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Effect of the Method of Processing and Preservation on Some Quality Parameters of Three Non-Conventional Leafy Vegetables

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Abstract: In order to determine the best and cheapest method of processing that will minimize nutrient loss, and preserve the sensory characteristics, the effect of different processing and preservation methods on the mineral composition of and sensory properties of *Vernonia amygdalina, V. colorata* and *V. calvoana var*. non bitter were studied. These leafy vegetables were subjected to intense squeeze-washing and crushing, and boiling with different concentrations of Kanwa. Results show that these species are good sources of mineral and that *V. colorata* was richest in iron (15.22 mg DW/100g). All the other minerals had losses with a maximum of 56% recorded for calcium when *V. amygdalina* was boiled and squeeze-washed. Processing with natron resulted in smaller losses in minerals and in some cases slight increases (maximum of 9.5%) were observed for iron and phosphorus). Calcium, phosphorus and iron levels appeared to be dependent on the type of processing methods used and not the drying techniques or freezing time used in the process. The green colour and the texture of the samples boiled with kanwa are most preferred. Equally and better preferred are frozen vegetables as compared to the dried.

Key words: Processing, preservation, minerals, vegetables, preference test

Introduction

Leafy vegetables are present on the table of all economic classes and may represent an important source of minerals for lower income people in developing countries especially those in the rural areas. They constitute a major component of most Cameroonian dishes (Westphal *et al.,* 1985). The bitterness and the foaming properties of some species necessitate the use of different processing techniques such as squeeze-washing and rinsing, boiling and the use of kanwa. Latunde-Dada (1990) found that *Vernonia amygdalina* contains high levels of minerals which are essential for the maintenance of nutritional and health status of the body. However, their bioavailability is low because of the presence of anti-nutritional factors. Udosen and Ukpanah (1993) observed that processing causes losses in some of the anti-nutritional factors and as a consequence, some minerals are also lost.

The primary quality attributes of a vegetable product is not only its nutritional quality but includes the sensory characteristics. Different processing and preservation methods can revealed the conditions for optimal nutritional quality and for an appreciable shelf life without any consideration for its sensory characteristics. From the quality stand point it is also desirable to preserve sensory characteristics of vegetables to their peak. What the consumer perceives as the most appealing attributes of vegetables are the fresh like appearance. Kays (1999) indicated that the appearance and colour are the main criteria to be considered to assess vegetable quality. Onayemi and Badifu (1987) proved that sun-dried vegetables had inferior colour, texture and acceptability compared to the vegetables dried in the cabinet dryer. Fathima *et al.* (2001) also showed that microwave drying of fenugreek and amaranth affected negatively their appearance. The different methods of processing and preservation can therefore have an effect on the organoleptic properties of vegetables and the overall acceptability by the consumer.

This study is aimed at studying the effect of local preparation and processing methods on the mineral composition and sensory characteristics of *Vernonia amygdalina*, *V. calvoana var* bitter and *V. colorata*.

Materials and Methods

Samples were collected in an experimental farmland in Ngaoundéré, Cameroon in the months of October and November. The leaves and growing shoots were sorted, rinsed under running tap water, left to drain, and subsequently sliced using a stainless steel kitchen knife before submitting them to the different treatments.

Processing by squeeze washing boiling and use of kanwa: To determine the effect of squeeze-washing, boiling and use of kanwa, a 5 x 3 factorial design was used on the sliced leaf samples. All 3 species were subjected to 5 different treatments; these include the raw, squeeze-washed, boiled and squeeze-washed and samples boiled with 2.5 and 5 % kanwa.

