results were subjected to univariate analysis of variance (ANOVA), and significant different of treatment means were compared by the methods, of Duncan, using the statistical package for the social sciences (SPSS) (18).

RESULTS AND DISCUSSION

Table 2 present the proximate composition and the gross energy values of raw (R), blanched (B), raw cooked (RC), and blanched cooked (BC) of some selected green leafy vegetables (GLV). Considering the raw vegetable samples (control), the moisture content of the samples ranged between 83.85g/100g in C. aconitifolis and 90.58g/100gg in C esculenta. The moisture level of samples in this study agrees with the report of Jenson, 1978 (19) that fruit and vegetables contain as high as 85% water. Blanching process caused significant ($P<0.05$) increase in the moisture content of the vegetables.

Table 5: Effect of cooking methods on structural carbohydrate content [g] 100g wet weight] of selected leafy vegetables

Sample	**Treatment**	**Total**		**Dietary Fibre**			**Cell wall Carbohydrate**	
			Soluble Fibre	**Insoluble Fibre**	**Total**	**Cellulose**	**Cellulose**	**Lignin**
T. triangulae	R	4.44^{d}	0.52^{a}	3.53^{c}	3.50^{d}	2.22^{d}	1.28^{d}	0.94^{a}
	B	4.16^{c}	0.63^{b}	3.02^{b}	3.18^{c}	2.05^{c}	1.13^{b}	0.98^{c}
	UBC	3.71^{b}	0.69^{c}	2.54^{a}	2.75^{b}	1.51^{b}	1.23^{c}	0.96^{b}
A. hybridus	BC	3.49^{a}	0.95^{d}	5.04^{d}	2.49^{a}	1.40^{a}	1.10^{a}	1.00^{d}
	R	5.51^{d}	0.47^{a}	4.83^{c}	4.07^{d}	2.58^{c}	1.49^{d}	1.43^{a}
	B	5.42^{c}	0.59^{b}	4.35^{b}	3.96^{c}	2.59^{d}	1.37^{b}	1.46^{c}
C. esculenta	UBC	5.07^{b}	0.72^{c}	3.98^{a}	3.63^{b}	2.16^{b}	1.45^{c}	1.44^{b}
	BC	4.86^{a}	0.88^{d}	4.63^{d}	3.70^{d}	2.04^{a}	1.34^{a}	1.48^{d}
	R	5.11^{d}	0.48^{a}	4.01^{c}	3.29^{c}	2.53^{d}	1.17^{d}	1.40^{a}
	B	4.73^{c}	0.72^{b}	3.74^{b}	3.16^{b}	2.24^{c}	1.06^{b}	1.44^{c}
T. occidentalis	UBC	4.58^{b}	0.84^{c}	3.09^{a}	2.77^{a}	2.01^{b}	1.15^{c}	1.42^{b}
	BC	4.22^{a}	1.13^{d}	4.18^{d}	3.15^{d}	1.75^{a}	1.02^{a}	1.45^{d}
	R	4.60^{d}	0.41^{a}	3.93^{c}	3.09^{c}	2.00^{d}	1.15^{d}	1.44^{a}
S. nigrum	B	4.55^{c}	0.62^{b}	3.41^{b}	3.09^{a}	2.03^{c}	1.06^{b}	1.46^{c}
	UBC	4.33^{b}	0.92^{c}	2.97^{a}	2.88^{b}	1.77^{b}	1.11^{c}	1.45^{b}
	BC	3.99^{a}	1.02^{d}	2.29^{d}	2.52^{a}	1.52^{a}	1.01^{a}	1.47^{d}
C. crepidiodes	R	5.89^{d}	0.61^{a}	5.29^{d}	4.27^{d}	2.77^{d}	1.49^{d}	1.62^{a}
	B	5.79^{c}	0.78^{b}	5.01^{c}	4.12^{c}	2.74^{c}	1.38^{b}	1.67^{c}
	UBC	5.62^{b}	0.96^{c}	4.66^{b}	3.97^{b}	2.53^{b}	1.45^{d}	1.65^{b}
	BC	5.27^{a}	1.15^{d}	4.12^{a}	3.59^{a}	2.23^{a}	1.36^{a}	1.68^{d}
C. aconitifolius	R	45.31^{d}	0.59^{a}	5.72^{d}	3.70^{d}	2.46^{d}	1.24^{d}	1.61^{a}
	B	4.95^{c}	0.79^{b}	4.16^{c}	3.33^{c}	2.20^{c}	1.13^{b}	1.62^{b}
	UBC	4.77_{b}	0.86^{c}	3.91^{b}	3.15^{b}	1.95^{b}	1.20^{c}	1.62^{b}
±SEM	BC	4.50^{a}	1.08^{d}	3.42^{a}	2.85^{a}	1.76^{a}	1.09^{a}	1.65^{c}
	R	4.68^{d}	0.55^{a}	4.13^{d}	3.44^{d}	2.22^{d}	1.22^{d}	1.24^{a}
	B	4.53^{c}	0.69^{b}	3.84^{c}	3.27^{c}	2.20^{c}	1.07^{b}	1.26^{b}
	UBC	4.20^{b}	0.87^{c}	3.33^{b}	2.92^{b}	1.78^{b}	1.14^{c}	1.28^{c}
	BC	3.91^{a}	0.99^{d}	2.92^{a}	2.62^{a}	1.59^{a}	1.02^{a}	1.29^{d}
		0.024	0.002	0.031	0.039	0.035	0.52	0.045

