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Solubility and Functional Properties of Boiled and Fried Sudanese Tree Locust Flour as a Function of NaCl Concentration

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Abstract: The functional properties of defatted boiled and fried locust flour as a function of NaCl concentration were investigated. The protein solubility, emulsifying activity, emulsifying capacity, emulsion stability, foaming capacity and foam stability, were determined. The results obtained for boiled locust indicated that the protein solubility and foam stability were slightly increased, while the emulsifying capacity, emulsifying activity and emulsion stability were slightly decreased as NaCl concentration was increased. However, no consistent change was observed in foaming capacity. For fried locust, the protein solubility, emulsifying activity, foaming capacity anf foam stability were increased with NaCl concentration while the emulsifying capacity and emulsion stability were decreased with NaCl concentration. Generally, it was observed that addition of NaCl to locust flour improved its functionality.

Key words: Tree locust, boiled, fried, functional properties, NaCl concentration

INTRODUCTION

Insects are the most successful group of animals constituting about 76% of known species of animals (Yoloye, 1988). Insects affect man either as destroyers of man's valuable materials and crops or as sources of his nutrients. Goodman (Goodman, 1989) reported that chitin, an important insect component, can significantly reduce serum cholesterol and serve as a haemostatic agent for tissue repairs and for accelerating healing of burns and wound. The cultural practice of entomophagy is an old and well-established custom in non-industrialized regions of the world (Sutton, 1988). The high cost of animal protein, which is beyond the reach of the poor has greatly encouraged entomophagy. Insects are valuable sources of animal protein for Zambia's rural population since meat from domesticated and wild animals are scarce (Mwizenge, 1993). A 10% increase in the world supply of animal proteins through mass production of insects can largely eliminate the malnutrition problem and also decrease the pressure on other protein sources (Robert, 1989). Studies in Nigeria have shown that entomophagy has contributed significantly to the reduction in protein deficiencies in the country (Ashiru, 1988; Fasoranti and Ajiboye, 1993). Functional properties constitute the major criteria for the adoption and acceptability of proteins in food systems. The physical and chemical characteristics as well as interactions of proteins with other components in the food are the major contributors to the usefulness and success of proteins in food systems. These characteristics influence processing, preparation and quality attributes of foods (Kinsella, 1981). Protein functional properties are determined to a large extent by a protein's physicochemical and structural properties (Damodaran, 1990). Protein solubility is an important prerequisite for food functional properties and it is a good index of potential applications of proteins (Kinsella, 1976). Hydration properties, dispersibility, water absorption, binding, swelling and viscosity are known to directly influence the characteristics of a food system (McWatters and Cherry, 1977). Hydration of proteins is vital for several functional properties, such as emulsion capacity, foaming, viscosity and gelation (Sathe and Salunkhe, 1981). In this study, we would like to investigate the effect of NaCl concentrations on boiled and fried locust flour protein solubility and functionality to predict the possibility to utilize locust flours as food ingredient.

MATERIALS AND METHODS

Two samples of boiled and fried tree locusts (*Anacridium melanorhodon melanorhodon*) were

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obtained from Mayo local market, Khartoum, Sudan. Refined Ground nut oil was brought from Bittar Co.ltd., Khartoum. Sudan. Unless otherwise stated all chemicals used in this study were of reagent grade. Locust was first cleaned, freed from foreign matter, separated inedible part and milled in a laboratory miller to pass through a 0.4 mm screen. To extract oil from milled flour, cold extraction method was used AOAC (1984). The flour was placed in a conical flask and mixed with hexane (10:1). The mixture was stirred using a mechanical shaker for 16 h and then filtered. The filtrate was washed again with hexane to remove traces of oil. The mixture was filtered again and the oil free flour was dried in an open air at room temperature. The dried flour was then ground to pass a 0.4 mm screen and stored at 0°C for further analysis.

Nitrogen solubility determination: Nitrogen solubility of both boiled and fried flour was determined at different NaCl solution by the procedure of Hagenmaier (1972) as described by Beuchat *et al.* (1975) with a slight modification. About 0.2 g material were dispersed in 10 mL distilled water or NaCl solutions of a concentration ranged from 0.2 to 1M. The mixtures were mechanically shaken for 1 h at room temperature, centrifuged at 3000 rpm for 20 min at room temperature. The soluble nitrogen in the supernatant was estimated by the micro-kjeldahl method (AOAC, 1984). Nitrogen solubility was expressed as percent of the nitrogen content of the sample.

