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The Effect of Drying and Salting on the Nutrient Composition and Organoleptic Properties of *Talinum triangulare* Leaves

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Authors' contributions

This work was a collaboration between both authors. Author FOJO designed the study, undertook the literature search and wrote the protocol and the first draft of the manuscript. Author GEM managed the analyses. Both authors performed the statistical analysis, read and approved the final manuscript.

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ABSTRACT

Aims: The present study was undertaken to determine the effects of drying and salting on the nutrient content and sensory properties of *Talinum triangulare* leaves.
Study Design: The methods of drying and salting were: oven drying to constant weight at 40℃ without any pretreatment, blanching in steam prior to oven drying to constant weight at 40℃, light salting (25 g dry salt/ kg leaves), light brine and vinegar treatment (50 g salt / L +50 ml vinegar/ kg leaves), and heavy salting (250 g/ kg leaves). Each salt treatment was provided for a duration of 14 days.
Methodology: Moisture, pH, ash, Ca, Fe, Na, crude fibre, β- and total carotene and vitamin C content of the fresh leaves and the products of the treatments were determined. Values for the fresh and the treated leaves on one hand, and those for products of the various treatments were then compared statistically. Sensory characteristics were also recorded.
Results: Compared with the fresh vegetable, oven drying, alone or after blanching of the leaves, resulted in a decrease in nutrient content, with retention ranging from 22.08% (for vitamin C in the leaves dried without prior blanching) to 95.69% (for Na in the blanched and oven-dried samples).

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Blanching prior to drying gave higher retention of β-carotene, total carotene and vitamin C than oven drying alone, but offered no advantage over the latter for the preservation of ash, iron, sodium and calcium (minerals). Compared with the fresh vegetable, salting resulted in high loss of β-carotene, total carotene, vitamin C and iron, and an increase in sodium and calcium.

Keywords: Water leaf; blanching; drying; salting; quality characteristics.

1. INTRODUCTION

Drying and salting are old and reliable food preservation methods. Pretreatment of leafy vegetables by blanching or scalding in hot water or steam makes the product tender, limits discolouration, eliminates intracellular gases responsible for oxidation reactions, kills harmful bacteria and deactivates enzymes which disintegrate the tissues [1,2]. Blanching and other thermal treatment of green leaves can also enhance the bioavailability of micronutrients by destroying antinutrients and by releasing micronutrients from entrapment in the plant matrix [3-5]. Thin-slicing makes for better heat and chemical penetration, and facilitates water loss during drying, resulting in shorter drying times and better preservation of heat-labile nutrients.

The salting or brining of vegetables offers tremendous possibilities both for their commercial and home preservation. In the process, the salt exerts a selective action on the naturally occurring organisms to promote a desirable fermentation. Salt tolerant microorganisms use as their nutritive material, the soluble constituents that diffuse out of the vegetable as a result of the action of the salt on vegetable tissue. These fermentative organisms produce various compounds, principally lactic acid but also acetic acid (both of which cause a decrease of pH), alcohols and considerable amounts of gas. The production of sufficient amount of acid makes the medium unsuitable for the growth of food spoilage bacteria. In addition, the acid and other microbial metabolites alter the flavour of the food [6]. Substances and organisms in fermented foods can cause changes in the composition and/or activity of the gastrointestinal microbiota resulting in several health benefits [7,8].

Water leaf (*Talinum triangulare* Jacq. Willd. Portulacaceae family) is an erect, fleshy, perennial herb with swollen taproot. It can be produced from seeds or by vegetative propagation from stem cutting. Its leaves are consumed as a vegetable in tropical regions including many countries in West and Central Africa [9]. They are used in the preparation of slightly slimy soups and stews to complement the starchy main dish. The leaves are also eaten raw in salads.

As with other leafy vegetables, post-harvest losses of *Talinum triangulare* leaves may occur due to inadequate preservation. In this study, three preservation techniques – drying without prior blanching, blanching in steam followed by drying, and salting were employed in order to investigate their effects on the nutrient composition and some sensory characteristics of *Talinum triangulare* leaves.

2. MATERIALS AND METHODS

2.1 *T. triangulare* Leaves

T. triangulare leaves were harvested from the vegetable garden of the Faculty of Agriculture and Agricultural Technology, from stands identified by staff of the Department of Crop Science of the faculty. Leaves were rinsed to remove extraneous matter and some of the vegetable thin-sliced (using a sharp knife) for blanching and drying tests. Whole leaves were used for salt treatments.

