IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 3 Issue 12, December 2016
ISSN (Online) 2348 – 7968 | Impact Factor (2015) - 4.332
www.ijiset.com

Influence of Salts at Different concentrations on the Foaming Properties, Water and Oil Absorption Capacities of Raw and Treated *Treculia africana* Seeds Flour

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Abstract

Effects of salts at different concentrations (0.00 – 10.0 % w/w) and traditional processing methods (dehulling, roasting and moist cooking), were investigated using standard analytical methods on the foaming properties, water and oil absorption capacities of the raw seeds flour of *Treculia africana* (African breadfruit). The results showed that between the salts concentrations range of 0.5 and 2.0 % w/w, for NaCl and $NaNO_3$ gave better foaming properties (capacity and stability) for the samples and the trend among the various processing methods were: whole seed flour > dehulled seed flour > seeds testa flour and raw sample > roasted sample > cooked sample. Also for the water and oil absorption capacities, dehulling and roasting enhanced the levels for salts (NaCl, CH_3COONa, Na_2SO_3 and $NaNO_3$) within the concentrations range of 0.5 to 2.0 % w/w. Based on the functional properties (foaming capacities and stabilities, water and oil absorption capacities) as affected by salts solutions and traditional treatments established in this report, complete or partial inclusion of *Treculia africana* seeds flour in cake making, toppings and snacks production should be encouraged.

Keywords: *Treculia africana, Processing methods, Functional Properties.*

1. Introduction

For decades and even presently, the main plant source of proteins in human diet remains legumes together with cereals. They have also been reported to be generally rich in dietary fibre and carbohydrates (Rochfort and Panozzo, 2007)). Legumes contain minor compounds such as lipids, polyphenols, and bioactive peptides (Pastor-Cavada *et al.*, 2009). Legumes will therefore continue to play important part in diets in the foreseeable future. Sirtorti and Lovati (2001) reported that legumes provide a good source of protein (18-35%), minerals and vitamins of B complex which could safely supplement cereals and their products, a good example is the refined cereals such as white wheat flour which are used in a poor diet with few supplementary foods. Plant food diets increase the level of fibre intake which reduces the risk of bowel diseases, including cancer and also reduction in osteoporosis incidence. Moderately high content of protein (9.0-16.0 %) and carbohydrates (65 - 75%) contents together with amino acid pattern complementary to that of cereal grains; however make *Treculia africana* seeds flour a potentially important nutritional component in the human diet (Adesina and Adeyeye, 2015).

In order to successfully introduce a new supplementation into any food item, it is imperative to find out if the supplementation possesses suitable functional properties for food applications and consumer acceptability. These functional properties are the intrinsic physico-chemical characteristics which may affect the behavior of food systems during processing, storage and consumption, such as solubility, foamability, gelation and emulsification properties (Oshodi and Ekperigin, 1989). It was reported that foamability is related to the rate of decrease of the surface tension of the air/water interface caused by absorption of protein molecules (Sathe *et al*., 1982), while Adebowale *et al.* (2005) linked good foamability with flexible protein molecules, which reduces surface tension. Low foam ability on the other hand can be related to highly ordered globular proteins, which resists surface denaturation. The basic requirements of proteins as good foaming agents are the ability to (i) absorb rapidly at the interface (air/water) during bubbling, (ii) undergo rapid conformational change and rearrangements at the interface and (iii) form a cohesive viscoelastic film via intermolecular interactions. The first two factors are essential for better foamability whereas the third is important for stability (Nwosu, 2010, Eltayeb *et al*., 2011).

Solubility of a protein is one of the critical functional attributes required for its use as a food ingredient, because solubility greatly influences other properties, such as emulsification, gelation and foaming (Wang and Kinsella, 1976). Thus it determines the behavior of a protein food product. For plant proteins to be useful and successful in food application they should ideally possess several desirable characteristics, referred to as functional properties. Therefore, the present study was aimed to study the effects of salts and traditional processing methods on the functional properties (foaming properties, water and oil absorption capacities) of the raw, roasted and cooked whole seeds, dehulled and testa flours of *Treculia africana* seeds.

2. Materials and Methods

2.1 Collection of samples

The samples of African breadfruit (*Treculia africana*) seeds were obtained from a local farm in Odo-Ayedun town in Ekiti State, Nigeria. The samples were identified in the Department of Plant Science and Biotechnology, Ekiti State University, Ado-Ekiti. The seeds were properly sorted to remove the defected ones.

2.2 Treatment of sample

A quantity of 450 g of the *Treculia africana* seeds used for the analysis was divided into three parts (about 150 g each for raw, roasted and cooked samples). These forms of samples were prepared following the method described by Adeyeye (2010).

3. Functional properties determination

3.1 Preparation of salt solutions

0.5, 1, 2, 5 and 10% (w/w) concentrations of various salts used were prepared by weighing 0.5, 1, 2, 5 and 10g of salts (NaC1, Na_2CO_3, CH_3COONa and Na_2SO_3) which are respectively added to 99.5, 99, 98, 95 and 90 ml of distilled water for each solution to make up to 100 ml mark in a standard flask.

3.2 Determination of foaming capacity and stability

1g of the sample was whipped with 50ml of distilled water for 5 minutes in a blender (Excella Mixer Grinder, Model: 3.S.S. Jars, India) at speed set at maximum and was transferred into a 100ml graduated glass cylinder. Total volume at time interval of 0.0, 0.05, 0.1, 0.2, 0.3 and 1.0 hour was noted to study the foaming stability. Volume increase (%) (Foaming capacity) was calculated according to the following equation to obtain the foaming capacity (Coffman and Garcia, 1977).

$$FC = \frac{\text{Vol.after whipping} - \text{Vol.before whipping}}{\text{Vol.before whipping}} \quad (1)$$

3.3 Determination of foaming stability

Foam stability is determined by dividing the volume of foam at a given time by total foam level.

$$FS = \frac{\text{Foam vol. after time,t}}{\text{Initial vol. of foam}} x100 \quad (2)$$

3.3 Determination of water and oil absorption capacities

The water and oil absorption capacities of the sample were determined as described by Beuchat *et al.* (1975). $10cm^3$ of water or salt solution was added to 1.0g of sample in a centrifuge tube. The suspension was mixed vigorously using vortex mixer. This was then centrifuged for 25 minutes and the volume of the supernatant left after centrifuging was noted. Water bound was calculated from the difference in volume of the initial volume of the solvent used and the final volume after centrifuging. The same procedure was used for oil absorption capacity (Inklaar and Fortuin, 1969).

4. Results and Discussion

4.1 Foaming capacity

Figures 1- 6 present the foaming capacity (FC) of raw, roasted and cooked *Treculia africana* seed flour samples under various salts (NaCl, Na_2CO_3, Na_2SO_3, CH_3COONa, $NaNO_3$) and salt concentrations (0.0 – 10 %) . The figures revealed that in the raw samples (raw whole seed flour, raw dehulled seeds flour, and raw testa flour), there was a decrease in foaming capacity with increase in concentration of salt from 0.0 – 10%. The FC values in Figure 1 showed that raw whole seed flour FC was $4.0cm^3$ (8.0%) at 0% concentration (distilled water), raw dehulled seeds flour FC was 8.0 cm^3 (16.0%), at zero percent concentration (distilled water) and raw seeds testa flour, FC was 2.0 cm^3 (4.0%) at zero percent concentration.

