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# Development and Evaluation of Vegetable Milk from *Treculia africana* (Decne) Seeds

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**Abstract:** *Treculia africana* seed milks (TRASMS) were developed using two blanching treatments (water and 0.2 % $NaHCo_3$) and five seed to solvent ratios (1:1 to 1:5). The developed milks were subjected to consumer acceptance test. The lower solvent TRASMS were most acceptable. Sensory, physico-chemical and microbiological properties of the four most acceptable TRASMS were compared with soymilk and a commercial vegetable milk-vitamilk using standard analytical methods. Blanching in alkali overtly affected the colour and taste scores of TRASMS. Water blanched TRASMS were preferred by taste panelists in terms of flavour, taste, mouth feel and overall acceptability. Sensory scores of TRASMS differed significantly ($P \leq 0.05$) in all attributes from those of vitamilk. Blanching in alkali resulted in 6%-15% decrease in protein content, marginal ($P > 0.05$) increase in pH and significant ($P \leq 0.05$) increase in total solids in comparison to blanching in water. Ether extract was lower by (1.32%-1.81%) in all TRASMS than codex standard. The levels of Calcium in TRASMS was low but iron (0.40-0.52 mg/100ml) and vitamin C (3.38-3.46 mg/100ml) were appreciably high when compared with the levels in dairy and human milk. The microbial load of TRASMS was below the acceptable limit for dairy milk.

**Key words:** Vegetable milk, *Treculia africana* (Decne) seeds, blanching, milk substitute

## Introduction

Milk is an excellent source of all nutrients except Iron and Ascorbate. Milk has long been recognized as an important food for infants and growing children (Obizoba and Anyika, 1994). Adults who consume milk at all in Nigeria do so by adding small amount of evaporated milk or milk powder to breakfast cereals, porridge, cocoa beverage, tea or coffee probably because of its exceptional scarcity and hence exorbitant cost in Nigeria. The scarcity of milk supply in developing countries perhaps led to the development of alternative milk from vegetable sources (Singh and Bains, 1988). However, prior to the development of such vegetable milks like soymilk which serve as a less expensive substitute for dairy milk, direct milk consumption as a beverage was not common in Nigeria (Iwuoha and Umunnakwe, 1997; Onweluzo and Owo, 2005). According to Harkins and Sarret (1967) development of milk substitutes extracted from legumes serves as an alternative way of producing an acceptable nutritious food based on vegetable. Vegetable milks can be used for babies in communities where babies are not given dairy milk for ethical reasons such as with vegans or for medical reasons as in milk allergies and galactosemia (Obizoba and Egbuna, 1992). Among the sources of vegetable milk, soybean has received very high research attention and more research is still being designed to improve the quality of soymilk (sun-young *et al.,* 2000). Relatively little research attention has also been given to bambara groundnut (Obizoba and Egbuna, 1992), baobab (Obizoba and Anyika, 1994), peanut (Odo, 2001) and melon seed (Akubor, 1998) as sources of vegetable milk but no attention has been given to such oilseeds as *Treculia africana* a source of vegetable milk. *Treculia africana* Decne commonly called African breadfruit is a member of the moracea family, widely grown in southern states of Nigeria for its seeds while the Polynesian breadfruit (*Artocarpus altilis*) is seedless. The seeds contain 19 % -23% crude protein, 11% crude fat and is a good source of potassium and phosphorus (Nwokolo, 1985, 1986). African breadfruit seeds have been used in a variety of ways traditionally and they serve as low cost meat substitutes for poor families in some communities. Extensive work has been done to elucidate the nutritional qualities of the seeds of *Treculia africana* (Edet *et al*., 1985; Ekpenyoung, 1985; Nwokolo, 1986). However, there is a need to diversify the use of the seeds by developing non traditional foods which would enhance wider utilization otherwise use of the seeds may be limited to only traditional culinary preparations when the seeds have potentials for other applications. This study therefore aims at developing a suitable processing method for the production of *Treculia africana* seed milk. The developed milk was also evaluated for sensory, physico-chemical and micro-biological properties.