Table 1: The effect of processing on the Ca, P and Fe levels of the three species of *Vernonia* on dry weight basis

	V. amygdalina			*V. calvoana var*. bitter			*V. colorata*		
	Ca g/100g	P g/100g	Fe mg/100g	Ca g/100g	P g/100g	Fe mg /100g	Ca g/100g	P g/100g	Fe mg/100g
R	0.97±0.02^{a1}	0.52±0.00^{a1}	7.52±1.57^{a1}	1.44±0.06^{a2}	0.61±0.01^{a2}	6.39±0.26^{a1}	1.13±0.07^{a3}	0.80±0.02^{a3}	15.22±0.35^{a2}
W	0.68±0.00^{c1}	0.29±0.03^{b1}	5.30±0.46^{ab1}	0.70± 0.20^{d2}	0.37±0.12^{b1}	3.46±0.24^{d2}	0.57±0.03^{b3}	0.24± 0.01^{b12}	9.77±0.32^{b3}
Wb	0.41±0.03^{d1}	0.27±0.01^{b1}	4.79±0.15^{ab1}	0.83±0.02^{d2}	0.28±0.01^{b1}	3.92±0.17^{d2}	0.70±0.12^{c2}	0.37± 0.02^{c2}	9.21±0.74^{b3}
W1	0.80±0.01^{b1}	0.62±0.02^{a1}	7.18±0.38^{a1}	1.04±0.11^{c2}	0.37±0.01^{b2}	5.81±0.01^{b1}	1.11±0.03^{c2}	0.40± 0.23^{c2}	15.02±0.96^{a1}
W2	0.57±0.00^{e1}	0.52±0.04^{a1}	8.01±0.73^{a1}	1.28±0.01^{b2}	0.39±0.01^{b2}	4.68±0.04^{c2}	1.39±0.04^{c3}	0.37±0.01^{c2}	16.67±1.10^{a3}

Means with different superscript letters for the same mineral in a column and numbers in a line are significantly different (P <0 .05);
R = unprocessed, W = Squeeze-washed, WB = Blanched and squeeze-washed, W1 = Blanched in 2.5%w/v kanwa and squeeze-washed;
W2 = Blanched in 5%w/v kanwa and squeeze-washed

Squeeze-washing was done by crushing, squeezing and rinsing 450g portion of sliced samples of each species to remove the green colour and bad odour. For *V. amygdalina* and *V. calvoana var*. bitter samples, squeeze-washing was done for 30 minutes with rinsing every 7 to 8 minutes while the *V. colorata* was squeeze-washed for only 15 minutes with double rinsing at same interval. For the blanched and squeeze-washed samples, blanching was done on 450g samples of each species for 5 minutes in 400 ml of boiling water followed by the traditional squeeze washing. For samples processed by combination of blanching in kanwa and squeeze-washing, the squeeze-washing was done after boiling for 5 minutes in 2.5 and 5%w/v concentrations of kanwa (a local alkaline salt). 450 gram portions of the fresh sliced samples were blanched in 400 ml of boiling water containing 10g (2.5% w/v) of kanwa for 5 minutes before squeeze-washed. These concentrations were determined following a survey of the amount used traditionally. The raw and processed samples were dried in an electric dryer (CKA200AUF), and pulverized into a powder to pass through a 1.0mm mesh using a culatti grinter. Ground samples were stored in airtight containers until required for analyses.

Drying and freezing: To determine the effect of drying, the five treated leaf samples of the *V. calvoana* was dried in solar radiation and moisture ovens at 45, 60, and 75^{o}C until the water was completely dried. Similarly, both the unprocessed and processed forms of the vegetable were stored at -18^{o}C in a freezer for 10, 30, 75, and 120 days before being dried at 45^{o}C. The dried samples obtained were ground to powder as above and stored in air tight containers before analysis.

Chemical and sensory analysis: The levels of Ca, and Fe from ash obtained after incineration at 550^{o}C were determined by atomic absorption spectrophotometry, while P was quantified using a spectrophotometer (AOAC, 1997).

The sensory analysis (preference test) was carried out in the sensory analysis laboratory of the University of Ngaoundere. Eighteen panelists were used to assess the differences in the vegetable products using a 4-point hedonic scale test. These panelist evaluated parameters such as colour, texture, and bitterness. These panelists assessed the differences in the different processing and preservation methods used in the study.

Statistical analysis: All chemical analyses were done in triplicate. Experimental results and the average of points assigned for each parameter were subjected to analysis of variance (ANOVA) and differences between means were assessed by least significant difference test using the program Statistical version 5 ,1995.