- *Mean values in a column within a group denoted by different superscripts differ significantly at P<0.05*

***±SM Standard error of the mean*

The change in moisture content of the samples in response to the cooking methods is similar in all the samples, with blanched cooked vegetables' soups having highest moisture content (87.38g/100g to 92.76g/100g). The increase in moisture content will lead to reduction in the dry matter contents due to dilution of soluble solids in the food sample.

The protein values for the unprocessed samples varied according to species, with S. nigrum and C aconitifolis falling within extremes of lower (2.58g/100g) protein values respectively. Although there are some variance, protein values obtained in this study are close to values obtained by Aletor and Adeogun, 1995 (7) on fresh leaves of some T. triangulae (2.5g/100g), C crepidiodes (3.4g/100g), S. nigrum (2.9g100g), A. hybridus (2.9g/100g) and T. occidentalis (4.3g/100g). Also protein value for C. A conitifolis differs slightly to that obtained by Oboh, 2005 (11) for the same samples (7.8g/100g). These variations may be caused by a lot of factors such as soil condition, the age of the vegetable sample, and agronomic factors. Blanching caused 16.95% to 30.82% reduction in protein contents of the vegetables. Cooking the raw vegetables caused reduction in their protein contents but the reduction was not as pronounced in the cooked blanched samples (28.25% - 47.20% reduction). The reduced protein contents of the cooked vegetables could be attributed to the severity of thermal process during cooking (20).

The carbohydrates (NFE) levels in these leafy vegetables were relatively low and their levels varied significantly (P<0.05) according to the species of the vegetables. The value is highest in C. aconitifolis (2.8g/100g to 4.18g/100g) and lowest in C. crepidiodes (0.97g/100g to 2.15g/100g). Aletor and Adeogun 1995 (7) observed lower values in T. triangulae (2.1g/100g), C. crepidiodes (1.0g/100g), A. hybridus (0.1g/100g), T, occidentals (0.1g/100g). The difference may be due to the physiological state of the plant before harvesting (21). Cooking caused a greater reduction (39.76% to 53.93%) in the level of carbohydrate than blanching (15.60% to 44.15%). However there was further reduction in carbohydrate when the blanching vegetables were subjected to cooking. The result also agrees with the earlier work carried out on C. aconitifolis by Oboh, 2005 (12). This significant (P<0.05) loss of carbohydrate may be attributed to thermal hydrolysis of the carbohydrate with the formation of simple disaccharides and monosaccharides that are relatively soluble and can be leached into the cooking water (22).