## Materials and Methods

African bread fruit (*Treculia africana)* seeds, sucrose and vanilla were procured from Nsukka main market in Enugu State, Nigeria. All chemicals used were of reagent grade and were bought from a chemical store in Nsukka.

**Preparation of sample:** African bread fruit seeds were dehulled after parboiling as described by Onweluzo and Odume (2007). Based on the results of some preliminary trial experiments, milk was extracted from the dehulled seeds by using two blanching treatments (water and alkali ) and five seed to water ratios (1:1 to 1:5). Parboiled freshly cleaned African breadfruit (2.5 kg) was soaked in deionized water at 27°C±2°C for 2 h. The soaked seeds were blanched for 30 min at 105°C, cooled to room temperature, divided into 5 equal lots (500 g) and wet milled with seed to water ratios of 1:1, 1:2, 1:3, 1:4, 1:5 (w/v). Milling was done in a variable speed kitchen blender (National, Japan). Each slurry was filtered through double layered cheesecloth. The second treatment involved soaking and blanching similar weights of dehulled *Treculia africana* seed (500 g) in 0.2 % sodium bicarbonate under similar conditions of temperature and time as the water blanch treatment. Each lot (500 g) was also wetmilled with similar seed to water ratios (1:1, 1:2, 1:3, 1:4, 1: 5 w/v) and filtered as described for the water blanched treatment. Sucrose 2 % (w/v) was added to each filtrate after which the extracts were homogenized and pasteurized by heating at 121°C for 15 min. Prior to bottling in 10 ml sterilized screw capped plastic bottles, each extract was flavoured with vanilla 0.1 % (w/v). Soymilk which served as a reference vegetable milk was produced with the 536 variety of soybean using the International Soybean Program (INTSOY) method as described by Enwere (1998).

**Sensory evaluation:** Sensory evaluation of the products was conducted in two stages. The first stage was a consumer preference test done by a panel of 20 judges who rated the products on a nine point scale where the highest point (9) represents the most preferred and the least point (1) represents the least preferred. Two most preferred products from each treatment were subsequently evaluated by a 20 member sensory panel on a 9 point hedonic scale (where 9 represents excellent and 1 very poor) for colour, flavour, taste, mouth feel and overall acceptability. The panelists were selected on the basis of their familiarity with vegetable milk. Soymilk and vitamilk served as controls.

**Physico-chemical analysis:** The selected *Treculia africana* seed milk (TRASMS) from both treatments were analyzed alongside the controls for composition, apparent viscosity, total solid, titrable acidity and pH using standard methods. Protein (N x 6.25), fat, ash, moisture, total titrable acidity (TTA) (calculated as lactic acid), total solids and pH were determined according to AOAC (1990) methods. Carbohydrate was calculated by difference. Viscosity was measured at 29 ± 2°C with the Ferranti portable viscometer. Mineral analysis was done by the dry ashing method. Calcium (Ca), Iron (Fe) and Zinc (Zn) were determined from the ash using Atomic Absorption Spectrophotometer. Phosphorus (P) was determined by the molybdovanadate method. Vitamin C was determined by the 2, 6,-dichlorophenol method as described by Osborne and Voogt (1978).

**Microbiological analysis:** Total viable count (TVC) of $10^2$ dilution of each beverage was determined by the pour plate method on nutrient agar as described by Harrigan and McCance (1976). Incubation was done at 37°C for 48 h Presumptive test for Coliform was done using MacConkey's broth and incubation was at 37°C for 48 h.

**Data analysis:** Data were analyzed statistically using the Genstat 5 release 3.2 (1995). The least significant difference (LSD) test was used to test differences between means.