Results

Effect of processing by squeeze-washing and use of kanwa on Ca, P and Fe: Application of different processing techniques to leafy vegetables did significantly affect the content of Ca, P and Fe in green leafy vegetables (Table 1). The changes observed varied with the type of processing methods used. Squeeze washing produced the highest loss (50%) of calcium in *V. colorata* while for *V. amygdalina*, the highest loss (56%) were observed following boiling and squeeze-washing (Wb). Where kanwa was used in the processing, the losses were systematically lower. Species differences for the different processing techniques were also significant at p<0.05 with *V. calvoana var*. bitter having the highest level of calcium. While 43% loss occurred in phosphorus content of *V. amygdalina* following squeeze-washing (W), an increase (19%) was observed in this same mineral when kanwa was used in processing this same species. Phosphorus levels also varied with species for the different processing techniques at (p<0.05). LSD test showed that there were variations between *V. amygdalina* and *V. calvoana*. var. non bitter for both the unprocessed and processed samples. For iron, *V. colorata* had higher levels (15.22mgDW/100g) compared to the other species. Boiled and squeeze-washed samples (Wb) had a maximum of 42% loss in *V. calvoana var*. non bitter while the use of the kanwa (W2) caused a slight increase (16.1%) in *V. amygdalina.* Interaction of both species effect and effect of processing techniques show that both factors affected significantly the content of calcium (F=3.8, P= 0.02), phosphorus (F = 17.5, P = 0.00) and iron (F = 61.1, P = 0.001).

Table 2: Effect of drying on Ca levels of processed and unprocessed *V. calvoana* dried and frozen under different conditions in g per 100g DW

		Un -processed	Squeeze-washed	Boiled and squeeze-washed	Blanched in 2.5% kanwa	Blanched in 5% kanwa
Drying conditions	Sundried					
	(30°C)	1.25±0.05^{a}	0.62±0.18^{b}	0.93±0.07^{c}	1.02±0.11^{c}	1.19±0.11^{c}
	45°C	1.44±0.06^{a}	0.79±0.18^{b}	0.83±0.02^{b}	1.04±0.11^{c}	1.28±0.01^{d}
	60°C	1.44±0.04^{a}	0.70±0.09^{b}	0.90±0.07^{c}	0.98±0.03^{c}	1.39±0.11^{a}
	75°C	1.42±0.13^{a}	0.66±0.05^{b}	0.90±0.09^{c}	0.94±0.08^{c}	1.26±0.03^{d}
Freezing time	0 day	1.44±0.06^{a}	0.79±0.18^{b}	0.83±0.02^{b}	1.04±0.11^{c}	1.28±0.01^{d}
	10 days	1.51±0.30^{a}	0.75±0.16^{b}	0.82±0.12^{b}	1.07±0.07^{c}	1.39±0.03^{a}
	30 days	1.38±0.06^{a}	0.55±0.25^{b}	0.71±0.02^{b}	1.11±0.15^{c}	1.25±0.04^{c}
	75 days	1.41±0.12^{a}	0.71±0.05^{b}	0.84±0.12^{b}	1.08±0.15^{c}	1.39±0.11^{a}
	120 days	1.54±0.11^{a}	0.68±0.13^{b}	0.77±0.07^{b}	1.03±0.14^{c}	1.35±0.03^{d}

Means of columns for drying and freezing are not significantly different. Mean values in same line with different superscript are significantly different (P > 0.05)

Effect of drying and freezing on the mineral composition: Results of the effect of drying and freezing on calcium content of processed and unprocessed *V. calvoana* is shown in Table 2. Calcium levels appeared to be dependent on the type of processing methods and not the drying techniques used. This is because the variations due to drying techniques appeared not to be significant. In this species, the unprocessed samples were significantly higher than the processed samples but no clear variations were observed between the different processing techniques (P>0.05). However, at 60^{o}C and 75^{o}C, some slight variations were observed between the different processing methods. Similar observations were found for freezing of this mineral and for drying and freezing of the other minerals (Tables 3 and 4).

