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EFFECT OF SALTS ON THE FUNCTIONAL PROPERTIES OF PROTEIN CONCENTRATE OF WATER MELON (*Citrullus vulgaris*) SEED

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ABSTRACT

The effects of the following salts, KCl, NaCl, Na_2SO_4 and CH_3COONa on the functional properties of water melon (*Citrullus vulgaris*) seed protein concentrate were studied. Results showed that the least gelation concentrate of 24% observed in the absence of the salts was improved and found between 12 and 22% in the presence of different salts concentrations. The foaming capacity of 18.7% in distilled water increased progressively from 21.1±0.1 to 61.0±0.2% depending on the concentrations and types of salts used. In the presence of salts the water absorption capacity decreased to between 118.2±0.2 and 141.4+0.1 compared to 152.0% in the absence of salts while emulsion capacity also decreased to between 66.4 ±0.1 and 78.4±0.6 with salt concentration of 10.0% from 85.3±0.3. The foaming stability of 13.0% in the absence of the salts decreased in the range of 3.1±0.1 to 11.4+0.3% by KCl and Na_2SO_4 but increased by NaCl and CH_3COONa in the range of 15.2±0.4 to 24. 4±0.1%. The solubility was enhanced in salt solution at pH 5, suggesting that the protein may be useful in acid food formulations.

Keywords: Salt, Functional properties, Protein, Melon seed.

INTRODUCTION

Melon (*Cucurbtaceae*) seeds are known to be very rich in protein and oil (Achinewhu, 1990). Water melon (*Citrullus Vulgaris*) seed, member of the family *cucurbtaceae,* is widely cultivated in Nigeria for their edible leaves, seed and fruits. It is well documented that the developing countries do not produce enough foods which have the right nutritional quality to meet daily needs (Aletor and Aladetimi, 1989). Therefore, there is a great need to search for more nutritionally good foods in order to ensure that all the potential sources of foods are effectively exploited and utilized industrially. In order to successfully introduce a new supplementation into any food item, it is necessary to find out good applications and consumer acceptability (Oshodi and Ekperigin, 1989).

Functional properties are the intrinsic physico-chemical properties which may affect the behaviour of food systems during properties (Oshodi et al. 1999). There is limited information on the functional properties of water melon seed. Therefore this article reports the effect of salts on the functional properties of protein concentration of water melon seed.

MATERIALS AND METHODS

Water Melon Seeds

Water melon seeds were purchased from a local market in Akure. The seeds were screened to remove stones and other impurities such as shells. The dried seeds were milled using a Kenwood food grinder, model KW10, sieved with 500 micrometer sieve and packaged in polythene bags and stored in a cool dry place.

Chemicals

The salts used were KCl, NaCl, Na_2SO_4 and CH_3COONa; all chemicals used were of analytical grade. The concentrations of the different salt solutions used were 0.5, 1.0, 5.0 and 10.0% w/v.

Preparation of protein concentrate of water melon seeds

The melon seed powder was defatted with soxhlet extraction using ether as solvent. Defatted melon seed powder was dispersed in distilled water. The suspension was gently stirred on a magnetic strirrer for 30 minutes. The pH of the resultant slurry was adjusted to 7 where the protein concentration was found to be most soluble by dropwise addition of 0.01M NaOH. The extraction was allowed to proceed with gentle stirring for 2h keeping the pH constant. Non-solublised material was removed by centrifugation at 3500 rpm for 30 minutes. The protein in the extract was precipitated by dropwise addition of 0.01M HCl with constant stirring until the pH dropped to 3 which is the point at which the protein was recovered by centrifugation at 3500 rmp for 30 minutes.

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Table 1: Effect of salt on the least gelation concentration (w/v) of protein concentrate of Citrullus vulgaris

Salt	Least gelation concentration (w/v) Salt solution concentration (% w/v)				
	0.0	0.5	1.0	5.0	10.0
KCl	^{a}24.0±0.2	^{a}22.0±0.1	^{a}22.0±0.1	^{b}16.0±0.2	^{b}14.0±0.2
NaCl	^{a}24.0±0.2	^{a}22.0±0.3	^{b}18.0±0.2	^{b}16.0±0.1	^{c}12.0±0.1
Na_2SO_4	^{a}24.0±0.2	^{a}24.0±0.2	^{b}18.0±0.1	c14.0±0.2	^{c}14.0±0.3
CH_3COONa	^{a}24.0±0.2	^{a}24.0±02	^{b}16.0±0.4	^{b}16.0±0.1	^{c}12.0±0.2

Values with a similar letter within a row were not significantly different at 5% level.

