Comparative Study of the Effects of Sodium Sulphate and Sodium Acetate on Some Functional Properties of Some Melon Seed Flours: Protein Solubility Profile and Water Absorption Capacity

Ogundele, J. O \textsuperscript{1,2}

\textbf{Abstract}— Sulphates and sodium acetate are used in the food and pharmaceutical industries as additives. The use of sodium sulphate (Na\textsubscript{2}SO\textsubscript{4}) and sodium acetate (CH\textsubscript{3}COONa) in this capacity may affect some functional properties of food. Therefore, the Protein solubility (PS) of some melon seed flours were determined as a function of Na\textsubscript{2}SO\textsubscript{4} and CH\textsubscript{3}COONa ionic concentrations. The PS of the seeds are least at 0.50 \% Na\textsubscript{2}SO\textsubscript{4} concentration and are highest at 2.00 to 10.00 \% Na\textsubscript{2}SO\textsubscript{4} concentration. The order of the highest protein solubility (%) of the melon seeds with Na\textsubscript{2}SO\textsubscript{4} is 84.24 (\textit{L. siceraria II}) > 83.79 (\textit{C. colocynthis}) > 66.88 (\textit{C. vulgaris}) > 62.43 (\textit{L. siceraria III}) > 34.64 (\textit{L. siceraria I}). Generally, PS of these seed flours are generally lower in sodium acetate solutions than in sodium sulphate solutions with the highest % protein solubility of 47.89\% for \textit{Citrullus colocynthis} seed flour at 5.00 (g/g \%) CH\textsubscript{3}COONa concentration. Na\textsubscript{2}SO\textsubscript{4} therefore favours the protein solubility of these melon seed flours at different concentrations than CH\textsubscript{3}COONa. The water absorption capacity (WAC) of the seed flours are generally highest at 0.50 \% Na\textsubscript{2}SO\textsubscript{4} and least at 10.00 \% Na\textsubscript{2}SO\textsubscript{4}.

\textbf{Keywords}— Protein solubility, Water absorption capacity, Sodium sulphate, Sodium acetate.

\textbf{I. INTRODUCTION}

A functional property is any non-nutritional property of a food or food additive that affects its utilization. It denotes those physico-chemical properties of food proteins that determine their behaviour in food during processing, storage, preparation and corruption. The protein nature and charge density facilitate interaction with the other food present such as water, ions, lipids carbohydrate, vitamins, colour and flavour constituents depending upon the environmental pH, ionic strength (salt concentration), and temperature during preparation, processing and storage (1).

Protein solubility is the percentage of total protein (nitrogen in a sample) that is water dispersible based on method used. Several terms are used to describe the solubility of food proteins, they include, Nitrogen Solubility Index (NSI), Water Soluble Protein (WSP), Water Dispersible Protein (WDP) and Protein Dispersible Index (PDI). Some correlations have been found between functional characteristics of proteins in various applications and the nitrogen solubility index. Generally. In order to obtain optimum functionality in foods where gelation, emulsification and foaming properties are required, a highly soluble protein is desirable (1). Protein functionality is dependent on hydrophobic, electrostatic, and steric parameters of the proteins, which are essential for defining the protein structure (2). Water absorption capacity is important in the development of ready to eat food cereal grains, since a high water absorption capacity may assure product cohesiveness (3). Some protein with high water absorption capacities when added to products being formulated may imbibe a disproportionate amount of water and dehydrate other component in the food systems or vice-versa. Thus, adjustments in water ratio may be necessary to obtain the required viscosity e.g., when soy proteins are added to dough, extra water must be added for proper development (1).

Sodium bisulfate is used as a \textit{food additive} to leaven cake mixes (make them rise) as well as being used in meat and poultry processing and most recently in browning prevention of fresh-cut produce. Sodium and sulphate ions are essential to all living organisms and their intracellular and extracellular (4); concentrations are actively regulated according to WHO (5). Sulphates are used as additives (5). In the food industry and the estimated average daily intake of sulphate in food in the USA is 453 mg/person, based on data on food consumption and reported usage of sulphates as additives. Sodium acetate has a wide range of applications in many industries. In pharmacology, it is used as either a diuretic or an expectorant. It is also an important food additive to preserve foods and enhance their flavors (6). Sodium acetate and acetic acid solutions act as buffers to maintain relatively constant pH. In the medical field, sodium acetate solutions treat patients with high blood acid levels and/or low sodium levels (7).

This research work is therefore to determine the effect of sodium sulphate and sodium acetate on the protein solubility.

\textsuperscript{1}Industrial Chemistry Department, Federal University Oye Ekiti, Ekiti State, Nigeria.

\textsuperscript{2}Chemistry Department, Federal University of Technology, Akure, Ondo State, Nigeria. e-mail: joan.ogundele@fuoye.edu.ng or o.ogundele@yahoo.co.uk.
and water absorption capacity of some gourd melon seeds.