Emulsion measurement: The Emulsifying Capacity (EC) of the sample was estimated by the method of Beuchat *et al.* (1975). One gm material was blended with 50 mL of distilled water or NaCl solutions ranged from 0.2 to 1 M for 30 sec. in a Braun electric blender; after complete dispersion, refined groundnut oil was added cautiously (0.4 mL sec^{-1}) from a burette and blending continued until there was a phase separation (visual observation/change in shaft sound). EC was expressed as milliliters of oil emulsified by one gram material. The Emulsifying Activity (EA) was measured by the procedure of Yatsumatsu *et al.* (1972). About 0.7 gm of material was added to 10 mL of distilled water or 10 mL of NaCl solutions of a concentration ranged from 0.2 to 1M and mixed well before addition of 10 mL of refined groundnut oil. The mixture was blended in Broun electric blender for 5 min, poured into centrifuge tubes and centrifuged at 2000 rpm for 5 min then poured into 50 mL measuring cylinders and stay a few minutes until the emulsified layer was stable. The Emulsion Stability (ES) was measured by recentrifugation followed by heating at 80 °C for 30 min and subsequently cooled to 15 °C. After centrifugation the emulsion poured into 50 mL measuring cylinders and stays a few minutes until the emulsified layer was stable and. ES was expressed as the percent of the total volume remaining emulsified after heating.

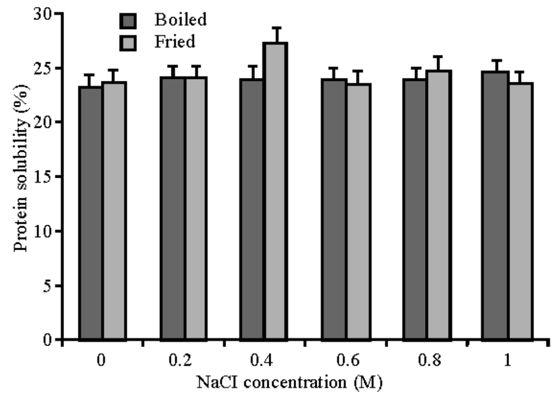

Fig. 1: Effect of NaCl concentration on protein solubility (%) of fried and boiled tree locust flour

Foam measurement: Foaming Capacity (FC) of the sample was determined by following the procedure described by Lawhon *et al.* (1972). About 2.0 gm of the sample was blended with 100 mL distilled water or 100 mL NaCl solutions of a concentration ranged from 0.2 to1.0 M in a Moulinex blender at "hi" speed for 2 min. The mixture was poured into a 250 mL measuring cylinder and the foam volume was recoded after 30 sec. The Foam Stability (FS) was conducted according to Ahmed and Schmidt (1979) method. The FS was recorded after the mixture was stands for 30 min.

Statistical analysis: Each determination was carried out on three separate samples and analyzed in triplicate. The data were subjected to analysis of variance and the Duncan's multiple range test was used to separate means.

RESULTS AND DISCUSSION

Effect of NaCl concentration on solubility of boiled and fried locust: Figure 1 shows the profile of flour solubility of boiled and fried locust at different NaCl concentrations. The results obtained for boiled locust showed that the flour solubility remains constant as NaCl concentration was increased up to 0.8 M NaCl and thereafter it slightly increased with a maximum value (24.3%) obtained at 1.0M NaCl concentration. The present finding agree with that reported by Mahajan *et al.* (1999) who stated that the protein solubility of rapeseed was improved in the presence of NaCl. For fried locust, the protein solubility was improved with addition of NaCl up to 0.4 M (27.13%) and thereafter it started to decline. The increment in