Determination of gelation capacity

The method of Coffman and Garcia (1977) was employed for determining the gelation capacity for each solution. Sample suspensions, 2 –30% (w/v) were prepared in distilled water or salt solution. Ten milliliters of each suspension was put in a test tube and heated for 1h in a boiling water bath followed by rapid cooling in a bath of cold water. The least gelation concentration was determined as that concentration when sample from the inverted tube did not fall down or slip.

Determination of foaming capacity

The foaming capacity for sample suspension was determined by the method of Coffman and Garcia (1977). Two grams of flour were dispersed in 100cm^3 distilled water or salt solution. The resulting solution was vigorously whipped for 3 min in a Kenwood blender. Volumes were recorded before and after whipping and the percentage volume increase caculated according to the following equation:

$$\% \text{ volume increase (foaming capacity)} = \frac{\text{Vol. After} - \text{Vol. Before}}{\text{Vol. Before}} \times 100$$

The volume of the foam was also noted after 2h to enable the foaming stability to be calculated.

Determination of emulsion capacity and stability

Inklaar and Fortuin (1969) procedure was used for the determination of emulsion capacity and stability. Two grams of protein flour were made into a slurry in 40cm^3 of distilled water or salt solution in a conical flask by stirring at 1000 rpm for 15 min. After 10cm^3 of vegetable oil was added over a period of 5 min with stirring at 1000 rpm, stirring was continued for some minutes. The system was transferred to a centrifuge tube, heated in a bath maintained at 85^{0}C for 15 min with occasional stirring, and then cooled for 15 min in a water bath maintained at 25^{0}C. The tube was finally centrifuged at 3000 rpm until the volume of oil separated from the emulsion was constant. The emulsion capacity was expressed as percentage of the height of the emulsified layer to the total height of the mixture. The volume of the emulsified layer was also noted after 2h to enable the emulsion stability to be determined.

Determination of water absorption capacity

Water absorption capacity was determined by the method of Beuchat (1977). One gram of the flour was mixed with 10cm^3 distilled water or salt solution. The sample was allowed to stand at 25^{0}C for 30 min, centrifuged at 5500 rpm for 30 min and the volume of the supernatant was noted. Density of water is assumed to be 1.00g/cm^3. The volume of water absorbed was converted to gram. Water bound was calculated as percentage of the mass of the initial volume of water used.

Determination of Protein Solubility

The protein solubility of the water melon

Table 2: Effect of salt on the foaming capacity of protein concentrate of Citrullus vulgaris

Salt	Foaming capacity (%)				
	Salt solution concentration (% w/v)				
	0.0	0.5	1.0	5.0	10.0
KCl	^{a}18.7±0.1	^{b}26.3±0.1	^{c}33.1±0.5	^{cd}36.2±0.4	^{d}38.1±0.3
NaCl	^{a}18.7±0.1	^{b}34.5±0.1	^{c}37.1±0.6	^{d}40.0±0.2	^{e}61.0±0.2
Na_2SO_4	^{a}18.7±0.1	^{a}21.1±0.1	^{b}25.5±0.4	^{b}26.1±0.6	^{b}28.0±0.3
CH_3COONa	^{a}18.7±0.1	^{a}22,0±0.3	^{b}29.4±0.1	^{c}33,0±0.5	^{b}25.5±0.2

Values with a similar letter within a row were not significantly different at the 5% level.

Table 3: Effect of salt on the foaming stability of protein concentrate of Citrullus vulgaris

Salt	Foaming stability (%)				
	Salt solution concentration (% w/v)				
	0.0	0.5	1.0	5.0	10.0
KCl	^{a}13.0 ±0.1	^{b}4.0±0.3	^{b}4.4±0.1	^{b}6.8±0.3	^{b}6.7±0.5
NaCl	^{a}13.0±0.1	^{b}16.5±0.4	^{c}18.3±0.2	^{c}20.0±0.6	^{c}19.4 ±0.1
Na_2SO_4	^{a}13.0±0.1	^{b}3.1±0.1	^{b}5.5±0.1	^{c}9.2±0.2	^{c}11.4±0.3
CH_3COONa	^{a}13.0±0.1	^{a}15.2±0.4	^{a}16.4±0.1	^{b}19.0±0.3	^{c}24.4±0.1

Values with a similar letter within a row were not significantly different at the 5% level.

protein concentrate in distilled water or salt solution was determined by mixing for 5 min 2g of the concentrate with 50cm^3 of distilled water or salt solution using a magnetic stirrer at room temperature. The pH of the resulting solution was adjusted to pH 5 using either 0.1M HCl or 0.IM NaOH. Samples were centrifuged for 30 min and the protein content of the supernatant determined by micro-kjeldahl method (AOAC, 1990).