II. MATERIALS AND METHOD

Materials: The seeds of Citrullus colocynthis, Citrullus vulgaris, Lageneria siceraria I (African wine kettle), Lageneria siceraria II (Basketball gourd) and Lageneria siceraria III (Bushel gourd) were bought from markets in Ilora Oyo State, Nigeria. They were dehulled, oven dried and milled into fine flour samples.

Protein solubility profile as a function of pH (PS): Mixture of 5% flour/distilled water was homogenized and left to solubilize at ambient temperature (35°C) for about 5 minutes. The pH of the mixture was adjusted to pH 2-11 with 0.1M HCl and 0.1 M NaOH and centrifuged at 3,500 rpm for 30 min (8). The supernatant was decanted and the soluble protein determined using Kjeldahl’s method (AOAC, 1990). The values were expressed as the percentage of the protein content of each flour sample and plotted against pH.

Determination of water absorption capacity (WAC): 1.00g of flour sample was mixed with 10.00cm³ distilled water and centrifuged for 30mins at 3,500 rpm/min. The supernatant was decanted into a 10.00cm³ graduated measuring cylinders. The volume noted was used to determine the volume of water absorbed by difference and was converted to gram using the density of water to be 1.00 g/cm³ (10).

Effect of salts on functional properties of samples: Na₂SO₄ and CH₃COONa solutions of concentrations 0.50, 1.00, 2.00, 5.00 and 10.00 % (g/g) were made. These were used in place of distilled water in the determination of the effects of ionic strength on protein solubility and water absorption capacity of the gourd seed flours, without adjusting the pH.

Statistical Analysis: One way analysis of variance (ANOVA) and least significance difference (LSD) were carried out on the replicate data generated using SPSS 18. The results are expressed as mean ± standard deviation. Duncan was also used to determine values that are significantly different with p≤ 0.05 (Ogundele (11)).

III. RESULTS AND DISCUSSION

The protein solubility of the five varieties of gourd melon seed flour samples with Na₂SO₄ concentration is relatively high and follow similar patterns (Figure 1). Citrullus colocynthis, Citrullus vulgaris, Lageneria siceraria II (BBG) and Lageneria siceraria III (BGG) all have their highest protein solubility (%) of 83.79, 66.88, 84.24 and 62.42 at 10.00(g/ml %) Na₂SO₄ concentration respectively while Lageneria siceraria I (AWG) has its highest protein solubility of 36.64% at 2.00 g/ml % Na₂SO₄ concentration. The order of the highest protein solubility (%) of the gourd seeds is 84.24 (L.siceraria II) > 83.79 (C.colocynthis) > 66.88 (C.vulgaris) > 62.43 (L.siceraria III) > 34.64 (L. siceraria I). These results are comparable with the protein solubility of between 65 and 82 % obtained by Masood and Rizwana on legume protein isolates (12). The solubility of a protein is usually affected by its hydrophilicity or hydrophobic balance, depending on surface active agents, can form and stabilize the amino acid composition, particularly at the protein surface (13). Generally, the least protein solubility (%) values of the five varieties of gourd seeds occur between 0.5 and 1.0 (g/ml %) Na₂SO₄ concentration with values of (29.91, 17.68, 21.04, 26.32 and 20.06) % for Citrullus colocynthis, Citrullus vulgaris, Lageneria siceraria I (AWG) and Lageneria siceraria I (BBG) and Lageneria siceraria III (BGG) respectively.

The (% ) protein solubility (PS) of the gourd seed flours with CH₃COONa concentrations in Figure 2 are relatively low compared with PS of the samples with Na₂SO₄. The highest % protein solubility are (47.89, 35.37, 29.47, 31.56 and 31.22) at (5.00, 10.00, 20.00, 50.00 and 10.00) (g/ml %) CH₃COONa concentration for Citrullus colocynthis, Citrullus vulgaris, Lageneria siceraria I (AWG) and Lageneria siceraria II (BBG) and Lageneria siceraria III (BGG) respectively. Hence, Citrullus colocynthis has the highest and Lageneria siceraria I (AWG) has the least % protein solubility among the five samples with CH₃COONa concentrations. These values are similar to the PS of mushroom samples results ranging from 6.00 ± 2.00 to 45.00 ± 2.00% (14). The least % PS of the melon seeds with CH₃COONa concentrations are (23.92, 26.54, 21.05, 26.32 and 13.38) %. These low values may be due to some hydrophobic groups produced as a result of the weak dissociation of CH₃COONa hence, CH₃COONa may have decreased the preferential binding effect of water to the gourd melon seed flours.