To investigate the effect of the preservation techniques on the nutrient composition and organoleptic characteristics of *T. triangulare* leaves, the following treatments were employed:

2.2 Preparation and Steam Blanching of Leaves

A known weight of thinly sliced *T. triangulare* leaves was wrapped in clean cheese cloth, tied with a string and put on the mesh above the water level in the water bath. The lid of the water bath was replaced and the samples were left to steam for 2 minutes.

2.3 Drying of Leaves

A known weight of thinly sliced *T. triangulare* leaves, with or without prior blanching was spread in a thin layer on shelves in a ventilated oven, and temperature maintained at 40℃. Vegetables were dried to constant weight and were crumbly.

2.4 Heavy Salting

T. triangulare leaves were gently rinsed to remove dirt, and the water drained. Salt (37.5 g) and leaves (150 g) were mixed well and filled in a plastic bucket. The mixture was covered with 2 layers of muslin cloth. A pressure plate was placed on it, on top of which a weight was placed. Brine made of salt (37.5 g) and water (150 ml) was added until the pressure plate was slightly submerged. The bucket was stored in a cool, dry and shaded place for two weeks [10]. Ambient temperature was 26.5-27.0℃.

2.5 Light Salting

Rinsed and drained *T. triangulare* leaves (150 g) were mixed well with dry salt (3.75 g) and filled in a plastic bucket, packing tightly. The mixture was covered with 2 layers of muslin cloth. A pressure plate was placed on it, on top of which a weight was placed. The set up was left for about 24 hr i.e. until the salt drew out enough liquid from the vegetables (i.e. for the leaves to become covered with brine). The bucket was stored in a cool, dry and shaded place for two weeks [10]. Ambient temperature was 26.5-27.0℃.

2.6 Light Brine + Vinegar

Light brine and vinegar was made by mixing salt (7.5 g), vinegar (7.5 ml) and water (150 ml). This was added to rinsed and drained *T. triangulare* leaves (150 g) in layers (i.e. by putting a layer of vegetables, adding brine and vinegar, adding another layer of vegetables, then more brine and vinegar, and so on) in a plastic bucket, packing tightly. The mixture was covered with 2 layers of muslin cloth. A pressure plate was placed on it, on top of which a weight was placed. The set-up was stored in a shaded part of the laboratory by the windows for two weeks [10]. Ambient temperature was 26.5-27.0℃.

2.7 Analytical Procedure

Moisture, ash, and crude fibre content were determined according to Official Methods [11]. The pH of the deionized water extract of the vegetable was determined at an ambient temperature of 27℃ using a previously calibrated pH meter. Calcium and iron content of the sample were determined by atomic absorption spectrophotometry; sodium content was determined by flame photometry [12,13].

For the determination of β-carotene content, leaves were extracted with dimethyl sulphoxide and methanol [14]. β-carotene was determined by spectrophotometry at 436 nm after methanolic KOH saponification and extraction with heptane [15].

Total carotenoid content was determined by spectrophotometry at 460 nm after KOH saponification of the methanol extract and extraction with diethyl ether [15].

Total vitamin C content of the fresh and treated leaves was determined spectrophotometrically [16]. Absorbance was read at 520 nm.

All determinations were done in triplicate.

2.8 Organoleptic Characteristics

A description of colour, taste, odour and appearance and texture based on sensory perception was undertaken by a panel of six judges (3 male and 3 female) selected from the final year biochemistry class, who apparently had no defect in their ability to perceive the characteristics examined. Labelled samples of the fresh and salted leaves were placed in glass petri dishes on a table covered with white cardboard which was placed in a well- lit and ventilated room. Prior to inspection of samples panellists were provided with a score sheet containing the following descriptions of characteristics and their corresponding scores, and were asked to score the samples based on their observations:

Colour: Yellow=1, lemon green=2, bright light green=3, dull light green=4, Dark green=5.

Taste: Bland=1, bland and tangy=2, leafy taste=3, leafy and salty=4, too offensive to taste=5.

Odour: None=1, fresh leafy=2, mildly offensive=3, moderately offensive=4, very offensive, rotten=5.

Texture: Succulent, firm and smooth=1, Succulent and firm=2, succulent, not firm but smooth=3, succulent but not firm=4, Degraded and slimy=5.

Examination of samples was by one panellist at a time.

Subsequent open discussion by the panellists of their observations (moderated by a leader chosen by the group) resulted in the final description of the fresh and salted leaves [17].