Statistical Analysis

The results were averages of triplicate determinations. Data obtained were subjected to Analysis of Variance (ANOVA) and means were separated by Duncan's Multiple Range Test at 0.05 probability level.

RESULTS AND DISCUSSION

The least gelation concentration is defined

as the lowest protein concentration at which gel remained in inverted tube and was used as an index of gelation capacity. The lower the least gelation concentration the better the gelating ability of the protein irrgredient. All the salts lowered significantly the least gelation concentration at the salt concentration of 5.0 and 10.0% w/v respectively (Table 1). KCl and NaCl at the concentration of 0.5% w/v gave the least gelation concentration of 22% which is higher than 14% w/v obtained for lupin seed (Sathe et al, 1982). At the concentration of 10% w/v, NaCl or CH_3COONa produced the least gelation concentration of 12% while the value by KCl or Na_2SO_4 was 14. These low values suggest that the salts can make the water melon seed protein concentrate to be a better gel forming or firming agent. The gelation properties would make the protein useful in food formation such as pudding and saucing which require thickening and gelling, suggesting that water melon may be important in food formulation in food industries. The improved gelating ability of the protein concentrate in the presence of salts (Table 1) could be due to higher protein solubilisation by the salt solution thereby creating an effective overlapping of the functional

Table 4: Effect of salt on the water absorption capacity of protein concentrate of Citrullus vulgaris

Salt	Water absorption capacity (%)				
	Salt solution concentration (% w/v)				
	0.0	0.5	1.0	5.0	10.0
KCl	^{a}15.2,0±0.1	^{b}140.4±0.2	^{b}137.3 ±0.3	^{c}122.2±0.1	^{c}118.2±0.2
NaCl	^{a}152.0±0.1	^{b}141.4±0.1	^{c}132.3±0.3	^{e}128.0±0.2	^{e}130.3±0.1
Na_2SO_4	^{a}152.0+0.1	^{b}130.0±0.3	^{c}136. 3±0.1	^{d}122.2±0.1	^{d}120.0±0.1
CH_3COONa	^{a}152.0±0.1	^{b}139.4±0.1	^{c}133.2±0.1	^{d}125.1±0.3	^{d}120.3±0.4

Values with a similar letter within a row were not significantly different at the 5% level.

Table 5: Effect of salt on the emulsion capacity of protein concentrate of Citrullus vulgaris

Salt	Emulsion capacity (%)				
	Salt solution concentration (% w/v)				
	0.0	0.5	1.0	5.0	10.0
KCl	^{a}85.3±0.3	^{a}83.5±0.3	^{a}79.9±0.3	^{b}76.3±0.5	^{b}73.4±0.4
NaCl	^{a}85.3±0.3	^{a}83.1±0.4	^{a}81.3±0.6	^{b}78.0±0.4	^{b}76.0±0.3
Na_2SO_4	^{a}85.3±0.3	^{b}70.3±0.4	^{b}69.3±0.3	^{b}67.4±0.3	^{b}66.4±0.1
CH_3COONa	^{a}85.3+0.3	^{a}81.3±0.1	^{a}80.4+0.3	^{a}81.3+0.5	^{b}78.4±0.6

Values with a similar letter within a row were not significantly different at the 5% level.

Table 6: Effect of Salt on the emulsion stability of protein concentrate of Citrullus vulgaris

Salt	Emulsion stability (%)				
	Salt solution concentration (% w/v)				
	0.0	0.5	1.0	5.0	10.0
KCl	^{a}36.1±0.1	^{ab}38.5±0.4	^{b}39.1±0.1	^{c}34.3±0.1	^{b}40.1±0.6
NaCl	^{a}36.1±0.1	^{b}32.3±0.5	^{a}36.5±0.3	^{a}37.3±0.1	^{c}40.1±0.3
Na_2SO_4	^{a}36.1±0.1	^{b}31.1±0.1	^{a}35.3±0.3	^{c}40.9±0.1	^{c}43.3±0.2
CH_3COONa	^{a}36.1±0.1	^{ab}38.3±0.4	^{b}39.3±0.5	^{c}44.4±0.1	^{d}50.1±0.3

Values with a similar letter within a row were not significantly different at the 5% level

Table 7: Effect of salt on the solubility of protein concentrate of Citrullus vulgaris at pH 5.

