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The Proximate and Effect of Salt Applications on Some Functional Properties of Quinoa (*Chenopodium quinoa)* Flour

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Abstract: The proximate and the effect of salt applications on the functional properties of quinoa flour were investigated. The salts used were, NaCl, Na_2SO_4, KCl, K_2SO_4 and CH_3COONa. The average proximate compositions were as follows: 13.50±0 0.05% Crude protein, 11.20±0.03% moisture, 6.30±0.03% fat, 9.50±0.02% fibre, 1.20±0.02% ash and 58.3±0.04% carbohydrate. The least gelation concentration of 16% w/v in deionized water was fairly improved to between 10% - 14% w/v in the presence of all the salts applied. The foaming capacity of 9% in deionized water was greatly improved to between 20.5-35% depending on the type and level of salts used. The water holding capacity decreased at low salt levels when compared with absence of salt and increased with increase in salt levels while the emulsion capacity decreased with increase in salt levels.

Key words: Salt, quinoa flour, emulsion capacity, emulsion stability

Introduction

Quinoa (*Chenopodium quinoa)* is one of the few crops grown in the salt flats of Southern Bolivia and Northern Chile. In this arid region of 230mm annual rainfall, quinoa is planted in holes of about 40cm deep where the soil is damped (Somers, 1982; Ogungbenle, 2003). Quinoa has some white/pink small seeds which comprise of 30 percent of the dry weight of the whole plant with yields of 2,500kg per hectare (Anonymous, 1990). Quinoa has moderate protein and better balanced essential amino acid profile than some cereals (Anonymous 1990; Ogungbenle, 2003). The seeds are traditionally used in soup or ground into fine flour for baking bread and cakes and are also used for brewing beer and animal feed (Anonymous, 1990). The effect of salt is significant because in many foods, salt concentrations are approximately 0.2 - 0.3M (Altschul and Wilcke, 1985). Sodium chloride or table salt at appropriate concentration aids foaming, presumably by aiding diffusion and spreading at the interface (Torberg, 1979), however, this concentration dependent but high levels of salt depress foaming. At high concentrations a reduction in hydration may occur (Kuntz, 1971; Bull and Breese, 1976). The relative effects of cation and anions are influenced by the intensity of their surface charge, which is influenced by the atomic radii. At this salt concentration, electrostatic interactions are of little importance with regards to the amount of water bounds to protein because competition of the ions and proteins for water becomes predominant. Fleming *et al.* (1974) reported that 5% salt enhanced the water holding capacity of soy flour but reduced that of soy isolate. The present report is designed to study the proximate and effect of salt applications on the quinoa flour.

Materials and Methods

The quinoa (*Chenopodium quinoa)* seeds were brought to Nigeria from Canada by Professor A.A. Oshodi. The screened seeds were dried and blended into flours using Kenwood food mixer. Prior to each analysis, a representative sample flour of the individual was carefully obtained. The flours were stored in polythene bags and kept in refrigerator at -18°C.

Proximate analysis of the sample for moisture, ash and fat contents were determined in at least triplicate using the air oven, dry ashing and soxhlet extraction methods described by Pearson (1976). Nitrogen was determined by the micro-kjeldahl method described by Association of Official Analytical Chemists (AOAC, 1990) and the percentage nitrogen was converted to crude protein by multiplying by 6.25.

The effect of salts application on some of the functional properties of the sample were determined as described by Ogungbenle *et al.* (2002); Oshodi and Ojokan (1997). The salts used were NaCl KCl, $NaS0_4$, K_2SO_4 and CH_3CO_2Na, all British Drug Houses Product (BDH). The required concentrations of the various salt solutions used were prepared by weighing 0.5, 1, 2, 5 and 10g of the salts which were dissolved in 99.5, 99, 98, 95 and 90g deionized water respectively.

Results and Discussion

Table 1 presents the proximate composition of quinoa flour.