Table 1 shows the water absorption capacity of the five varieties of gourd seeds with different concentrations of Na₂SO₄. The WAC of C. colocynthis ranges from 1.93±0.12 (at 0.50 % Na₂SO₄) to 0.07±0.13 (at 10.00 % Na₂SO₄), for C.

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from water associated with the bound ions. Generally, all the interactions are of importance as far as binding of water to protein is concerned because competition of the protein ion for high hydration capacity of Na\textsubscript{2}SO\textsubscript{4} to 0.22±0.22 (at 10.00 % Na\textsubscript{2}SO\textsubscript{4}); L. siceraria II WAC ranges from 2.17±0.12 (at 2.00 % Na\textsubscript{2}SO\textsubscript{4}) to 0.14±0.25 (at 10.00 % Na\textsubscript{2}SO\textsubscript{4}); L. siceraria III 2.86±0.45 to 0.00±0.0. The relatively high values of WAC observed at 0.5% Na\textsubscript{2}SO\textsubscript{4} concentration may be due to electrostatic repulsion at low salt concentration and salting in effect on the seed flours. When the seed flours are desired as ingredient in food system especially as soup thickeners, salt concentration of about 0.50% may be used. This is because hydrated salt ions does not affect the hydration shell of the charged groups on the protein (14).

Therefore, the increase in the water absorption capacity results from water associated with the bound ions. Generally, all the samples have the least WAC at 10.00 % Na\textsubscript{2}SO\textsubscript{4}.\textit{C. colocynthis} and \textit{C. vulgaris} both exhibit gradual decrease in WAC with increasing % Na\textsubscript{2}SO\textsubscript{4}. Akintayo reported similarly, a steady decrease in WAC with increasing salt concentration of some beans (15). WAC is affected by anion, pH, amino acid and surface charge. At high salt concentration, electrostatic interactions are of importance as far as binding of water to protein is concerned because competition of the protein ion for water becomes predominant. (16) reported for acetylated and succinated derivatives of African yam-bean (\textit{Sphenostylis sternocarpa} that upon further increase in the ionic strength (exceeding 0.2 M), larger amount of the water remains essentially bound to the salt ions thereby leading to the dehydration of the protein molecule with subsequent decrease in the water absorption capacity (16). Fagbemi reported that Na\textsubscript{2}SO\textsubscript{4} encouraged higher WAC for full fat and defatted bread fruit nut and fluted pumpkin probably because of the high hydration capacity of Na\textsubscript{2}SO\textsubscript{4} (1).

IV. CONCLUSION

There is appreciable effect of sodium sulphate solution on the protein solubility of these five varieties of gourd melon seed flours at different concentrations. The least protein solubility occur at 0.50 % Na\textsubscript{2}SO\textsubscript{4} and the highest occur between 2.00 and 10.00 % Na\textsubscript{2}SO\textsubscript{4}. Protein solubility of these seed flours with sodium sulphate solutions are higher than in sodium acetate solutions. The water absorption capacity of the melon seed flours are generally higher at 0.50% Na\textsubscript{2}SO\textsubscript{4} and reduces gradually with increasing salt concentration and ventually became least at 10.00 % Na\textsubscript{2}SO\textsubscript{4} concentration.

### TABLE I

<table>
<thead>
<tr>
<th>Sample</th>
<th>Concentration (g/g)</th>
<th>0.50</th>
<th>1.00</th>
<th>2.00</th>
<th>5.00</th>
<th>10.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>\textit{C. colocynthis}</td>
<td>1.93±0.12b</td>
<td>1.80±0.35b</td>
<td>1.61±0.00b</td>
<td>1.59±0.12b</td>
<td>0.07±0.13b</td>
<td></td>
</tr>
<tr>
<td>\textit{C. vulgaris}</td>
<td>1.67±0.12b</td>
<td>1.53±0.12b</td>
<td>1.42±0.22bw</td>
<td>0.35±0.12b</td>
<td>0.07±0.13b</td>
<td></td>
</tr>
<tr>
<td>\textit{L. siceraria I}</td>
<td>1.93±0.12c</td>
<td>1.74±0.12c</td>
<td>1.97±0.12c</td>
<td>1.32±0.12c</td>
<td>0.22±0.22c</td>
<td></td>
</tr>
<tr>
<td>\textit{L. siceraria II}</td>
<td>1.73±0.12c</td>
<td>2.07±0.12c</td>
<td>2.17±0.12c</td>
<td>0.90±0.12c</td>
<td>0.14±0.25c</td>
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</tr>
<tr>
<td>\textit{L. siceraria III}</td>
<td>1.93±0.42b</td>
<td>1.87±0.24b</td>
<td>1.89±0.10b</td>
<td>2.86±0.45b</td>
<td>0.00±0.00b</td>
<td></td>
</tr>
</tbody>
</table>

Values with different superscripts on the same row are significant at ($p \leq 0.05$).