2.9 Statistical Analysis

All values (except pH) were expressed as mean ± SEM. The statistical analysis was carried out using unpaired student's t-test to detect significant differences in the concentration of nutrients between different treatments [18]. Tests with a probability value, $P<0.05$ were considered statistically significant.

3. RESULTS AND DISCUSSION

The organoleptic characteristics of *T. triangulare* leaves subjected to various preservation treatments are presented in Table 1.

The fresh leaves were light green in colour and had a characteristic leafy taste and smell. The leaves were firm, succulent and smooth. Light salt treatment gave leaves that were a dull slightly darker (than fresh leaves) green. They were rotten and had an offensive smell. They were slimy, were not structurally intact and had undergone some disintegration. Light brine and vinegar treatment gave leaves that had a light dirty green colour. They had a tangy taste and a slightly offensive smell. The leaves retained their shape but were less firm than the fresh leaves. The leaves that had undergone heavy salting were firm and had a light green colour and a leafy smell similar to that of the fresh. However, they had a very salty taste.

The acidity of foods is very important because it influences the kind of spoilage that can occur and hence the way that they are processed. Most bacteria grow readily at a pH near 7, when a food is neutral. On the other hand, microbial growth is more easily inhibited at lower pH of about 4 to 6 [19,20]. Low acid foods have a pH greater than 4.6 [21]. Table 2 shows the pH values of *T. triangulare* leaves subjected to different salting procedures.

The leaves showed a decrease in pH from 6.49 for the fresh sample to 4.40 5.36, and 4.45 respectively for the products of heavy salting, light salting and light salt and vinegar treatment. In addition to the light salt and vinegar (dilute acetic acid) treated leaves (in which vinegar contributed to the decrease in pH value), the light and heavy salt treatments also resulted in decrease in pH due to microbial fermentation, giving products with decreased susceptibility to microbial spoilage. Fresh *T. triangulare* leaves and those preserved by light salting, which had pH values of 6.49 and 5.36 respectively, can be classified as low acid foods. Such foods are susceptible to spoilage by organisms, such as the heat resistant, mesophilic spore forming anaerobic bacteria, *Clostridium butilinum,* (which produces a lethal water-soluble toxin) and the putrefactive anaerobe no. 3679, a *Clostridium sporogenes* type organism [21]. These microbes do not grow in high acid foods, such as the products of heavy salting (pH 4.40) and light brining and vinegar treatment (pH 4.45) and should therefore not be a problem in these. At these pH values the vegetable would be preserved through the prevention of the growth of these and other microorganisms that cause spoilage and food poisoning. Due to the poor sensory properties and relatively low acidity of the product of light salt treatment, it was not analysed further.

The effects of the various treatments on the nutrient composition of *T. triangulare* leaves are shown in Table 3. The β-carotene content of the fresh leaves (0.570 mg/100 g) was higher than that of the blanched and oven dried vegetable (0.382 mg / 100 g, 67.02% retention), the oven dried vegetable without pretreatment (0.259 mg / 100 g, 45.44% retention) and of the products of salting. Heavy salting and light brine and vinegar treatment resulted in heavy loss of β-carotene with retention values of only 1.93 and 2.11% respectively (Table 4). Total carotene content of the fresh vegetable was 1.070±0.045 mg / 100 g. This was highly retained in the blanched and oven-dried product (85.14%) but was poorly retained in the product from oven drying alone (35.61%). Preservation in salt resulted in serious losses (retention of total carotene was only 2.15% and 1.87% in the products of light brine and vinegar treatment and heavy salt treatments respectively).

Blanching in steam prior to oven drying appears to have had a protective effect on β-carotene compared with drying alone. The loss of this pro-vitamin was therefore probably not due to heat denaturation but as a result of enzymatic degradation. This would explain the higher loss in the leaves that were dried without prior blanching, in which enzymes had not been

Table 1. Characteristics of fresh and fermented *T. triangulare* leaves

Property	Fresh	Light salted	Light brine + vinegar treated	Heavy salted
Colour	Bright light green	Dull, light (slightly darker than the fresh) green	Dull light (slightly darker than the fresh) green	Bright light green
Taste	Fresh green leafy taste	Too offensive to taste	Bland taste with a hint of tanginess	Leafy taste but very salty
Odour	Fresh green leafy smell	Very offensive, rotten smell	Mildly offensive (but no rotten smell)	Leafy smell similar to that of the fresh leaves
Texture	Firm and succulent. Smooth feel	Slimy and degraded	Succulent but not firm. Smooth feel	Firm and succulent. Smooth feel

inactivated before drying. The lower value may also be the result of better extractability of lipids from the blanched and dried product during the determination of β-carotene.