In the raw whole seeds flour, the highest FC observed from the salts influence was in NaCl at 2.0 % concentration [i.e. 11.0 (22.0 %)], in the raw dehulled seed flour, the highest FC was observed in CH_3COONa at 2.0 % conentration with the value being 13.5cm^3 (27.0 %) whereas the highest FC was observed in $NaNO_3$ at 10 % salt concentration for raw seed testa [3.5cm^3, (7.0 %)]. The figures also revealed that foaming capacity depends on concentration and types of salts used. There was a decrease in the foaming capacity with increase in concentration of salt from 1.0 to 10%. Fairly high variation in foaming capacity existed within the salt concentrations in all the samples as shown by the CV%. The values of foaming capacity in all the three samples were lower than the values earlier reported for hulled seed flours of African yam bean (AYB) (39.9- 55.4%), dehulled AYB seeds (21.3-48.4%) (Adeyeye and Aye, 1998), *Dolichos biflorus* L (Diwakar *et al.*,1996), *Cassia fistula* and *A. africana* (30.1 – 22.4%) (Adesina and Osobamiro, 2012). The low foaming capacities will reduce the functionality of *Treculia africana* seed in its uses for the production of some foods where foaming is an important factor like cakes (Johnson *et al.*,1979; Lee *et al.*, 1993).

Foaming capacities of roasted samples are depicted in Figure 2. For the roasted whole seeds flour, the FC value at 0.0% concentration (distilled water) was 8.0 cm^3 (16.0%), 9.0 cm^3 (18.0%) for the roasted dehulled seeds flour and 4.0 cm^3 (8.0%) for the roasted seeds testa flour. From the influence of salt concentration, the highest FC from the salt was observed in NaCl, the value being 8.0 (16.0%) at 2.0% salt concentration in the roasted whole seeds flour, 8.0 cm^3 (16%) observed in NaCl salt concentration for roasted dehulled seed flour whereas in the seeds testa flour, the highest value of 3.0 cm^3 (6.3%) was observed in NaCl at 0.5% salt concentration, in $NaNO_3$ 3.0 cm^3 (6.0%) at 0.5% salt concentration and 3.0 cm^3 (6.0%) in Na_2CO_3 at 1.0% concentration.

Figure 3 gave the foaming capacity of cooked whole seeds flour, cooked dehulled seeds flour, and cooked seeds testa flour at various salts concentrations. At zero percent concentration (distilled water), the FC values were: cooked whole seed flour (5.0 (12%)) cooked dehulled seed flour (6.0 cm^3 (12%)) and cooked seeds testa flour (3.0 cm^3 (6.0%)). With respect to the influence of salts in the cooked whole seed, the highest FC was observed in NaCl, at 2.0 % salt concentration (7.0 cm^3 (14 %)), in the cooked dehulled, the highest FC was noticed in NaCl and Na_2SO_3 at 1.0% concentration (6.0 cm^3 (12 %)), whereas in the testa flour, the highest FC was (3.5 cm^3 (7.0%)) as 2.0% NaCl concentration.

The reduced foaming capacities of heat processed flours in the present report could be explained on the basis of protein denaturation since proteins are heat-labile. According to the report of Desphande *et al.* (1982), the foaming capacities of dehulled dry beans (*Phaseolus vulgaris* L) flour was attributed to the ability of the proteins to denature, precipitate and lower the surface tension at the air-liquid interface of the foam. Diwakar *et al.* (1996) attributed foamability of flours to the configuration of the protein molecules; flexible protein molecules give good foamability but highly ordered globular molecules, which resist surface denaturation give low foamability (Adebowale *et al.*, 2005). The low foaming capacities of the heat processed *Treculia africana* seeds flour may therefore be attributed to denatured globular molecues as a result of high temperature of processing. Sathe *et al.* (1982) reported that foamability is related to the rate of decrease of the surface tension of the air/water interface caused by absorption of protein molecules. Furthermore, Graham and Philips (1976) linked good foamability with flexible protein molecules which reduces the surface tension. The basic requirements of proteins as good foaming agents are ability to (i) absorb rapidly at air/water interface during bubbling, (ii) undergo rapid conformational change and rearrangement at the interface and (iii) form a coehesive viscoelastic film via intermolecular interactions (Akaerue and Onweka, 2010).

In general the foaming capacities were better in the raw samples than both the roasted and cooked samples. Although, the FCs were low in the present samples, however, the values are comparably close to the values reported for pigeon pea (3.53 %) (Arawande and Borokini, 2010), pear millet and quinoa flours (11.3 and 9.0% respectively) (Oshodi *et al*.,1999). For a flour to be suitable for use as aerating agents in food systems, the values of FC should be high to sustain high foams when whipped (Kinsella, 1979). Other researchers have reported considerable reduction in the foaming capacities of heat-treated flours: mung bean (Akaerue and Onweka, 2010); cowpea (Giami, 1993); winged bean (Narayana and Nearing Rao, 1982); roasted bambara (Olapade and Adetuyi, 2007) and jack fruit (Odoemelam, 2005).

4.2. Foaming stability in various salt solutions

The foaming stability (FS) rate values for raw wholeseed flour in various salts solutions are presented in Figure 4 (NaCl, CH_3COONa, Na_2CO_3, Na_2SO_3 and$NaNO_3$). For the raw wholeseed flour sample, the order of increasing stability rates among the salts were Na_2SO_3 (0.106cm^3/min) > CH_3COONa (0.067cm^3/mins) = $NaNO_3$ (0.067cm^3/min) > NaCl (0.066cm^3/min) >Na_2CO_3

(0.061cm^3/min). The best concentration in terms of stability for NaCl was 2.0% (w/w), 2.0 % (w/w) for CH_3COONa, 2.0 % (w/w) for Na_2CO_3, 2.0 % (w/w) for Na_2SO_3 and 10 % (w/w) for Na_2CO_3, 2.0 % (w/w) for Na_2SO_3 and 10 % (w/w) for $NaNO_3$.

The foaming stability (FS) rate values for raw dehulled seeds flour in various solutions as shown in Figure 4 also revealed that most of the values of FS were better than those reported for AYB seeds (Adeyeye and Aye, 1998), pigeon pea (Oshodi and Ekperigin, 1989) and raw cowpea flour (Padmashree *et al.*, 1987). Foaming stability is important since success of a whipping agent depends on its ability to maintain the whip as long as possible.

The order of increasing foaming stability rates for raw dehulled seeds flour among the salts were: CH_3COONa (0.041cm^3/min) <NaCl (0.051cm^3/min) <Na_2CO_3 (0.061cm^3/min) < $NaNO_3$ (0.073cm^3/min) < Na_2SO_3 (0.093cm^3/min). The best salt concentration in terms of stability for NaCl was 5.0% (w/v); for CH_3COONa, 2.0% (w/w); for Na_2CO_3, 0.5% (w/w); for Na_2SO_3, 1.0% (w/w) and for $NaNO_3$, 1.0% (w/w).

Also in Figure 4, the foaming stability (FS) rates of raw seeds testa flour at various salts concentration showed that the order of increasing foaming stability rates among the salts were: CH_3COONa (0.083cm^3/min) < Na_2CO_3 (0.113cm^3/min) < Na_2SO_3 (0.121cm^3/min) <NaCl (0.15cm^3/min) < $NaNO_3$ (0.157cm^3/min) while the best salt concentrations in terms of foaming stability are: for NaCl, 2.0% (w/w); for CH_3COONa, 0.50% w/w); Na_2CO_3,1.0% (w/w); Na_2CO_3, 0.50% (w/w) and $NaNO_3$, 1.0% (w/w).