## Results and Discussion

Results of the consumer preference test showed that the overall acceptance of the ten products was in the order of water blanched milk (WBM) 1:1 > WBM 1:2 > Alkali blanched milk (ABM) 1: 1 > ABM 1:2 > WBM 1: 3 > ABM 1: 3 > WBM 1: 4 > ABM 1: 4 > WBM 1: 5 > ABM 1: 5. with corresponding values of 8.2, 7.6., 7.5, 6.7, 4.9, 4.8, 4.2, 3.8, 3.5 and 3.0 respectively. In both water and alkali blanched treatments, the 1:1 and 1:2 ratio milks showed relatively higher mean scores which differed significantly ($P \leq 0.05$) from the mean scores of the 1:3, 1:4 and 1:5 ratio milks consequently the 1:1 and 1:2 ratios of both treatments were produced and compared with the reference vegetable milks. Table 1 shows the mean sensory evaluation scores of the selected formulated milks and the control vegetable milks (soymilk and vitamilk). Significant ( $P \leq 0.05$) differences were observed between products from the two treatments and between the formulated *Treculia africana* seed milk and the controls. Milks from the alkali blanched treatment were light brown in colour and had low mean colour score which differed significantly ($P \leq 0.05$) from the colour scores of the controls and water blanched milks. The light brown colour may have been caused by a mild degree of enzymatic browning (Omueti *et al.*, 1992). Alkali blanching has been used in soy products to reduce flatulence, beany flavour and throat catching sensations (Ihekoronye and Nnanyelugo, 1989). The water blanched milks on the other hand had egg shell white colour and mean colour scores that compared with the controls. The flavour, taste and overall acceptability mean scores of milks from the water blanch treatment were higher ( $P \leq 0.05$) than those of the alkali blanch treatment but lower ($P \leq 0.05$) than those of the vitamilk ( control). Vitamilk had the highest ( $P \leq 0.05$) mean score for mouth feel. This high mean score of vitamilk for mouth feel was attributed to its higher fat content (Table 2). Fat is known to promote

Table 1: Mean sensory evaluation of selected *Treculia africana* milk, soymilk and Vitamilk

| Sample | Colour | Flavour | Taste | Mouth feel | Overall acceptability |
|---|---|---|---|---|---|
| $TRASM_W$ 1:1 | 6.15$^{a}$ | 6.45$^{b}$ | 6.20$^{ab}$ | 6.63$^{bc}$ | 5.95$^{b}$ |
| $TRASM_W$ 1:2 | 6.10a | 6.05$^{bc}$ | 5.90$^{bc}$ | 6.25$^{c}$ | 5.75$^{b}$ |
| $TRASM_a$ 1:1 | 5.50$^{b}$ | 5.35$^{c}$ | 4.70$^{c}$ | 6.47$^{bc}$ | 4.60$^{c}$ |
| $TRASM_a$ 1:2 | 5.68$^{b}$ | 5.20$^{c}$ | 4.75$^{c}$ | 6.33$^{c}$ | 4.65$^{c}$ |
| Vitamilk | 6.60$^{a}$ | 8.75$^{a}$ | 7.30$^{a}$ | 8.27$^{a}$ | 8.95$^{a}$ |
| Soymilk | 5.95$^{ab}$ | 5.90$^{c}$ | 6.10$^{b}$ | 7.20$^{b}$ | 6.30$^{b}$ |
| LSD | 0.68 | 1.15 | 1.20 | 0.85 | 1.10 |

*Treculia africana*Mean with different superscripts on the same column differ significantly ($P < 0.05$). $TRASM_W$ = Water blanched. Treculia africana seed milk. $TRASM_a$ = Alkali blanched *Treculia africana*. 1:1 and 1:2 = Ratio of *Treculia africana* to extractant (deionised water)

Table 2: Selected physio-chemical properties of *Treculia africana* seed milk, soymilk and Vitamilk