Sensory evaluation: Different processing and preservation methods affected the consumer preference based on colour and texture for *V. calvoana var*. bitter, *V. colorata* and *V. amygdalina* (Table 5). For the difference in species, the colour of *V. colorata* was the most preferred in the squeeze- washed form while the highest colour preference for species boiled and squeeze washed were both *V. colorata* and *V. calvoana*. For all three species, panelists preferred the samples processed with kanwa (W1 and W2) to the other processed samples at P < 0.05. This is confirmed by the fact that kanwa is used locally in boiling vegetables to improve on the green colour. LSD tests showed no significant differences for the samples processed with kanwa i.e. W1 and W2 (P > 0.05). The least preferred form of *V. colorata* was that boiled and squeeze washed while the squeeze washed samples were the least preferred for the other two species.

No significant variations in texture were observed between the different species processed under same conditions (P>0.05) except *V. amygdalina* blanched with 5% Kanwa that showed a slightly higher preference for texture (Table 6). The texture of samples boiled with kanwa (W1 and W2) were the most preferred for all the species analyzed (P < 0.05).

Table 6 presents the effect of conservation and processing on the bitterness of *V. calvoana*. For fresh samples, panelists preferred samples blanched with kanwa on equal strength with samples boiled and squeeze-washed and the squeeze-washed samples (W) were least preferred. For the frozen and dried samples no significant variation was observed for the different processing methods (P<0.05). When the different methods of conservation were compared for bitterness, the dried samples were preferred least. This is evident as the dried samples had a higher concentration of saponins that increases the bitter taste. Frozen samples compared favourably with the fresh samples for all the processed samples.

Table 7 presents the effect of conservation and processing on the colour and texture of *V. calvoana*. For the colour, the panelists preferred first, the fresh samples followed by the frozen samples. The sun-dried samples were appreciated least. However in cases of samples processed with kanwa, no significant variations were observed for both the fresh and frozen samples (P>0.05). It is therefore glaring that for the fresh and frozen samples, the squeeze-washed samples were preferred least.

For the texture, though the fresh and frozen squeeze-washed samples were preferred least compared to the other methods of processing, the frozen samples compared favourably with the fresh samples and the dried samples was preferred least.

In spite of the overall preferences for species, processing or preservation methods, the entire panellists indicated their general acceptability of the products.

Discussion

Iron, calcium and phosphorus are important in the diet of both pregnant and nursing mothers as well as infants, the convalescent and the elderly to reduce cases of diseases associated with deficiency of these minerals like anaemia and rickets (Awoyinka *et al*., 1995). The high levels of Ca, P and Fe observed in all the three

Table 3: Effect of drying on P levels of processed and unprocessed *V. calvoana* dried and frozen under different conditions in g per 100g DW

		Un- proc-essed	Squeeze-washed	Boiled and squeeze-washed	Blanched in 2.5% kanwa	Blanched in 5% kanwa
Drying conditions	Sun dried					
	(30°C)	0.60±0.00^{a}	0.37±0.01^{b}	0.30±0.01^{c}	0.44±0.01^{d}	0.31±0.82^{c}
	45°C	0.61±0.03^{a}	0.37±0.12^{b}	0.29±0.07^{b}	0.37±0.01^{b}	0.39±0.01^{b}
	60°C	0.58±0.02^{a}	0.30±0.02^{b}	0.33±0.06^{c}	0.40±0.02^{d}	0.36±0.00^{e}
	75°C	0.59±0.10^{a}	0.26±0.00^{b}	0.28±0.01^{c}	0.37±0.02^{d}	0.40±0.03^{e}
Freezing time	0 day	0.61±0.1^{a}	0.37±0.12^{b}	0.34±0.06^{b}	0.37±0.01^{b}	0.39±0.01^{b}
	10 days	0.50±0.13^{a}	0.39±0.07^{a}	39±0.04^{a}	0.42±0.0 2^{a}	0.34±0.00^{ab}
	30 days	0.59±0.03^{a}	0.42±0.00^{b}	0.41±0.06^{b}	0.33±0.03^{c}	0.43±0.00^{b}
	75 days	0.47±0.07^{a}	0.49±0.01^{a}	0.46±0.01^{b}	0.39±0.01^{c}	0.35±0.00^{d}
	120 days	0.41±0.01^{a}	0.29±0.06^{b}	0.34±0.02^{b}	0.40±0.00^{a}	0.39±0.02^{a}