The foaming stability (FS) rates of roasted whole seeds, dehulled seed and testa flour at various salt concentrations were shown in Figure 5. For the roasted whole seeds flour as shown in the figure, the rates of foaming stability among the salts were in the following order: NaCl (0.059cm3/min) < Na_2CO_3 (0.094cm^3/min) < CH_3COONa = $NaNO_3$ (0.102cm^3/min) < Na_2SO_3 (0.113cm^3/min). The best salt concentrations as implied by the foaming stability were: for NaCl, 0.5% and 1.0% (w/w); for CH_3COONa, 1.0% (w/w); for Na_2CO_3, 0.5% (w/w); for Na_2CO_3, 0.5% (w/w); and for $NaNO_3$, 1.0% (w/w). The foaming stability of roasted dehulled seeds flour at various salt concentrations was also shown in Figure 5. It was revealed that the average rates of foaming stability in the various salts concentration are in the following order: NaCl (0.064cm^3/min) < CH_3COONa (0.068cm^3/min) < Na_2SO_3 (0.088cm^3/min) < Na_2CO_3 (0.140cm^3/min) < $NaNO_3$ (0.160cm^3/min). The best salt concentrations in terms of stability of the foams are: for NaCl, 0.5% (w/w); CH_3COONa, 2.0 % (w/w); Na_2CO_3, 0.5%, Na_2SO_3, 2.0% (w/w) and $NaNO_3$, 0.5% (w/w) whereas for the roasted seeds tetsa flour, the foaming stability raets in Figure 5 at various salts concentrations also showed that the order of increasing rates of foaming stability at various salt concentrations is as follows: CH_3COONa (0.114cm^3/min) <NaCl (0.139cm^3/min) < Na_2CO_3 =$NaNO_3$ (0.147cm^3/min). The best salt concentrations in terms of foaming stabilities were: NaCl (0.50% w/w), (1.0% w/w), CH_3COONa (0.55% w/w), Na_2CO_3 (1.0% w/w), Na_2SO_3 (0.50% w/v) and $NaNO_3$ (0.50% w/w).

Foaming stability of cooked whole seed, dehulled seed and testa flour at various salt concentrations were presented in Figure 6. The rates of foaming stabilities in the various salt solutions and at varying concentrations for the cooked wholeseeds flour are in the following order: NaCl=Na_2SO_3 (0.094cm^3/min) <$NaNO_3$ (0.123cm^3/min) < CH_3COONa (0.131cm^3/min). The best salt concentration with respect to foaming and stability were: NaCl (2.0%w/v), CH_3COONa (2.0 % w/v), Na_2SO_3 (10 % w/v), and $NaNO_3$ (2.0 % w/v). On the other hand, for the cooked dehulled seeds flour, the foaming stabilities as shown in the figure revealed that the average rates of foaming stability are in the following order: NaCl (0.085cm^3/min) < Na_2SO_3(0.11cm^3/min) <CH_3COONa=Na_2CO_3 (0.139cm^3/min) < $NaNO_3$ (0.146cm^3/mm) with the best salt concentration regarding the stability of the foams as NaCl (1.0 % w/w), CH_3COONa (2.0 % w/w), Na_2CO_3 (0.5 % w/w), Na_2SO_3 (1.0% w/w) and $NaNO_3$ (0.5 % w/w) and the foaming stabilities of the cooked testa flour at various salt concentrations were in the following order: CH_3COONa=$NaNO_3$ (0.92cm^3/min) > NaCl (0.150cm^3/min) with the best salt concentration in terms of foaming stability as: NaCl (2.0 % w/w), Na_2SO_3 (1.0% w/w) and $NaNO_3$ (0.5% w/w).

Generally going by the results of the foaming capacities and stabilities on sample group-wise basis, the trend was: whole seed flour > dehulled seeds flour >seeds testa flour and raw sample > roasted sample >cooked samples. However, the values obtained for raw and heat treated samples of *Treculia africana* seeds flour were comparatively lower than those reported for mung bean (Akaerue *et al.*, 2010); cowpea (Giami, 1993) and jack fruit (Odoemelam, 2005). The nature of native proteins and their responses to treatments actually dictate the levels and rates of foaming stability of legume flours. The poor foaming stability of the roasted and cooked *Treculia africana* seeds flour could be attributed to the denatured proteins in the flour (Yasumatsu *et al.*,1972). Despite the low stabilities in the present samples, it could be utilized as aerating agents for food products that require average foaming properties like whipped toppings, frozen desserts, sponge cakes etc.

4.3 Water Absorption Capacities

In Figure 7, the effect of salt on water absorption capacity of raw whole seeds flour showed that for all the salt the values of WAC increase with increase in salt concentration up to 2.0% and then decline within the concentration range, $NaNO_3$ salt has the highest level of WAC% among all the salts, the values being 170-200%.

In Figure 8, it appears that dehulling improved the %WAC at 0% concentration (123%).In all the salt solutions the %WAC increased between 0.5-2.0% concentrations with the peak occurring at 2.0% with a range of 130-150%. A little decline was noticed between 5.0% and 10% in all salt solutions; however an increase was noticed in Na_2SO_3 solution.

In Figure 9, the raw testa flour at 0 % salt concentration (distilled water) showed high %WAC of 220% compared to whole seeds flour and dehulled seeds flour. However, in the salt solution the %WAC increases with increase in concentration of salt (from 0.5-10%). In general, for the raw samples, the trend on WAC% can be summarized as raw < dehulled < testa flour.

Figures 10 - 12 gave the % water absorption capacities and effects of salt on the % WAC of roasted wholeseeds, dehulled seeds and testa flour. At 0 % salt concentration (distilled water), the %WAC were: roasted whole seeds (106 %), roasted dehulled seeds (105%) and roasted seeds testa (110 %). In Figure 10, for all the salts, the %WACs increase uniformly from 0.5% to 2.0% except for Na_2CO_3 and $NaNO_3$ whose values increased up to 5.0 % salt concentration, the range being 110-200 %. The highest values were observed in Na_2SO_3 and $NaNO_3$, 200% at 2.0% and 200 % at 5.0 % respectively. In Figure 11, at 0 %(water) roasted dehulled seeds flour has the value of %WAC of 105% among the salts used, NaCl, CH_3COONa, Na_2SO_3 and $NaNO_3$,have their %WAC value increasing with increase in salt concentrations (from 0.5-10 %) with their peak at 150-180 % range. However Na_2CO_3 solution has its values increased with increasing concentration up to 5.0% and then declined the highest being 150%. In Figure 12, the highest WAC was 150 % and a value of 110% at 0.0% (distilled water), and in all the salt solutions, the %WAC increased uniformly from 0.5% through 5.0% concentration with exception of Na_2CO_3 and $NaNO_3$ where the value increased with increase in concentration up to10% salt concentration. Roasting affected the %WAC of sample forms in the following order: roasted whole seeds flour < roasted dehulled seeds flour < roasted seeds testa flour. The best salt was Na_2CO_3.