Fat content for the raw samples varied with species, with the highest value of 0.83g/100g observed in C. esculenta and the lowest value of 0.36g/100g found in S. nigrum. These low values of fat obtained in all the vegetables used in this study corroborate the findings of many authors which showed that leafy vegetables are poor sources of fat. (7, 12, 23, 24, 25). Due to the generally low level of crude fat in the vegetables' leaves, their consumption in large amount in a good dietary habit and may be recommended to individuals suffering from overweight or obesity (6). Blanching of the leaves did not cause any significant change in the fat content of the leafy vegetables, this jconfirms the reports of Oboh, 2005 (12) and Mepba et al, 2007 (7) on effect of blanching on similar leafy vegetables. However an increase in fat content was observed in both raw vegetable soups and blenched vegetable soups. This increase may be attributed to the fat content of the palm oil that was used to prepare the soups.

The ash content of a foodstuff is the inorganic residue remaining after the organic matter has been destroyed in a muffle furnace (26, 27.) The ash contents of both cooked and uncooked green leafy vegetables as depicted in table 2 revealed that blanching caused a significant ($P<0.05$) decrease (25.15% to 36.85%) in the ash content. The reason for the decrease in ash content may be as a result of leaching of some onorganic salt into the blanching water (8, 11). It was however observed that the vegetable soups have higher ash content (1.84g/100g to 6.95g/100g) than the raw vegetables (1.60g/100g/ to 6.35g/100g) and the blanched vegetables. This is because heating does not destroy the inorganic component of food and even if the inorganic salt were leached into the soup sauce they were not completely lost. The ash contents of the unprocessed vegetables are moderately high, with the highest found in A. hybridus (6.35g/100g) and the least ash content obtained in T. trinagulae (1.0g/100g). This result is in conformity with the observation of previous workers (7, 12, 5), on the ash content of similar green leafy vegetables consumed in Nigeria. The high values of ash observed in all the leafy vegetables is a good indicator that these food samples are good sources of minerals when compared to values obtained for cereals and tubers (28, 3).

The gross energy value of the unprocessed green leafy vegetables are all between 26.21kcal and 49.18kcal per 100g of wet sample with highest levels found in C. aconitifolis and the lowest found in S. nigrum. These levels are low due to low crude fat level and relatively high levels of moisture. The daily energy requirement of 2500 to 3000kcal has been reported for adults (29). For an adult to obtain form any of these vegetables an energy value of 2750kcal per day which is within the range reported by Brigham,1978 (30), the individual would need to consume between 5kg and 10kg or vegetables is fresh state. Because only up to 3.0% of each of this amount is eaten by an individual per day, these leafy vegetables can therefore be classified as low energy foods. (6). All the processing techniques caused significant reduction in the gross energy values of the GLVS with blanched cooked vegetable soups having the lowest gross energy level.

The respective mean GLVS as depicted in table 2 revealed that blanching and cooking increase the crude fibre contents of the GLVS. However there is no significant difference ($P<0.05$) between blanched vegetables and cooked blanched vegetables.