Means of columns for drying and freezing are not significantly different. Mean values in same line with different superscript are significantly different (P > 0.05)

Table 4: Effect of drying on the Fe levels of *V. calvoana* subjected to different processing conditions in mg/100g DW

Temperature		Un -proc-essed	Squeeze-washed	Boiled and squeeze-washed	Blanched in 2.5% kanwa	Blanched in 5% kanwa
Drying conditions	Sun dried					
	(30 °C)	5.60±0.58^{a}	4.07±0.18^{b}	4.83±0.80^{b}	5.84±0.10^{a}	5.04±0.49^{a}
	45°C	6.39±0.96^{a}	3.46±0.24^{b}	3.92±0.17^{b}	5.81±0.01^{a}	4.68±0.04^{c}
	60°C	6.46±0.15^{a}	3.89±0.13^{b}	4.48±0.51^{b}	4.40±0.72^{b}	4.11±1.23^{b}
	75°C	6.79±0.01^{a}	4.48±0.84^{b}	4.49±1.96^{b}	5.12±0.40^{c}	3.57±0.11^{d}
Freezing time	0day	6.39±0.96^{a}	3.46±0.24^{b}	3.92±0.17^{b}	5.81±0.01^{a}	4.68±0.04^{b}
	10days	4.52±0.27^{a}	4.14±0.60^{a}	3.13±0.08^{b}	6.30±0.97^{c}	5.46±0.03^{c}
	30days	5.26±0.64^{a}	4.64±0.24^{a}	4.79±0.46^{a}	6.13±0.61^{b}	5.37±0.11^{c}
	75days	6.06±0.85^{a}	5.40±0.59^{a}	4.44±0.19^{b}	6.61±0.27^{a}	5.05±0.97^{a}
	120days	6.06±0.48^{a}	4.62±0.53^{ab}	5.50±0.56^{b}	6.51±0.77^{a}	5.75±0.80^{b}

Means in a column for both freezing and drying are not significantly different at P> 0.05; Means on the same line sharing the same superscript letter are not significantly different (P>0.05)

Table 5: Effect of processing and species on the colour and texture of Ndole

	V. amygdalina		*V. calvoana*		*V. colorata*	
	Colour	Texture	Colour	Texture	Colour	Texture
w	1.5±0.55^{a1}	1.5±0.84^{a1}	1.17±0.41^{a1}	1.167±0.41^{a1}	2.5±0.55^{b1}	1.67±0.42^{a1}
Wb	2.5±0.39^{b1}	2.5±0.32^{a1}	1.33±0.52^{a1}	2.17±0.21^{a2}	3.17±0.75^{b12}	1.67±0.22^{a1}
W1	3.67±0.62^{b2}	2.83±0.89^{b1}	3.17±0.75^{b2}	3.33±0.36^{b3}	3.67±0.52^{b2}	3.67±0.19^{b2}
W2	3.67±0.22^{b2}	4±0.64^{b2}	3.5±0.31^{b2}	2.67±0.41^{b23}	3.5±0.21^{b2}	2.5±0.21^{b3}

Mean values with same superscript letter in a line and number in a column are not significantly different (P > 0.05).
R = unprocessed, W = Squeeze-washed, WB = Blanched and squeeze-washed, W1 = Blanched in 2.5%w/v kanwa and squeeze-washed; W2 = Blanched in 5%w/v kanwa and squeeze-washed,

Table 6: Effect of conservation method and processing on the bitterness of V. calvoana

	Fresh	Frozen (60days)	Dried (45^{O}C)
Squeeze-washed	1.83±0.75^{a1}	3.0±1.11^{b1}	2.167±0.17^{b1}
Boiled and squeeze-washed	3.83±0.41^{b2}	3.67±0.52^{b1}	2.333±0.21^{b1}
Blanched in 2.5% kanwa and squeeze-washed	3.17±0.75^{b2}	3.67±0.52^{b1}	3.0±0.26^{c2}
Blanched in 5% kanwa and squeeze-washed	3.17±0.75^{b2}	3.67±0.52^{b1}	2.33±0.61^{b1}

Mean values with same superscript letter in a line and letter in a column are not significantly different (P >.05).