Figures 13 - 15 gave the percentage water absorption capacities (%WAC) and the effects of salts on the cooked whole seeds, cooked dehulled seeds and seeds testa flour of *Treculia africana* seeds. In Figure 13, the effects of salt on water absorption capacity of cooked whole seeds flour showed that at 0.0% concentration (distilled water) the value of WAC (%) was 85.6.

At the various salts concentration the values increased rapidly and uniformly up to 10.0% concentration for Na_2SO_3 and $NaNO_3$, up to 5.0 % salt concentration for CH_3COONa and 2.0% for Na_2CO_3 before declining whereas fluctuations in % WAC at the various concentrations was noticed in NaCl. The best salt that encouraged WAC was $NaNO_3$. Na_2CO_3 had the highest % WAC of 200 at 2.0%. In Figure 4.8, % WAC and the effects of salts on cooked dehulled seed flours are shown in the following salt solutions; the % WAC increased with increase in salt concentrations from 0.5 to 10.0% in Na_2CO_3 and $NaNO_3$ whereas for NaCl, CH_3COONa and Na_2SO_3 solution, the % WAC increased with increased concentration up to 2.0%. The best salt concentration was Na_2SO_3 with a %WAC of 200 at 2.0%. For the cooked seed testa flour the %WAC level are presented in Figure 4.9. Percentage WAC increases with increased salt concentrations (0.5 to 10.0%) in CH_3COONa, Na_2CO_3 and $NaNO_3$. The best salt in this regard was Na_2CO_3 with a % WAC value of 220 at 2.0%. The variation in the water absorption capacity (%) among the various sample parts and treatments can be summarized as raw > roasted > cooked.

Protein has both hydrophilic and hydrophobic properties thereby can interact with water and oil in foods. The variation in water absorption capacity (%) in the samples may be due to different protein concentrations, their degree of interaction with lipids and possibly their conformational characteristics. Where there are lower values of % WAC the reason could be due to less availability of polar amino acid residue (Kuntz, 1971). Ragab *et al*. (2004) found that water absorption capacity for cowpea protein isolates was 220%, in the case of pea protein isolate, Fernandez-Quintela *et al*. (1997) observed 170% WAC. According to El-Adawy (2000), mung bean had water absorption capacity of 200% and for pigeon pea 87% (Mizubuti *et al*., 2000), 138% for pigeon pea flour, 107% for sunflower and 62.2% for wheat flour (Lin *et al*., 1974). The present results fell within the range earlier reported as enumerated above. The results were comparably lower than the values reported for cowpea flour (246%) (Olaofe *et al*., 1993) and bambara groundnut seeds flour (Adeyeye *et al*., 2013).

The values obtained for RWF and CWF agreed well with the values reported for wheat and soy flours (84.2 and 84.4% respectively) (Lin *et al.,* 1974). All the OAC values in the present report were comparatively higher than OAC value reported for *Triticum durum* (72.44%) (Adeyeye and Aye, 2005), *Afzelia africana* and *Cassia fistula* flours (Adesina and Osobamiro, 2012) and lower than the values obtained for many leguminous seeds (Adeyeye and Aye, 1998; Fagbemi and Oshodi, 1991). Oil absorption capacity is important since oil acts as a flavour retainer and increases the mouth feel of foods (Kinsella, 1976) and are as well important due to their storage stability especially in the development of oxidation rancidity (Siddiq *et al.*, 2010). The oil absorption capacity (OAC) of the raw undehulled mungbean flour was observed to be significantly ($p<0.05$) increased by toasting and boiling treatments (Akaerue and Onweka, 2010). Odoemelam (2005) reported that heat processing increased the oil absorption capacity of jackfruit flour from 2.8ml/g flour to 3.1ml/g flour. Giami (1993); Narayana and Nearing Rao (1982) reported similar increase in the OAC of heat processed cowpea flour and winged beanflour respectively. McWatters and Cherry (1981) also reported that proteins in foods influence fat absorption. It can be implied that some bean flours are better suited than others when a fried product is to be prepared (Siddiq *et al.*, 2010). The increased OAC have been attributed to the denaturation and dissociation of the constituent proteins that may occur on heating which unmasks the non-polar residues from the interior of the protein molecule (Narayana and Nearing Rao, 1982). The variations in the OAC of all the flour samples depend on the degree of denaturation of the proteins, the higher the denaturation, the higher the OAC. *Treculia africana* seeds flour would therefore be useful as a flavour retainer in certain food products.

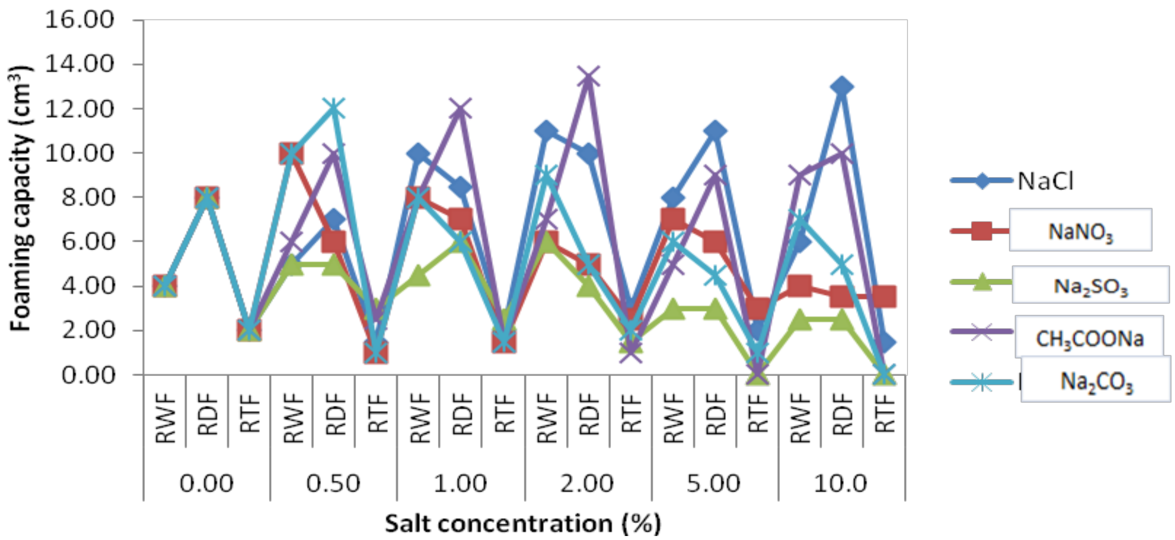

Figure 1. Foaming capacities of raw whole seed, dehulled seed and tetsa flours of *Treculia africana* in different salts and at varying concentrations