Salt	solubility (mg/l)				
	Salt solution concentration (% w/v)				
	0.0	0.5	1.0	5.0	10.0
KCl	^{a}0.9±0.1	^{b}58.2±0.3	^{c}28.3±0.1	^{b}60.1±0.2	^{b}63.5±0.4
NaCl	^{a}0.9±0.1	^{b}21.1±0.2	^{c}52.0±0.4	^{d}3.0±0.1	^{e}8.1±0.2
Na_2SO_4	^{a}0.9±0.1	^{b}40.2±0.3	^{c}51.4±0.2	^{b}43.2±0.1	^{c}51.1±0.3
CH_3COONa	^{a}0.9±0.1	^{b}38.0±0.2	^{c}32.0±0.3	^{d}9.2±0.1	^{e}21.0±0.2

Values with a similar letter within a row were not significantly different at the 5% level.

groups between adjacent protein molecules, a condition necessary for a network or gel formation (Catsimpoolas and Meyer, 1970).

Table 2 shows results on foaming capacity while Table 3 shows results on foaming stability. Foaming capacity and stability depend on concentration and types of salt used. For the four salts used, there is an increase in the foaming capacity with increase in concentration of salt from 0.0 to 5.0%. This may be due to the fact that salts usually reduce surface viscosity and rigidity of protein films but increase spreading rate, thereby weakening interpeptide attractions and increasing foams volume for certain proteins (Altschul and Wilcks, 1985). The improved foaming capacity in the presence of salts may consequently improve the functionality of the water melon seed protein concentrate in its uses for the production of cakes and whipped toppings where foaming is an important property (Kinsella, 1979). Table 3 shows that a progressive increase in foaming stabilities at 2h indicates that NaCl and CH_3COONa used at concentrations up to 5.0% w/v improved the foaming stability while KCl

and Na_2SO_4 did not.

The results for water absorption capacity of water melon seed protein concentrate in various salt solutions are shown in Table 4. The water absorption capacity in distilled water was found to be 152% which is comparably higher than the values reported by Lin et al. (1974) for sunflower flour (137%), Oshodi and Ekperigin (1989) for pigeon pea flour (138%) but lower than that of the protein concentrate of *Adenopus breviflorus* benth seed flour (201%) and Olaofe et al. (1993) for cowpea flour (246%). It is observed that there is a progressive decrease in water absorptivity with increase in salt concentrations. The high water absoptivity reported suggested that water melon seed may be used in the formulation of some foods such as sausage, doughs, processed cheese, soups and baked products (Oshodi and Ojokan, 1997).

The results obtained for emulsion capacity and stability are presented in Table 5 and 6 respectively. These indicate that water melon seed protein concentrate has good emulsion capacity in the absence of salts. At high concentration (10.0%), the values of emulsion capacity, KCl (73.4%), NaCl (76.0%),Na_2SO_4 (66.4%) and CH_3COONa (78.4%) were significantly lower than the value obtained in absence of salts whereas the value of emulsion stability, KCl (40.1%), Nac6(40.1%), Na_2SO_4 (43.3%) and CH_3COONa (50.1%) were significantly higher than the value obtained in the absence of salts.

Table 7 shows the effect of salts on the protein solubility of water melon seed protein concentrate at pH 5. The protein solubility in absence of salt at this pH 5 is very low. The results indicate that for all the four salts used, the concentrate is significantly more soluble at pH 5 in salt solution than in distilled water. This is in agreement with the results obtained by Ogungbenle et al (2002) who found that proteins in benniseed are more soluble in salt solutions than in the absence of salts in the acid region of pH. The solubility of protein depends on hydration and the degree of hydrophobicity of the protein molecules (Sathe and Salunkhe, 1981)

CONCLUSION

From the results, it can be concluded that the functionality and potentiality of water melon protein concentrate may be enhanced or inhibited by selective use of salt at appropriate concentrations.

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