Table 2. pH values of *T. triangulare* leaves

Leaves	pH
Untreated	
Fresh	6.49
Treatments	
Heavy salting	4.40
Light salting	5.36
Light salt + vinegar	4.45

Vitamin C content (dry basis) was higher for the fresh leaves (1082 mg / 100 g) than for the blanched and dried (404.0 mg / 100 g) and for the leaves that were dried, without prior blanching (283±38.9 mg / 100 g). Vitamin C content was also lower for the salted leaves (27.39±2.739 mg / 100 g for the light brine and vinegar preserved and 17.29±0.820 mg / 100 g for the heavy-salted). Thus this vitamin was poorly retained in the dried products (22.08% for oven dried and 32.33% for the blanched and oven dried products), and highly decreased in the salt-preserved products (retention was only 1.87% for the heavy salted and 2.15% for the light brine and vinegar treated, Table 5). Vitamin C is heat-labile and the decrease in the content of this substance on drying may be due to destruction at the drying temperature and probably during the preparation of the material for preservation. The severe loss of this water soluble vitamin, in the salted products was probably due to leaching into the brine and/or as a result of destruction by enzyme(s).

Fresh *T. triangulare* leaves had a moisture content of 87.60%. Moisture reduction is a simple food preservation technique. This was achieved in this work by drying. Drying of the vegetable was carried out until constant weight was achieved; the resulting product was crumbly. Heavy salting and light brine and vinegar treatment (which gave moisture content of 83.8 and 84.2% respectively) did not reduce moisture content significantly. Fresh leaves had crude fibre content of 4.2±0.67 mg/g (dry basis). Preservation by heavy salting alone and in salt and vinegar resulted in a decrease in crude fibre content to 1.85±0.2 mg/g and 2.01±0.73 mg/g respectively; thus less than half (37.65 - 47.29%) of the crude fibre of the fresh leaves was retained in the preserved products (Table 5).

Table 4 shows the ash, iron, calcium and sodium content of fresh and preserved *T. triangulare* leaves.

Ash content of the fresh *T. triangulare* leaves (3.90 mg/g) was higher than that of the dried (2.10 mg/g and 2.03 mg/g) and similar to that of the light brine and vinegar preserved product (3.35 mg/g); that of the product of heavy salting (4.45 mg/g) was slightly higher. Thus ash (i.e. mineral matter) was well retained in the light brine and vinegar preserved leaves (86.03%), but its content in the product of heavy salting was 114% that of the fresh, due to the higher amount of salt employed (Table 5).

Fresh *T. triangulare* leaves had a calcium content of 2.64 μg/ g. This was lower than that of the light brine and vinegar treated (4.84 μg/ g), higher than that of the blanched and oven dried (1.87±0.91 μg/ g$^-$), and leaves dried without pretreatment (2.11±0.91 μg/ g), but similar to that of the heavy-salted leaves (2.68±0.77 μg/ g). The higher calcium content of the light brine and vinegar preserved leaves was probably due to absorption of this mineral from the vinegar. It could neither have been absorbed from the salt nor the water that it was dissolved in since the calcium content of the product of heavy salting was not significantly different from that of the fresh leaves). The calcium content of the vinegar was however, not determined. The iron content of fresh leaves (0.46±0.08 µg/ g) was higher than that of the dried (0.29 µg/ g), heavy-salted (0.11±0.02 µg/ g⁻) and brine and vinegar treated (0.13±0.07 µg/ g) samples. Thus all the treatments decreased the content of this mineral (63.04% retention for the dried product, 28.26% and 23.91%, respectively for the heavy salted and light brine and vinegar treated leaves, Table 5).

Fermentation, with production of acid (reduction in pH) was observed in this study (Table 1). Teucher et al. [22], have observed that low molecular weight organic acids produced during fermentation have the potential to enhance iron absorption via the formation of soluble ligands, while simultaneously generating the low pH that optimizes the activity of endogenous phytase. From a nutritional standpoint, these benefits may serve to mitigate the loss of iron during preservation of this vegetable in salt.

The sodium content of fresh and preserved products showed a distinct pattern. Compared with the fresh leaves (1.16 µg / g), oven-drying, with or without blanching did not significantly affect the sodium content (1.114 and 1.01 µg/ g respectively). Heavy salting and light brine with vinegar treatment however, resulted in an increase (20974.14% and 13103.45% respectively, Table 5) in the sodium content of products due to uptake of salt during preservation. Thus, salted *T. triangulare* leaves contained much more sodium than the fresh or dried leaves and may therefore be used as condiment, where they would be better as enhancers of the main dish rather than as the main ingredient because of their high salt content.