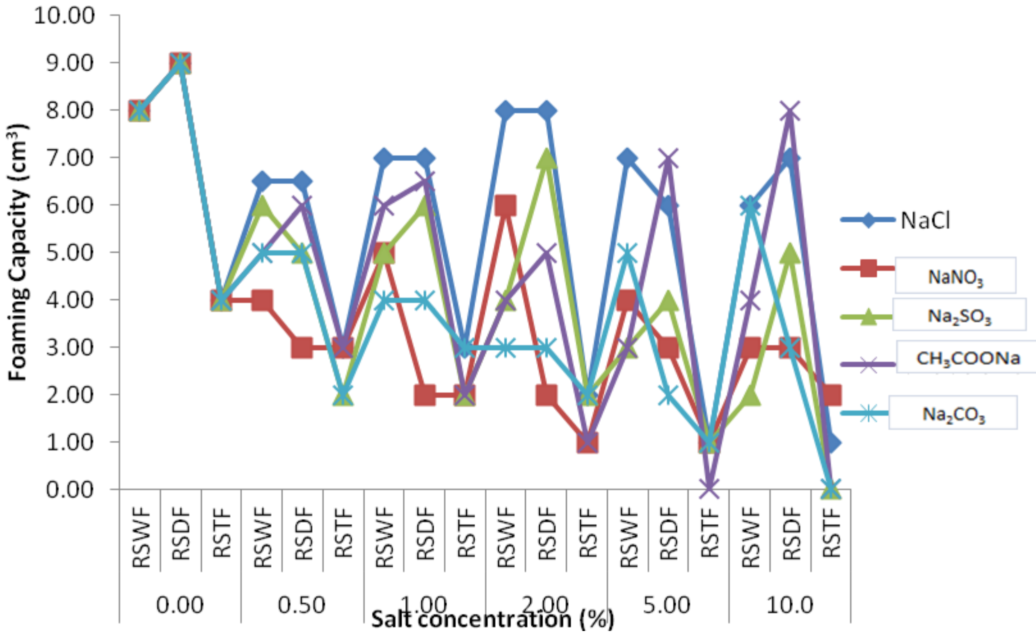

Figure 2. Foaming capacities of roasted whole seed, dehulled seed and tetsa flours of *Treculia africana* in different salts and at varying concentrations

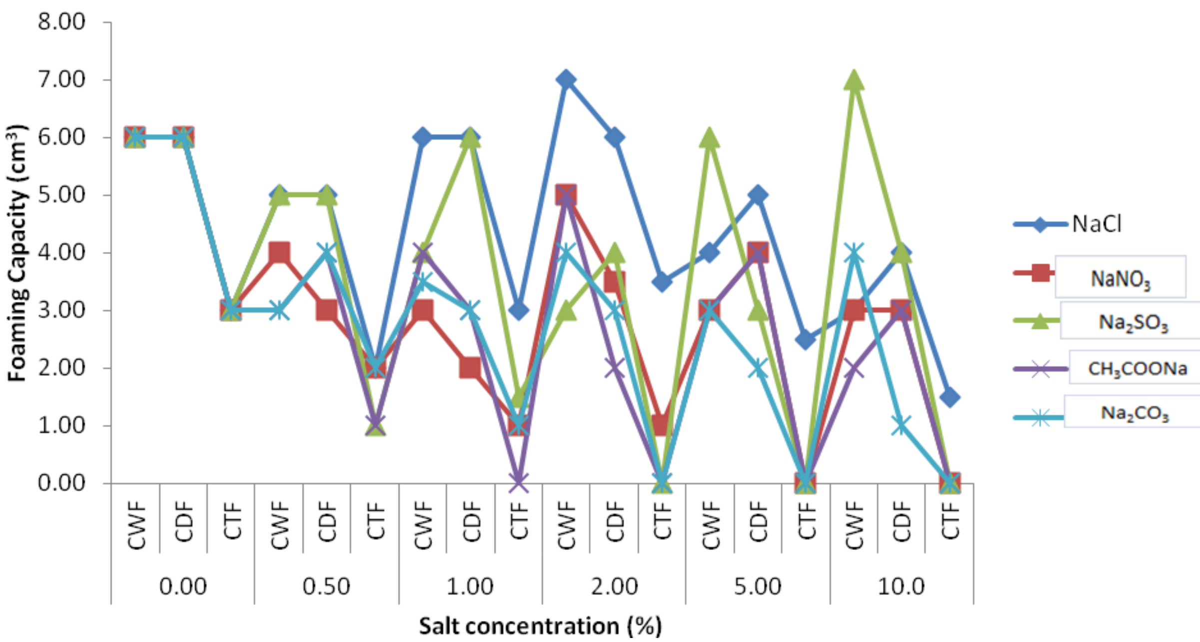

Figure 3. Foaming capacities of cooked whole seed, dehulled seed and tetsa flours of *Treculia africana* in different salts and at varying concentrations

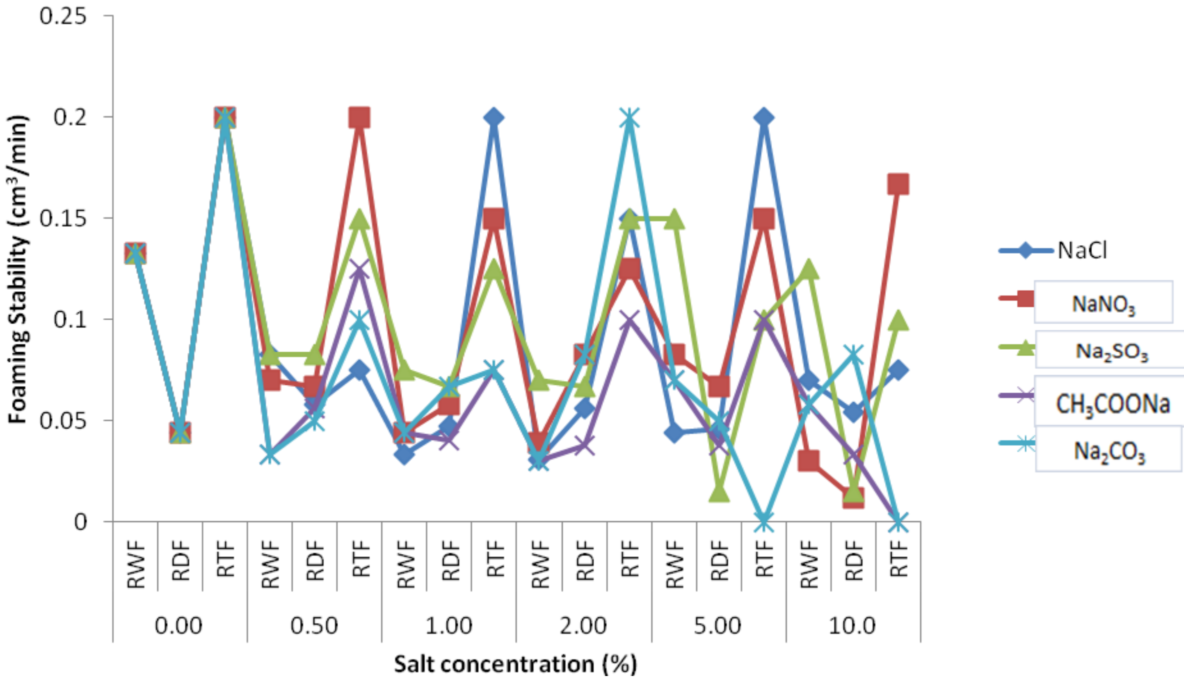

Figure 4. Foaming stabilities (cm^3/min) of raw whole seed, dehulled seed and tetsa flours of *Treculia africana* in different salts and at varying concentrations