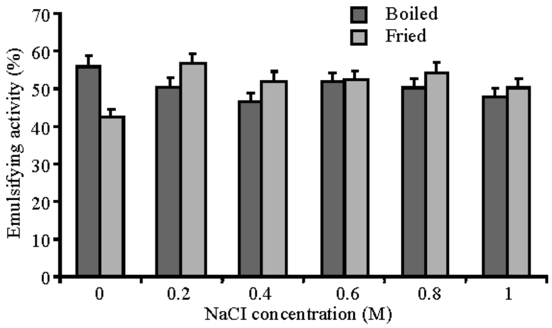

Fig. 2: Effect of NaCl concentration on the emulsifying activity (%) of fried and boiled tree locust flour

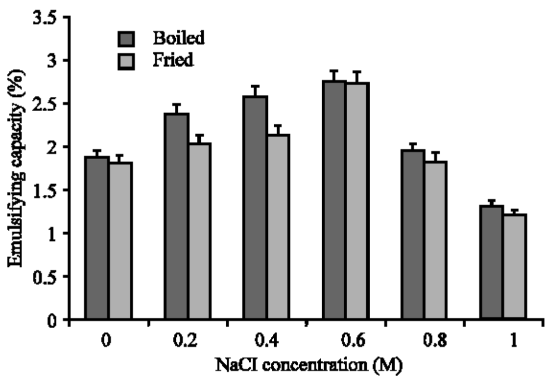

Fig. 3: Effect of NaCl concentration on the emulsifying capacity (%) of fried and boiled tree locust flour

protein solubility for both boiled and fried locust after addition of NaCl could be explained by the fact that NaCl enhanced the polarity of the flour protein.

Effect of NaCl concentration on emulsifying properties of boiled and fried locust: Figure 2 shows the Emulsifying Activity (EA) of boiled and fried locust at different NaCl concentrations. The EA of boiled flour was higher before addition of NaCl but was lowered slightly by addition of NaCl. A lowest value (46.6%) of EA was obtained at 0.4 M, while a maximum value (55.5%) was observed in the absence of NaCl. The results agree with that reported by Osman *et al.* (2005). who stated that the EA of chickpea was higher in distilled water and then decreased at 0.2 M NaCl, but no obvious reduction was observed after 0.6 M salt concentration. For fried locust, the EA was improved with the addition of salt regardless of its concentration. The results also showed that in the lack of NaCl, the EA of fried locust was significantly higher than that of boiled one. This finding agrees with that reported by Osman *et al.* (2005) who concluded that application of high heat decreased the emulsifying activity. Figure 3 shows the effect of NaCl concentration on the Emulsifying Capacity

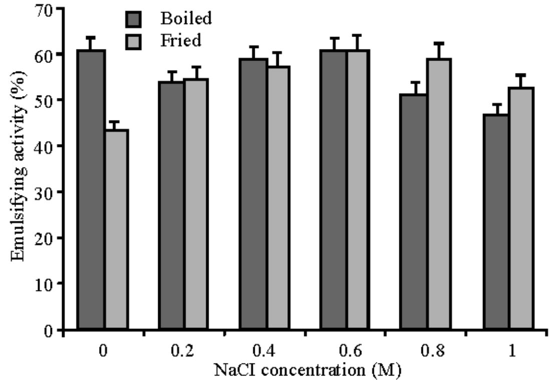

Fig. 4: Effect of NaCl concentration on emulsion stability (%) of fried and boiled tree locust flour

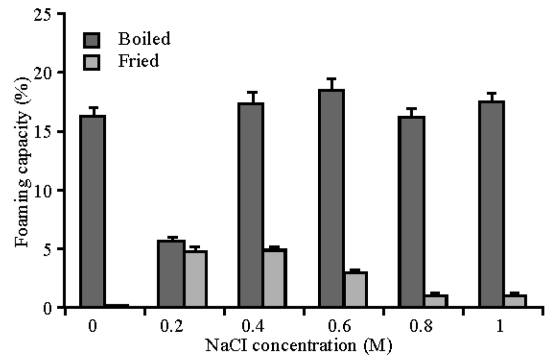

Fig. 5: Effect of NaCl concentration on foaming capacity (%) of fried and boiled tree locust flour