| Constituents | $TRASM_W$ 1:1 | $TRASM_W$ 1:2 | $TRASM_A$ 1:1 | $TRASM_A$ 1:2 | Soymilk | Vitamilk | LSD |
|---|---|---|---|---|---|---|---|
| Protein (N x 6.25) | 3.85$^{b}$ | 3.35$^{b}$ | 3.27$^{bc}$ | 3.15$^{c}$ | 3.20$^{b}$ | 6.0$^{a}$ | 0.54 |
| Fat (%) | 1.78$^{c}$ | 1.32$^{e}$ | 1.81$^{c}$ | 1.55$^{d}$ | 3.40$^{b}$ | 3.84$^{a}$ | 0.04 |
| Ash (%) | 0.93$^{b}$ | 0.89$^{b}$ | 0.96$^{b}$ | 0.92$^{b}$ | 0.98$^{b}$ | 1.23$^{a}$ | 0.21 |
| Moisture (%) | 89.92$^{b}$ | 91.20$^{a}$ | 90.88$^{a}$ | 91.36$^{a}$ | 90.09$^{b}$ | 81.41$^{c}$ | 0.65 |
| Carbohydrate | 3.52$^{b}$ | 3.33$^{b}$ | 3.08b$^{c}$ | 3.02$^{bc}$ | 3.13$^{b}$ | 5.62$^{a}$ | 0.42 |
| pH | 5.37$^{b}$ | 5.41$^{b}$ | 5.84$^{b}$ | 5.75$^{b}$ | 6.25$^{a}$ | 6.44$^{a}$ | 0.52 |
| Viscosity (cp) | 0.58$^{b}$ | 0.54$^{bc}$ | 0.69$^{b}$ | 0.66$^{b}$ | 0.56$^{b}$ | 0.98$^{a}$ | 0.22 |
| Total solid (%) | 9.64$^{c}$ | 9.22$^{c}$ | 11.50$^{b}$ | 11.24$^{b}$ | 9.62$^{c}$ | 13.60$^{a}$ | 0.96 |
| Total titrable acidity (%) | 0.32 | 0.33 | 0.36 | 0.34 | 0.24 | 0.23 | 0.001 |
| Mineral (mg/100ml) | | | | | | | |
| Calcium | 0.44$^{b}$ | 0.40$^{c}$ | 0.45$^{b}$ | 0.38$^{c}$ | 0.47$^{b}$ | 8.25$^{a}$ | 0.02 |
| Iron | 0.52$^{b}$ | 0.40$^{c}$ | 0.48$^{b}$ | 0.46$^{b}$ | 0.56$^{b}$ | 0.64$^{a}$ | 0.06 |
| Phosphorus | 36.20$^{c}$ | 34.8$^{cd}$ | 35.6$^{c}$ | 34.50$^{cd}$ | 38.40$^{b}$ | 44.60$^{a}$ | 1.40 |
| Zinc | 0.42$^{cd}$ | 0.32$^{d}$ | 0.40$^{c}$ | 0.35$^{d}$ | 0.70$^{b}$ | 0.75$^{a}$ | 0.04 |
| Vitamin (mg/100ml) | | | | | | | |
| Vitamin C | 3.62$^{ab}$ | 3.46$^{b}$ | 3.54$^{b}$ | 3.38$^{b}$ | 4.21$^{a}$ | 4.67$^{a}$ | 0.64 |

*Treculia africana*, $TRASM_W$ = Water blanched *Treculia africana* seed milk. $TRASM_a$ = Alkali blanched *Treculia africana*.
1:1 and 1:2 = Ratio of *Treculia africana* to extractant (deionised water)