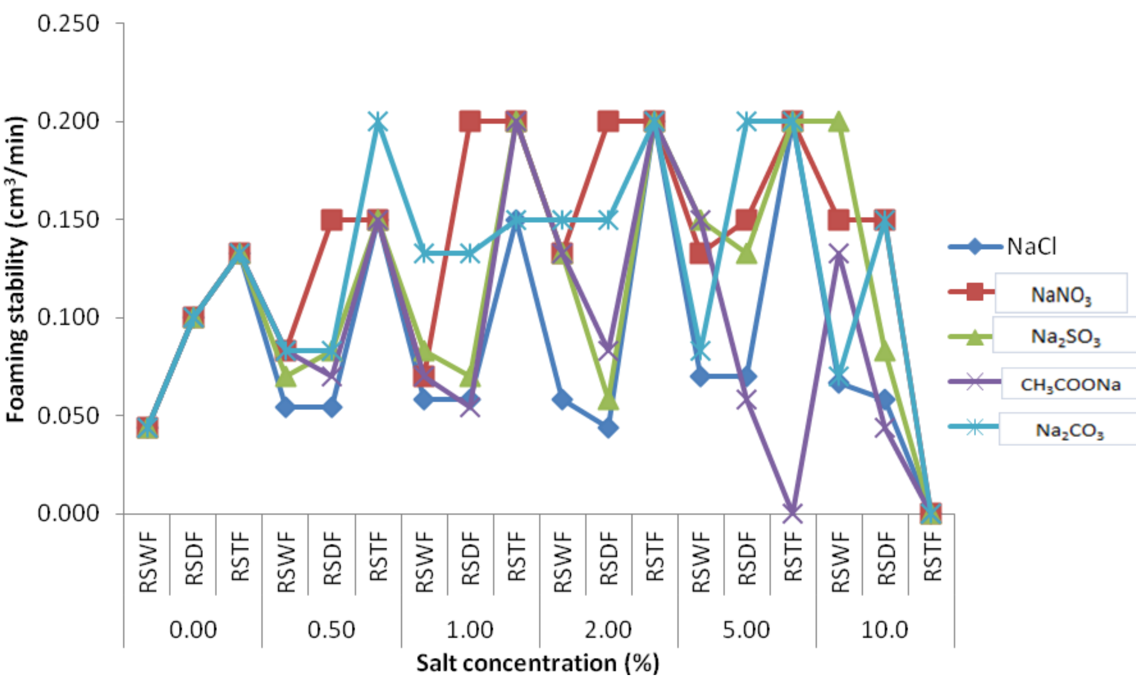

Figure 5. Foaming stabilities (cm^3/min) of roasted whole seed, dehulled seed and tetsa flours of *Treculia africana* in different salts and at varying concentrations

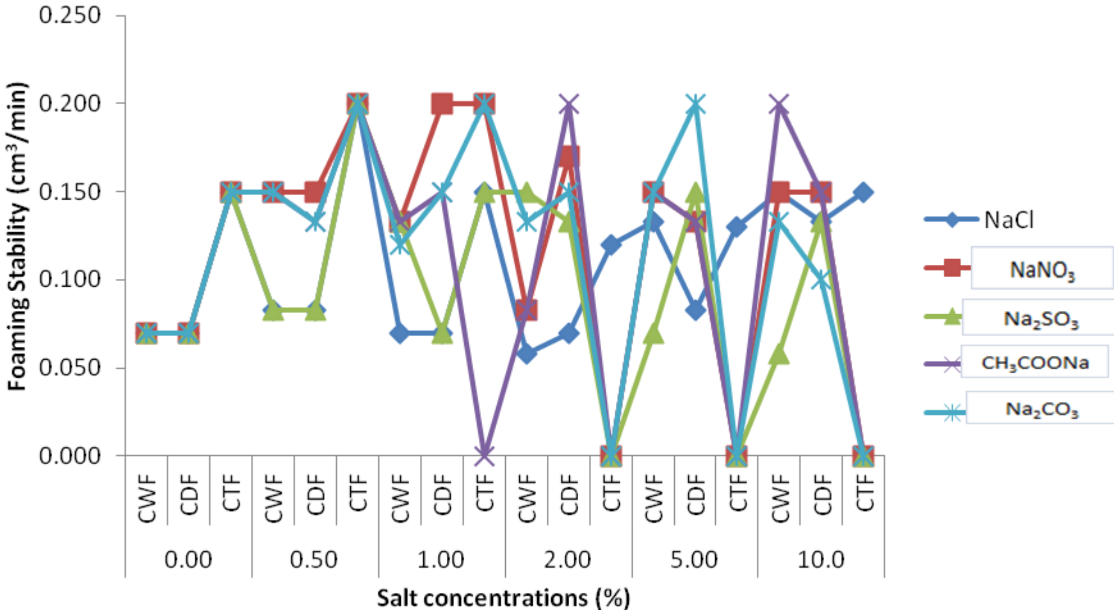

Figure 6. Foaming stabilities (cm^3/min) of cooked whole seed, dehulled seed and tetsa flours of *Treculia africana* in different salts and at varying concentrations

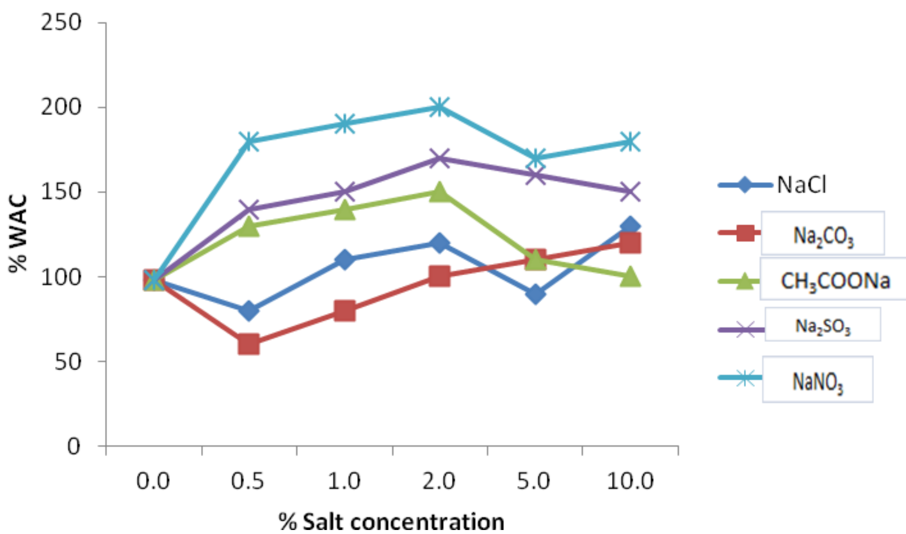

Figure 7. Effects of salts on the % water absorption capacity (WAC) of *Treculia africana* raw wholeseeds flour

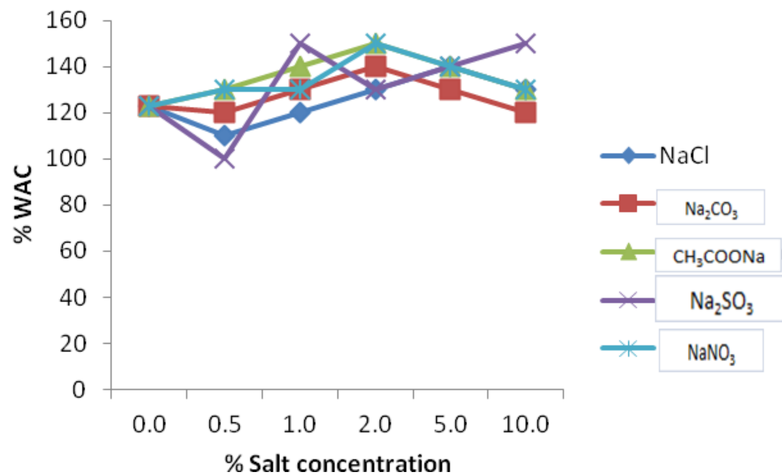

Figure 8. Effects of salts on the % water absorption capacity (WAC) of *Treculia africana* raw dehulled seeds flour