(EC) of both boiled and fried locust. The EC of both was significantly ($p \leq 0.05$) increased with the addition of NaCl, except at 1.0 M at which it was decreased. The present findings disagreed with that reported by Narayana and Narasinga (1982) who found that incorporation of NaCl up to 0.4 M increased the emulsifying capacity of wing bean flour. This variation may be due to the chemical differences between the samples. Nakai (1983) stated that the emulsifying property cannot be solely due to proteins, but it depends on other constituents such as carbohydrates and lipids. On the other hand, no significant differences were observed for the emulsifying capacity obtained for boiled and fried locust at all NaCl concentrations. As shown in Fig. 4, the Emulsion Stability (ES) of both boiled and fried locust was higher at 0.6 M NaCl concentration (60.0 and 60.4%) and then gradually decreased on either side of this concentration. The results were in agreement with that reported by Osman *et al.* (2005) who stated that addition of NaCl significantly decreased the emulsion stability of untreated flour. On the other hand, the results obtained

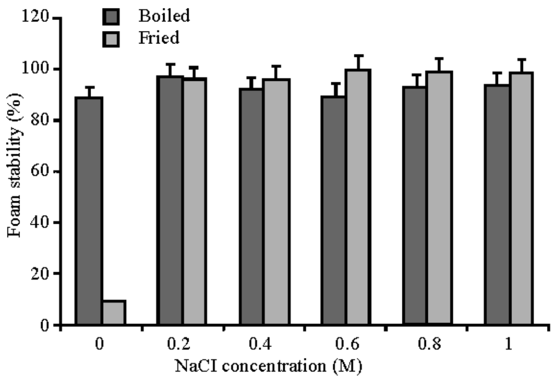

Fig. 6: Effect of NaCl concentration on foam stability (%) of boiled and fried locust flour

for fried locust showed that the emulsion stability was improved with the addition of salt, till 0.6 M and thereafter it slightly decreased. Similar observation was reported by Odoemelam (2005) who concluded that, addition of NaCl improved the emulsion stability of processed jackfruit flour. The results also showed that in the absence of NaCl the emulsion stability of fried locust was significantly lower than that of boiled one. Results obtained agreed with that reported by Pawar and Ingle (1988) who stated that application of high heat decreased the emulsion stability of moth bean flour.

Effect of NaCl concentration on foaming properties of boiled and fried locust: Figure 5 illustrates changes in Foaming Capacity (FC) for boiled and fried locust at different NaCl concentrations. It was observed that no consistent pattern of change as the concentration of NaCl increased for the boiled locust. The lowest value of foaming capacity was observed at 0.2 M NaCl concentration, while the maximum value observed at 0.6 M NaCl. For the fried locust the results showed that the foaming capacity was improved with addition of NaCl till 0.4 M and then it decreased gradually. The results obtained disagree with that reported by Osman *et al.* (2005) who found that the maximum improvement of foaming capacity for chickpea was observed at 0.2 M NaCl, while higher foaming capacity was observed at low salt concentration. Variation in these results is likely due to chemical differences in the tested protein. Kinsella (1976) stated that foaming capacity at different concentrations of salt is usually affected by the protein solubility at the interface of the colloidal suspensions during foam formation. The effect of NaCl concentration on Foam Stability (FS) of boiled and fried locust is shown in Fig. 6. Foam stability of boiled locust flour was found to be depending on NaCl concentration. When then foam stands for 30 min significant changes were observed in FS as NaCl concentration was increased. When the foam stands for 30 min, the foam stability of boiled locust flour increased from 87.86 to 92.53% with a maximum value (96.6%) obtained at 0.2 M NaCl. For fried locust similar trend was observed except in the absence of NaCl the flour slightly foamed. The results obtained disagreed with and that reported by Osman *et al.* (2005) who found that, as the salt concentration increase the FS of chickpea flour increased significantly and also disagree with that reported by Mahajan *et al.* (1999) who stated that the FS was better at average of 0.2 to 0.6 M NaCl. However, the results is supported by the findings of Bera and Mukherjee (1989) who reported that the foam stability of rice bran concentrates, slightly improved when salt concentration was increased from 0.1 to 1.0M NaCl. The Foam Stability (FS) of a protein is governed by the cross linking of protein molecules and creation of films Osman *et al.* (2005). Therefore, our results expected to be vary from that of proteins of plant source.

CONCLUSION

In conclusion, addition of salt to locust flour after boiling or frying improves solubility of the protein as well as its functional properties.

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