good mouthfeel (Mustakas, 1974). However, the panelists commented that all the formulated *Treculia africana* seed milks had no prominent throat catching sensation that is characteristic of some vegetable milks. The formulated *Treculia africana* seed milks were all acceptable because the mean scores of the sensory attributes were above the average score of 4.5, however milks from the alkali blanch treatment were least preferred. Table 2 show selected physico-chemical properties of the products. The crude protein content of *Treculia africana* seed milks ranged from 3.15 % to 3.85 % and were comparable to the protein content of soymilk (3.20 %) but lower ($P \leq 0.05$) than the crude protein content of vitamilk (6.0 %). Vitamilk is actually a blend of vegetable and dairy milk. The level of protein in *Treculia africana* seed milks were comparable to the protein content of melon seed milk (3.67 %) and soybean milk (3.3 %) reported by Akubor (1998) and Onweluzo and Owo (2005), but higher than the protein content of benniseed milk (2.86 %) and soybean milk (2.71 %) reported by Nnam (2003). Yazici *et al.* (1997) had earlier reported a protein content of 5.25 % for soybean milk. Apparently these differences in protein values reflect differences in seed variety, composition, method of extraction and pre-extraction treatments. It is however noteworthy that the protein content of *Treculia africana* seed milk compare favourably with that of dairy milk (3.5 %) reported by Passmore and Eastwood (1986). *Treculia africana* seed milk from the alkali blanch treatment had marginally ($P > 0.05$) lower crude protein than milk from the water blanched treatment. The difference was attributed to leaching. Alkali treatment may have enhanced hydration of the seeds consequently causing increased permeability of the cotyledons and hence more efficient leaching of some soluble proteins into the soaking and blanching medium. Omueti *et al.* (1992) reported similar decrease in alkali blanched samples. However Beuchat and Nail (1978) in contrast reported higher protein in peanut milk extracted after 1 % Sodium bicarbonate treatment than in the untreated milk. Although alkali blanching reduces beany flavour and throat catching sensation in vegetable milks, it has been shown that alkali process can also have undesirable nutritional toxicological consequences like the formation of unusual peptides and amino acids such as lysino-alanine and D-amino acids (Friedman *et al.*, 1984). Crude ether extract of the milks ranged from 1.32 % to 1.78 % and 1.33 % to 1.81 % for the water and alkali blanched extracts respectively. The slightly higher ($P > 0.05$) ether extract in alkali blanched milks relative to the water blanched milks may be a reflection of the losses in protein and carbohydrate due to leaching. The level of ether extract in all the *Treculia africana* seed milks were unexpectedly lower than those of the controls and the minimum (3 %) level required by the Codex Alimentanrius Standard (Passmore and Eastwood, 1986). Total ash in the milks were low but comparable to the ash content of melon seed milk (Akubor, 1998). Milks from the alkali blanched *Treculia africana* seed had slightly ($P > 0.05$) higher ash level than those from the water blanched seeds. All the *Treculia africana* seed milks and the controls had lower carbohydrate content than human (6.8 %) and dairy (5.0 %) milks. Leaching may have caused the observed lower ( $P > 0.05$) carbohydrate in alkali blanched milks compared to that in water blanched milks. *Treculia* seed milks had pH that ranged from 5.37 to 5.84 and inversely related to the titrable acidity. Milks from the alkali blanch showed slightly ( $P > 0.05$) higher pH than the water blanched milks. Beuchat and Nail (1978) reported similar effect in peanut milk. The alkali treatments may have induced the solubilization of some basic components that influenced the slight increase in pH. The slightly acidic pH of *Treculia* seed milk may be an advantage because it may not encourage the growth of pathogens that may cause gastrointestinal problems. Soymilk and vitamilk had higher pH (6.25) and (6.44) respectively than *Treculia africana* seed milks and the pH were comparable to the pH of melon seed milk (6.25) cowpea milk (6.79) and soymilk (6.6) reported by Akubor (1998); Nnam (2003) and Onweluzo and Owo (2005). *Treculia africana* seed milks from the alkali blanch had higher ($P \leq 0.05$) total solids than the water blanched milks. Alkali soaking and blanching probably influenced the extractability of more *Treculia africana* seed solids. Nsofor and Osuji (1997) reported higher total solids in soymilk from alkali blanch treatment than in soymilk from water blanch treatment. Total solid content of *Treculia africana* seed milk from the water blanch compared favourably with those of soymilk (Table 2). However the values were lower than the total solids content reported for melon seed milk (13.0 %) by Akubar (1998) but higher than the values reported for soymilk (7.16 %), benniseed milk (6.94 %), melon seed milk (7.21 %) and groundnut seed milk (7.21 %) by Nnam (2003). Expectedly the apparent viscosity of *Treculia africana* seed milks from the alkali blanch was higher ($P > 0.05$) since it contained higher concentration of suspended solids. The observed higher apparent viscosity may have adversely affected the taste and mouthfeel scores for these products (Table 1). High apparent viscosity usually influence sensory attributes of foods particularly mouth feel and taste.