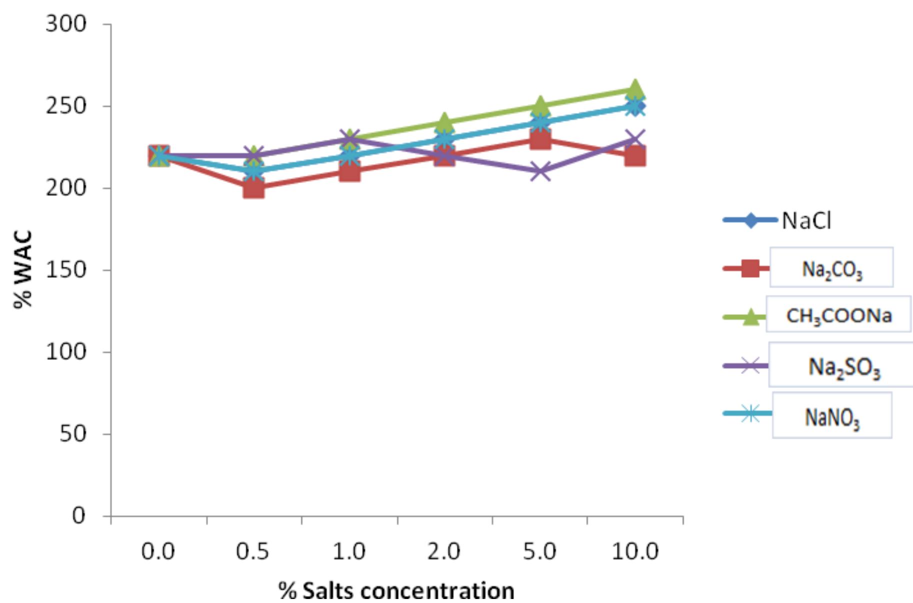

Figure 9. Effects of salts on the % water absorption capacity (WAC) of *Treculia africana* raw seeds testa flour

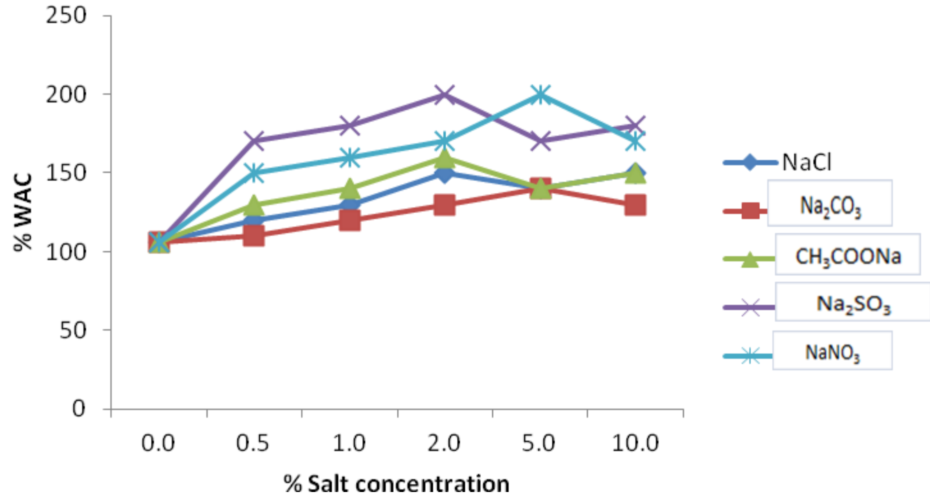

Figure 10. Effects of salts on the % water absorption capacity (WAC) of *Treculia africana* roasted whole seeds flour

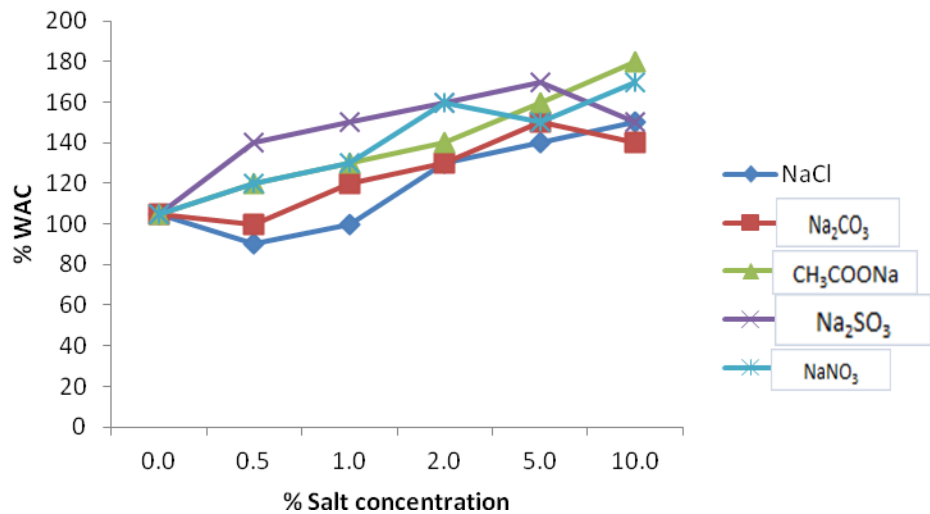

Figure 11. Effects of salts on the % water absorption capacity of *Treculia africana* roasted dehulled seeds flour

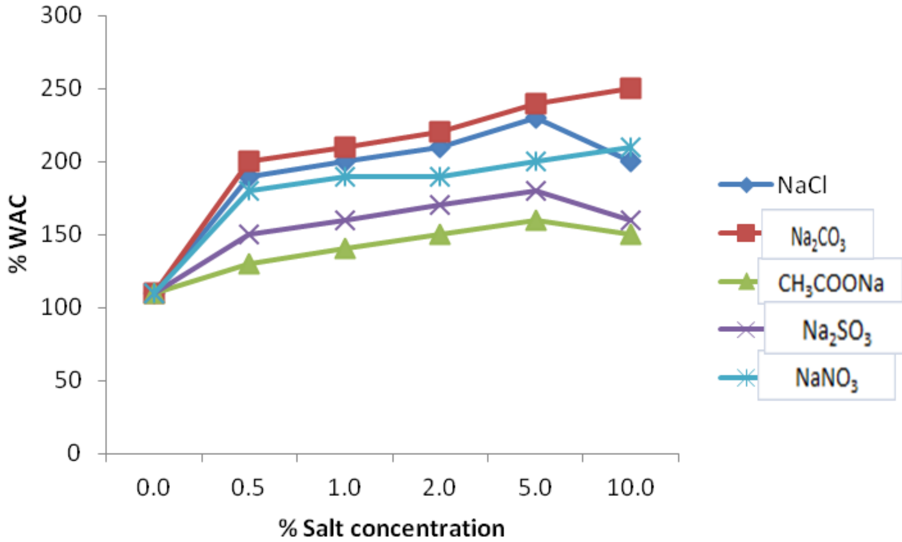

Figure 12. Effects of salts on the % water absorption capacity of *Treculia africana* roasted seeds testa flour