Table 3. β-carotene, total carotene, vitamin C and moisture content of *T. triangulare* samples subjected to different preservation methods

Leaves	β-Carotene (mg/100 g db*)	Total carotene (mg/100 g db)	Vitamin C (mg/100 g db)	Moisture, % fresh wt)	Crude fibre (mg/g db)
Fresh	0.570±0.071	1.070±0.045	1082.2±82.040	87.60± 3.22^{d}	4.250±0.67
Light brine + vinegar treated	0.012±0.001^{a,b}	0.023±0.001^{a,c}	27.39±2.739^{a}	83.8±1.10^{d}	2.01±0.73^{a,e}
Heavy salted	0.011±0.001^{a,b}	0.020±0.006^{a,c}	17.29±0.820^{a}	84.20±3.00^{d}	1.85±0.2^{a,e}
Blanched and oven dried	0.382±0.017^{a}	0.911±0.041^{a}	404.0±63.080^{a}	-	1.74±0.23^{a}
Oven dried without blanching	0.259±0.048^{a}	0.381±0.066^{a}	238.9±38.900^{a}	-	1.6±0.06^{a}

Values were recorded as mean ± standard deviation of three independent samples.
**db: Oven dry basis, t-test: ^{a}: Values differ significantly compared with the fresh sample mean, P < 0.05*
$^{b, c, d, e}$ Values that have the same superscript are not significantly different (P >0.05) for the characteristic

Table 4. Ash, iron, calcium and sodium content (oven dry basis) of fresh and preserved *T. triangulare* leaves

Leaves	Ash (mg/g)	Fe (µg/ g)	Ca (µg/ g)	Na (µg/ g⁻)
Fresh	3.90±0.35	0.46±0.08	2.64±0.36^{e}	1.16±0.07^{f}
Light brine + vinegar treated	3.35±0.6^{b}	0.13±0.07^{a}	4.84±1.22^{a}	152.0±41.2^{a}
Heavy salted	4.45±0.17^{a}	0.11±0.02^{a}	2.68±0.77^{a,e}	243.3±8.25^{a}
Blanched and oven dried	2.10±0.08^{a,c}	0.29±0.14^{a,d}	1.87±0.91^{a}	1.11±0.04^{b,f}
Oven dried without blanching	2.03±0.04^{a,c}	0.29±0.16^{a,d}	2.11±0.91^{a}	1.02±0.04^{b,f}

Values are recorded as mean ± standard deviation of three independent samples.
t-test: ^{a} Values differ significantly compared with the fresh sample mean (P < 0.05),
^{b} Not significantly different compared with the fresh sample,
$^{c, d, e, f}$ Values are not significantly different (P < 0.05) for the characteristic

Table 5. Percentage retention or increase of nutrients after treatments[a]

	% β-carotene	% total carotene	% Vit. C	% moisture	% crude fibre	% Ash	Fe	% Ca	% Na
Fresh	100	100	100	100	100	100	100	100	100
Light brine + vinegar treated	2.11	2.15	2.53	95.66	47.29	86.03	28.26	183.3	13103.45
Heavy salted	1.93	1.87	1.60	96.12	43.53	114.10	23.91	101.52	20974.14
Blanched and oven dried	67.02	85.14	37.33	-	40.82	53.85	63.04	70.83	95.69
Oven dried without blanching	45.94	35.61	22.08	-	37.65	52.05	63.04	79.92	87.93

[a]*Percentage retention or increase = (Concentration of constituent in the treated leaves / Concentration of constituent in the fresh leaves) x 100*

4. CONCLUSION

The effect of blanching, drying, and salting on the nutrient composition of *T. triangulare* leaves was studied. When compared with the fresh leaves, drying resulted in loss of nutrients. Steam blanching prior to drying was better than drying without this pre-treatment for the protection of β- carotene, total carotene and vitamin C. Salt treatment resulted in decrease in pH in all cases (evidence of production of acid by salt tolerant fermentative microorganisms). However salt treatment resulted in high loss of β- and total carotene, vitamin C, crude fibre, and Fe but an increase in Na when compared with the fresh vegetable. From the viewpoint of nutrient content, drying was a better preservation method than salting, as it resulted generally, in higher nutrient retention.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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