STRUCTURAL CARBOHYDRATES

Dietary fibre is considered to be plant cell skeletal remains that are resistant to digestion. Although primarily, plant cell walls consisting of cellulose, hemicellulose and lignin, dietary fibre also includes soluble polysaccharides such as pectin, plant gums, and mucilages. Fibre is not totally carbohydrate because it includes lignin which is a non-carbohydrate polymer (31, 32). Table 3 presents the dietary fibre contents (souble, insouluble, and total), cell was carbohydrate and lignin of the raw, blanched and cooked vegetables. The dietary fibre level in raw vegetables in between 4.44g/100g in *T. trinagulae* and 5.89g/100g in S. nigrum. Lintas and Cappelloni, 1988 (32) recorded a lower dietary fibre levels ranging from 0.54g/100g to 4.45g/100g, fresh weight as their findings of the analysis performed on several vegetables and fruits. As regards the soluble: insoluble dietary fibre ratio, a marked prevalence of insoluble fibre components was observed in all cases, the insoluble fractions representing > 85% of total dietary fibre. On the average, cooked vegetables had ower dietary fibre and a prevalence of insoluble fibre.

Table 5: Effect of cooking methods on structural carbohydrate content [g] 100g wet weight] of selected leafy vegetables

SAMPLE	TREATMENT	Moisture	Protein	Crude Fibre	Carbohydrate	Fat	Ash	Energy
	R	90.32^{a}	2.67^{d}	1.35^{a}	3.63^{d}	0.44^{a}	1.60^{c}	29.59^{d}
	B	91.37^{c}	2.03^{b}	2.01^{c}	2.73^{c}	0.79^{c}	1.07^{a}	26.49^{c}
T. *triangulea*	UBC	91.07^{b}	2.47^{a}	1.76^{b}	2.19^{b}	0.68^{b}	1.84^{d}	25.02^{b}
	BC	92.27^{d}	1.19^{a}	2.16^{d}	1.60^{a}	0.89^{d}	1.17^{b}	22.28^{a}
	R	85.55^{a}	3.87^{d}	1.22^{a}	2.50^{d}	0.51^{a}	6.35^{c}	30.40^{d}
A. hybridus	B	87.87^{d}	2.94^{b}	1.77^{c}	2.11^{c}	0.73^{a}	4.5^{a}	27.08^{c}
	UBC	86.34^{b}	3.20^{c}	1.53^{b}	1.34^{b}	0.64^{b}	6.95^{d}	24.10^{b}
	BC	88.87^{d}	2.04^{a}	1.77^{c}	1.01^{a}	0.73^{c}	5.58^{b}	18.94^{a}
C. esculenta	R	90.58^{a}	3.32^{d}	1.28^{a}	2.25^{d}	0.83^{a}	1.74^{c}	29.99^{d}
	B	92.16^{c}	2.42^{b}	1.68^{c}	1.26^{b}	1.37^{c}	1.11^{a}	27.16^{c}
	UBC	91.24^{b}	2.82^{c}	1.51^{b}	1.27^{c}	1.12^{b}	2.05^{d}	26.54^{b}
	BC	92.76^{d}	2.02^{a}	1.68^{c}	0.82^{a}	1.37^{c}	1.35^{b}	23.78^{a}
T. occidentalis	R	85.94^{a}	4.72^{d}	1.08^{a}	2.59^{d}	0.30^{a}	5.39^{c}	32.21^{d}
	B	88.10^{c}	3.49^{b}	1.67^{c}	2.12^{c}	0.70^{c}	3.89^{c}	29.34^{c}
	UBC	86.52b	4.22^{c}	1.46^{b}	1.19^{b}	0.55^{b}	6.06^{d}	26.71^{b}
S. nigrum	BC	88.66d	2.87^{a}	1.67^{c}	1.17^{a}	0.74^{d}	4.89^{b}	22.95^{a}
	R	88.19a	2.58^{d}	1.64^{a}	3.06^{d}	0.36^{a}	4.17^{d}	26.21^{d}
	B	90.25^{c}	2.14^{b}	2.03^{c}	2.37^{c}	0.41^{b}	2.63^{a}	23.54^{c}
C. crepidiodes	UBC	89.75^{d}	2.41^{c}	1.84^{b}	1.46^{b}	0.43^{c}	4.71^{d}	19.53^{b}
	BC	90.75^{d}	1.85^{a}	2.03^{c}	1.06^{a}	0.68^{d}	3.63^{b}	19.53^{b}
	R	89.73^{a}	4.24^{d}	1.51^{a}	2.15^{d}	0.52^{a}	1.85^{c}	30.51^{d}
	B	91.25^{c}	2.93^{b}	1.97^{c}	1.57^{c}	0.58^{a}	1.25^{a}	27.50^{c}
C. aconitifolis	UBC	90.22^{b}	3.64^{c}	1.76^{b}	1.42^{b}	0.89^{c}	2.07^{d}	28.40^{b}
±SEM	BC	92.25^{d}	2.33^{a}	1.97^{c}	0.97^{a}	1.03^{d}	1.45^{b}	22.62^{a}
	R	83.85^{a}	6.69^{d}	1.44^{a}	4.18^{d}	0.58^{a}	3.26^{c}	49.18^{d}
	B	86.38^{c}	4.84^{b}	1.95^{c}	3.38^{c}	0.61^{b}	2.44^{a}	42.41^{c}
	UBC	84.64^{b}	5.69^{c}	1.86^{b}	3.10^{b}	0.83^{c}	3.91^{d}	42.98^{b}
	BC	87.38^{d}	4.04^{a}	1.95^{c}	2.68^{a}	1.01^{d}	2.94^{b}	36.32^{a}
		0.091	0.023	0.011	0.073	0.07	0.052	0.313