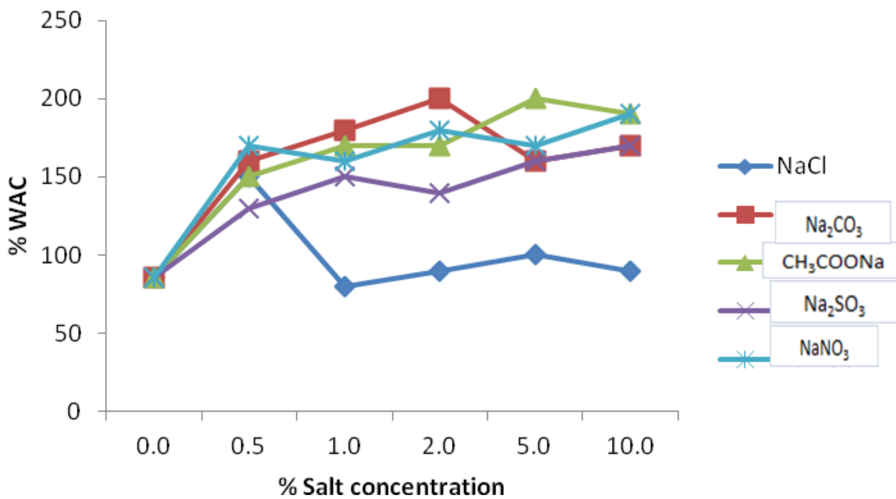

Figure 13. Effects of salts on the % water absorption capacity (WAC) of *Treculia africana* cooked wholeseeds flour

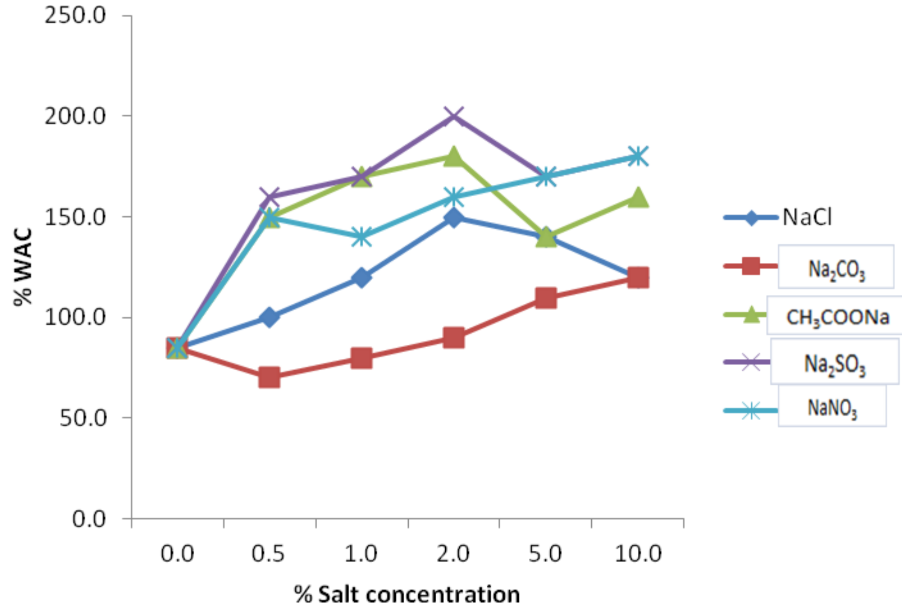

Figure 14. Effects of salts on the % water absorption capacity of *Treculia africana* cooked dehulled seeds flour

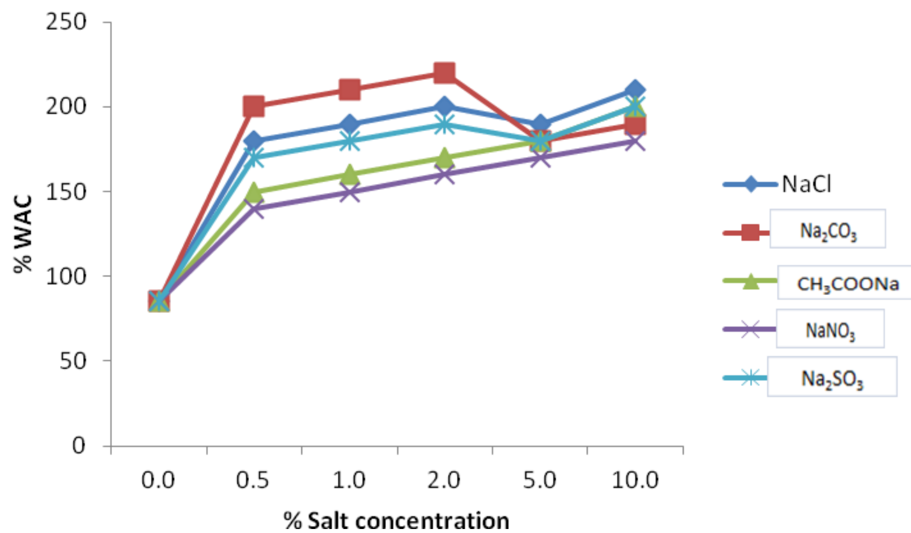

Figure 15. Effects of salts on the % water absorption capacity (WAC) of *Treculia africana* cooked seeds testa flour

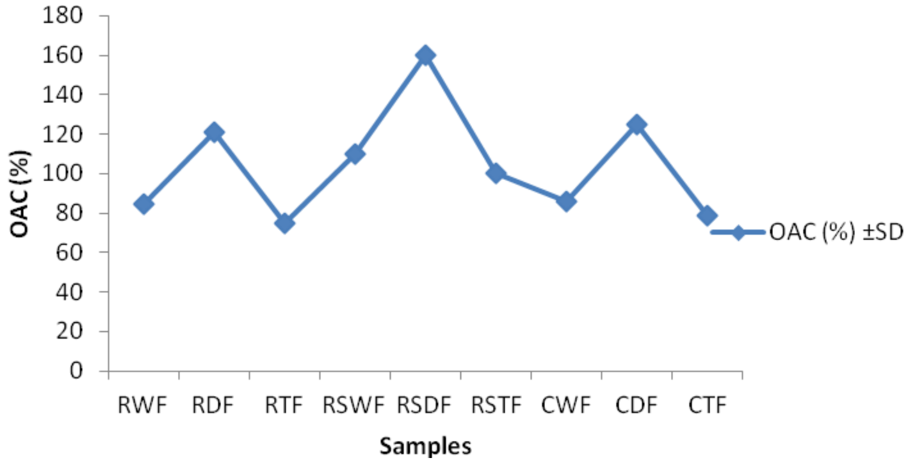

Figure 16. Oil absorption capacities (OAC) of raw, roasted and cooked *Treculia africana* seeds flour

5. Conclusion

The samples were good in water absorption capacity and oil absorption capacity but foaming capacity and stability are fair, although roasting improved these properties to an appreciable extent. Based on the functional properties already established in this research work, complete usage or partial inclusion of *Treculia africana* seeds flour in cake making and snacks production should be encouraged. Since a lot of improvements were noticed in mineral salts treatments, to further strengthen the functional properties in food formulations, salts such as NaCl and $NaNO_3$ may be employed. However, because of the health implications of sodium element, potassium salts (in this case KCl and KNO_3) may be used to replace NaCl and its nitrate since sodium and potassium salts have similar chemical behaviours. Also, when it is being used as food supplement especially for infants, *Treculia africana* seeds should be dehulled and roasted.

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