species of vegetables studied clearly indicate that these vegetables are potential good sources of this mineral when compared to values obtained for cereals (Oumarou *et al.,* 2005). This vegetable could therefore contribute to requirements for humans and other animals as other common vegetables (Friederike and Claus, 1996). This range of values compares favourably with values found by (Igile *et al*.,1995) and (Udosen and Ukpanah ,1993) for *V. amygdalina*. The content of iron, calcium and phosphorus in these samples may appear lower than values obtained by other authors (Oshodi, 1992) and higher than those reported for *Amarathus paniculatus* and *A. teunifolious* (Singhal and Kulkarni, 1987). These differences may be due to differences in cultivar, location, agricultural practices, rainfall, use of irrigation and possibly temperature. In the present study Fe, P and Ca levels were observed to decrease with processing probably as a result of the losses with

Table 7: Effect of conservation on the colour and texture of *V. calvoana*

	Fresh		Frozen		Dried	
	Colour	Texture	Colour	Texture	Colour	Texture
w	2.50±0.41^{a1}	1.83±0.51^{a1}	1.83±0.33^{a1}	1.5±0.29^{a1}	1.00±0.32^{a1}	1.00±0.26^{a1}
Wb	3.33±0.39^{b12}	2.83±0.33^{b2}	2.83±.14^{b2}	2.5±0.11^{b2}	1.50±0.26^{a1}	1.50±0.16^{a2}
W1	3.83±0.21^{b2}	3.17±0.42^{b23}	3.17±0.51^{b3}	3.33±0.16^{c3}	1.0±0.21^{a1}	1.00±0.31^{a1}
W2	3.83±0.36^{b2}	3.33±0.18^{b3}	3.83±0.42^{b3}	3.67±0.24^{c3}	1.50±0.24^{a1}	1.50±0.19^{a2}

Mean values with same superscript letter in a line and number in a column are not significantly different (P > 0.05). R =unprocessed, W = Squeeze-washed, WB = Blanched and squeeze-washed, W1= Blanched in 2.5%w/v kanwa and squeeze-washed; W2 = Blanched in 5%w/v kanwa and squeeze-washed,

washing water. For samples treated with kanwa losses were relatively much lower probably as a result of additions from Kanwa or as the result of the formation of insoluble salts in the basic medium of the process used. Though the unprocessed samples revealed no significant variations with time of storage in freezers, slight changes were observed for the processed samples. These changes are likely not due to freezing itself but due to some losses that may be encountered during thawing. These trends are similar to those obtained by (Negi and Roy, 2004) for storage of amaranth.

Preservation of chlorophyll in leafy vegetables is of vital importance to maintain its sensory quality (Castaner *et al.*, 1999). The loss of the green colour in the samples boiled and squeeze-washed can be attributed to loss of pigmentation due to heat treatment and release of acids and enzymes (Heaton *et al*.,1996). Bolin and Huxsoll (1991) also observed degreening in lettuce during processing and attributed the losses to losses in pigmentation (Castaner *et al.*, 1999).

Besides colour, quality loss can also be observed with changes in texture. The principal parameters that affect texture of vegetables are cell wall structure, cell tugor water content and the biochemical components (Harker *et al*., 1997). The textures of samples boiled with kanwa (W1 and W2) are the most preferred for all the species analysed (P < 0.05). This is attributed to the presence of cations in kanwa. These cations form a crosslink between free carboxyl groups of pectin chains resulting in the strengthening of the cell wall (Izimu and Watada, 1994). The least preference of the dried samples in terms of texture can be attributed to their water content and cell wall structure (Harker *et al*., 1997).

Conclusion: The vegetable species studied contain relatively high levels of iron, calcium and phosphorus which are lost during processing. Boiling with kanwa minimizes losses of these mineral probably through the addition of kanwa. Boiling with kanwa tenderise the leaves and make it more attractive by conserving the attractive green colour found in the fresh vegetable. Panelists therefore prefer the samples processed with kanwa (W1 and W2) to the other processed samples, For processed samples, frozen samples compare favourably with the fresh samples, though in terms of ranking the fresh samples are preferred first, followed by the frozen samples. The sun-dried samples are appreciated least though all panelists indicated that they liked the dried samples.

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