**Minerals and vitamin C:** Calcium content of *Treculia africana* seed milks ranged from 0.38 to 0.45 mg/100ml and compared with the calcium content of soymilk (0.47 mg/100ml) but differed ($P \leq 0.05$) from that of vitamilk (8.25 mg/100ml. Apparently only a negligible proportion of this mineral was extracted into the milk because parboiled *Treculia africana* seeds has been reported to contain between 15 mg/100g to 23.6 mg/100g Calcium (Edet *et al*., 1985; Lawal and Bassir, 1986; Onweluzo and Odume, 2007). The level of Calcium in *Treculia africana* seed milk can be augmented through controlled fortification that will not induce instability problems particularly with regards to the protein content (Rasyid and Hansen, 1991). Vegetable milk preparations are usually fortified with Calcium and Iron salts. Treatment did not have any significant ($P > 0.05$) effect on the mineral content of *Treculia africana* seed milk. The observed marginal differences were attributed to dilution effect. The level of Iron in *Treculia africana* seed milks (0.40 to 0.52 mg /100ml) compared with the level in soymilk (0.56 mg/100ml) reported by Enwere (1998). This level of Iron in *Treculia africana* seed milk is slightly higher than the level in dairy and human milk (0.1 to 02 mg/100ml) which are known to be deficient in Iron (Passmore and Eastwood, 1986). The level of Phosphorus (36.2 mg/100ml-34.5 mg/100ml) in *Treculia africana* seed milks were quite low compared to values reported for beniseed milk (49.24 %) and groundnut milk (64.2 %) by Nnam (2003). The level of phosphorus extracted into the milk was equally low since parboiled *Treculia africana* seeds has been reported to contain as high as 139.0 mg/100g phosphorus (Lawal and Bassir, 1986). Phosphorus content of *Treculia africana* seed milks was also low ($P \leq 0.05$) compared to the control. The zinc content of *Treculia africana* seed milks ranged from 0.32 mg/100ml to 0.42 mg/100ml and differed significantly ($P \leq 0.05$) from that of the controls (0.7 mg/100ml and 0.75 mg/100ml for soymilk and vitamilk respectively). The level of Zinc in *Treculia africana* seed milks was low compared to the level in parboiled *Treculia africana* seed (7.5 mg/100g) reported by Edet *et al*. (1985). This level of Zinc is also lower than the value reported for African yam bean milk (3.25 mg/100ml) by Nnam (2003). It is however expected that the levels of minerals in vegetable milk will vary with the level in the seeds from where the extracts were produced, the method of extraction and ratio of extractant to the seed or meal among other factors.

**Vitamin C:** *Treculia africana* seed milks contain appreciable amount of vitamin C varying from 3.62 mg/100ml to 3.46 mg/100ml for the water blanched sample and from 3.54 mg/100 to 3.38 mg /100 ml for the alkali blanched samples. The level of vitamin C in *Treculia africana* seed milk was lower ( $P \leq 0.05$) than the level in soymilk (4.21 mg/100ml) and vitamilk (4.67 mg/100ml) but higher than the level in dairy milk (2.0

mg/100ml). This difference is understandable because vitamin C is synthesized primarily by plants.

**Microbiological quality:** There was no gas positive tube indicating the absence of coliform in any of the milk sample used for the study. The total viable count (TVC) of the milks were 2.30 x $10^2$, 2.20 x $10^2$, 1.80 x $10^2$, 1.50 x $10^2$ 2.20 x $10^2$ and 2.24 x $10^2$ cfu/ml for water blanched *Treculia africana* seed milk (TRASM) 1:1, TRASM 1:2, alkali blanched TRASM 1:1, TRASM 1:2, soymilk and vitamilk respectively. These values are below the limit of acceptable counts for dairy milk (Jay, 1978) Evidently pasteurization of the vegetable milk extract as was done at 121°C for 15 min effected maximum destruction of micro-organism and made the products microbiologically safe.

**Conclusion:** Results of this study show that water blanching treatment ensures the inclusion of the inherent nutrients in *Treculia africana* seed into the milk extract better than alkali treatment. Alkali blanching in addition had adverse effect on the sensory attributes and acceptability of the milk though it enhanced some physico-chemical properties. It is evident that the nutrient composition of *Treculia africana* seed milk compare favourably with other vegetable milks like soymilk. The level of Fe in the milk is particularly noteworthy considering the nutritional significance of this trace mineral and the fact that its level in dairy and human milk is relatively low.

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