- *Mean values in a column within a group denoted by different superscripts differ significantly at P<0.05*

***±SM Standard error of the mean*

A comparison of dietary fibre contents in selected raw and cooked vegetables as recorded in Table 3 revealed that, in general cooking had significant (P<0.05) reduction effect on the total dietary fibre content of the vegetables considered in this study. Blanching and cooking caused significant increase in soluble fibre content, with corresponding decrease in insoluble fibre content. This finding is in agreement with the reports of Slavin, 1987 (33), and Lintas and Cappelloni, 1988 (32) that heat treatment caused solubilization of dietary fibre with alteration of its physiological properties.

Taking the raw vegetables into consideration, the hemicellulose levels (2.00g/100g to 2.58b/100g) are higher than the cellulose contents (1.15g/100g to 1.49g/100g). This corroborated the fact that the types of fibre present in vegetables and fruit are largely water soluble pectin and hemicellulose, while in cereals the majority of fibre are non-souble cellulose and lignin (34), The response of lignin contents of the leaves to cooking methods varied in each specie. However, except in T. occidentalis, cooking caused slight increase in the lignin contents of the leaves. It is a known fact that factors such as botanical variety, growing conditions, and particular degree of maturity, affect the fibre content of vegetables (32). Sometimes there is confusion as to the differences between crude fibre and dietary fibre of foodstuff. The method for determining crude fibre consists basically of measuring the residue remaining after acid and basic hydrolysis. It is known that the crude fibre method covers 50-80% of the cellulose, 10-50% lignin, and 20% of the hemicellulose. The aforementioned explained the variation observed in the crude fibre contents (1.08g/100g to 1.64g/100g) and the total dietary fibre levels (4.44g/100g to 5.89g/100g) of the green leafy vegetables considered in this study.

CONCLUSION

This revealed that the different species of green leafy vegetable contain appreciable quantity of protein and dietary fibre. Also Cooking and blanching have inevitable consequences on the nutritional values of the vegetables. The macronutrients (proteins, carbohydrates, fats) contained within the vegetables showed varying degree of stability when they were cooked. Cooking the leafy vegetables caused only small changes in total dietary fibre contents of the samples. However, redistribution from insoluble to soluble fibre components was observed. The changes in dietary fibre stability reported in this study are suggestive of modification in cell wall components during cooking. It is known that factors such as botanical variety, growing conditions and degree of maturity affect the nutritive values of vegetables. Consequently it appears quite difficult to interpret eventual differences observed among vegetables when such parameters are not known.

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