The value of crude protein in the sample is 13.50%. This value is higher than those of maize (9.0%) reported by Ejidike and Ajileye (2007), 8.8 - 11.6% for bambara groundnut, 8.8 - 12.1% for cowpea (C_1 - C_2) reported by Aremu *et al.* (2005). This is in agreement with the earlier

Table 1: Proximate analysis of the sample

Proximate	%
Moisture	11.20±0.03
Crude protein	13.50±0.05
Crude Fat	6.30±0.03
Crude fibre	9.50±0.02
Ash	1.20±0.02
Carbohydrate (by difference)	58.3±0.04

Table 2: Salt effect on the least gelation concentration of the sample (%w/v)

Salt (%)	0	0.5	1	2	5	10
KCl	16	14	12	10	10	10
NaCl	16	14	12	12	10	10
K_2SO_4	16	12	12	10	10	10
Na_2SO_4	16	12	12	10	10	10
CH_3COONa	16	14	12	12	10	10

observation that quinoa contains moderate protein and better balanced essential amino acid than most cereals e.g. maize, millet sorghum etc. The crude protein value is lower than that of pigeon pea (22.4 ± 0.05%) reported by Oshodi and Ekperigim (1989) and some varieties of legumes (22.75 ± 2.0% - 37.9 ± 1.0%) reported by Ogungbenle (2006). Quinoa flour has a high level of carbohydrate and low fat. It contains moderate quantity of fibre (9.5%) which enhance its nutritional performance and acting as a catalyst in digestion and absorption in the intestine.

Table 2 indicates the variation of least gelation concentration with percentage of salts. It has been shown from the Table 2 that the least gelation concentration of quinoa is 16% w/v in distilled water. The addition of salts decreased the least gelation concentration which depended on the concentration and type of salts used and values obtained ranged from 10% to 14%. It is observed that addition of different salts at relatively low concentration of 0.5% improved the gel-forming property of quinoa and this effect is well pronounced with the use of KCl.

The values obtained for emulsion capacity and stability of quinoa are presented in Table 3 showed that quinoa has good emulsion capacity and stability at zero concentration of salts. Emulsion capacity and stability depend on the types and the concentration of salt under consideration. Table 3 indicates further that, after 24hrs, the quantity of water separated from emulsion produced increased with the concentration of the salt under consideration, indicating a decrease in emulsion stability in the presence of salts. The degree of water separation varies from salt to salt. In the presence of K_2SO_4 and KCl, the volume of water separated increases with increase in salt concentration, while in the presence of CH_3COONa, Na_2SO_4 and NaCl, the volume of water separated was almost constant up to 5.0% of these salts. Three separate mechanisms that appear to be involved in the formation of a stable emulsion may be (i) reduction of interfacial tension (ii) formation of a rigid interfacial film and (iii) electrical charge (Mc Waters and Cherry, 1981). The surfactancy of proteins is related to their ability to lower the interfacial tension between water and oil in the emulsion. The decrease in emulsion stability as seen in Table 3, may be due to increase contact leading to coalescence which thereby reduces stability (Ogungbenle *et al.,* 2002). From Table 3, it has clearly shown that the higher the concentration of the salt added the higher the volume of water separated.

The results for water holding capacity of quinoa in the different salt solutions are presented in Table 4. The water holding capacity in distilled water is found to be 147% which is higher that the values reported for some sun flower (107% and 137%) protein concentrates (Lin *et al.,* 1974) and bovine plasma protein concentrate (94%) reported by Oshodi and Ojokan (1997) but lower than the value reported for the protein concentrate of Adenopus breviflorus benth (201%) seed flour (Oshodi, 1992). The high water holding of quinoa may make it more susceptible to heat denaturation (Kinsella *et al.,* 1985). Table 4 also shows a progressive decrease in water holding as the concentration of the salt increases at least up to 5% salt, after which the water holding rises. The degree of decrease or increase in water holding capacity varies with the type of salt. This may be due to the fact that the effects of salt vary with the cation and anion species involved (Kinsella *et al.,* 1985). The observed trend at low salt concentration may be due to masking of charges which may reduce electrostatic interaction and hydration but increase hydrophobic interaction. At high salt concentrations, electrostatic interactions are apparently of little importance with regard to the amount of water bound to protein because competition between the ions and protein for water becomes predominant (Shen, 1981). The lower water holding at high salt concentrations may be an advantage

Table 3: Salt Effect on the emulsion capacity/stability of the sample (%)

	Emulsion Capacity						Emulsion Stability					
Salt(%)	0	0.5	1	2	5	10	0	0.5	1	2	5	10
KCl	104	84.5	84.0	86.3	88.2	80.0	45	46.5	44.0	48.2	56.0	58.0
NaCl	104	83.9	80.0	80.2	75.0	74.0	45	40.0	42.5	41.1	56.8	57.5
K_2SO_4	104	88.1	88.9	85.0	84.5	84.0	45	38.5	39.0	40.2	43.0	31.8
Na_2SO_4	104	85.0	84.0	86.1	86.0	85.3	45	37.7	38.0	39.1	41.5	58.5
CH_3COONa	104	84.5	78.8	80.0	80.9	83.0	45	35.9	37.9	38.9	39.8	5.0

Table 4: Salt Effect on the Water holding Capacity of the sample (%)

Salt(%)	0	0.5	1	2	5	10
KCl	147	100.0	99.5	99.5	85.0	96.5
NaCl	147	95.0	92.1	80.5	94.0	95.5
K_2SO_4	147	90.0	90.5	85.5	85.5	88.0
Na_2SO_4	147	68.5	95.0	84.0	84.5	92.0
CH_3COONa	147	87.4	87.0	79.5	80.5	86.0

Table 5: Salt effect on the foaming capacity/stability of the sample (%)

	0	0.5	1	2	5	10	0	0.5	1	2	5	10
KCl	9	21.0	23.6	26.0	24.1	35.0	2	9.0	11.3	13.0	11.9	21.3
NaCl	9	20.5	23.0	25.3	24.0	33.0	2	9.6	10.4	11.0	11.6	19.0
K_2SO_4	9	23.4	24.0	23.0	25.2	34.0	2	10.0	12.5	10.7	12.9	19.5
Na_2SO_4	9	22.5	24.0	24.8	23.0	34.5	2	10.8	12.0	12.1	11.0	20.0
CH_3COONa	9	22.6	23.3	24.0	24.7	31.5	2	11.0	11.2	11.5	12.0	18.0

in drying and storage stability of quinoa flour and its products.

The effect of salts on the foaming capacity is presented in Table 5. It shows that foaming capacity depends upon the type of salt under consideration. For Na_2SO_4 KCl, NaCl, CH_3COONa, there is an increase in the foaming capacity with increase in concentration of salts from 0.5% to 2% and there is a drop at 5.0% salt concentration later starts to increase at 10% salt concentration. This may be due to the fact that salts usually reduce surface viscosity and rigidity of protein films but increase spreading rate, thereby weakening intepeptide attractions and increasing foam volume for certain proteins Altschul and Wilcke (1985). It has been shown by Altschul and Wilcke (1985) that salts at appropriate concentrations aid foaming, presumably by aiding diffusion and spreading at the interface, but high levels of salts will depress foaming. For example, depression at 10% salt concentration was observed in the present study. In general, all the salts used increase the foaming capacity of quinoa but the lowest effect is obtained with NaCl. The improved foaming capacity in the presence of salts may consequently improve the functionality of quinoa and its uses for the production of cakes (Johnson *et al.*, 1979; Lec *et al.*, 1983). And as a supplement or substitute for wheat flour in bread baking process. The results for foaming stabilities after 2hrs are shown in Table 5, which indicates in general, that all salts used at different concentrations significantly improved the foamability of quinoa (*Chenopodium quinoa)* and this effects may play important roles in the observed results in these works. The results show that the water holding capacity emulsion capacity/stability, foaming capacity/stability and gel foaming capacity are influenced by salts and these depend on the types of salt and their levels. Hence, application of salts at appropriate levels may greatly improve or prohibit the functionality of quinoa flour.

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