Functional Properties of Seed Meals and Protein Concentrates From Tomato-processing Waste

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ABSTRACT: Functional properties of tomato seed meals (whole and de-oiled) and protein concentrates (water, alkali, salt) were evaluated. Water and fat absorption of the meals were higher than the protein concentrates. The bulk density of the salt-extracted protein concentrate was the highest. The pH values of the meals were neutral, whereas those of protein concentrates were in the acidic pH range. The foaming capacity and stability of meals and concentrates were poor but improved slightly with the addition of salt and sugar. The emulsion capacity of meals and concentrates was good, while the emulsion stability was excellent except for alkali-extracted protein concentrate.

Keywords: tomato seeds, meals, protein concentrates, functional properties

Introduction

The food industry produces wastes consisting of good-quality nutrients that could be extensively used as food, feed, or fertilizer. Economical and technological limitations result in nonutilization of the waste thereby contributing to environmental pollution. Tomato paste manufacturing units generate 70 to 75 kg of solid waste per ton of fresh tomatoes and 71 to 72% of this waste is pomace (Sogi and Bawa 1998; Sogi 2001). Seeds, the major constituent of the pomace, contain 22.2 to 33.9% (dry basis) protein and 20.5 to 29.6% (dry basis) lipids (Tatsaronis and Boskou 1975; Carlson and others 1981; Geisman 1981; Latlief and Knorr 1983; Sogi and Bawa 1998). The seed protein could be extracted to produce protein concentrate/isolate (Kramer and Kwee 1977a; Latlief and Knorr 1983; Tchorbanov and others 1986; Liadakis and others 1995, 1998; Sogi 2001).

The proteins extracted from tomato vine and cannery waste differed substantially in functional properties from those of soybean (Kramer and Kwee 1977b). The fraction precipitated at pH 3.5 had less coagulated protein, lower foam height, and less wettability than the fraction precipitated at higher pH while the soluble protein, total solids, and bulk density values were greater.

The nitrogen solubility index of de-oiled meal in water and NaCl (5%) solution was high; however, between the two, NaCl solutions gave greater values (Rahma and others 1988). Water and fat absorption, as well as emulsifying capacity values, showed that meal had a good wettability and can mix well with water and oil systems. Foaming properties of meal were very poor since foam capacity was too low, foam structure was very weak, and foam stability at room temperature was also low.

Emulsification properties indicated that NaCl content, pH, and oil phase volume affected both globule size and rate of coalescence (Doxastakis and others 1988). Emulsions with a pH nearer to isoelectric point, high NaCl content, and lower oil phase volume had greatest stability. In general, protein isolates obtained from tomato seeds produced emulsions with larger globule size as compared to soybean protein isolate; however, both the concentrates were equally effective in stabilizing the emulsions. Liadakis and others (1998) observed variations in functional properties of tomato protein concentrate due to extraction method. Protein concentrate extracted with NaCl showed lower solubility, heat coagulation, and calcium precipitability. The bulk density of NaCl- and Na_2SO_4-extracted concentrates was lower; however, oil and water absorption capacities were higher than those for water-extracted protein concentrate. Foamability as well as emulsion capacity and solubility were lower for NaCl-extracted protein concentrate.

This study was carried out to determine the functional properties of tomato seed meals (whole and de-oiled) and protein concentrates (alkali-, water-, and salt-extracted) to ascertain their behavior on supplementation in food products.

Materials and Methods

Tomato seeds were separated from pomace, which had been collected from a tomato paste manufacturing plant located at Amritsar (India), by a sedimentation technique (Sogi and others 2000) and dehydrated at 70 °C for 5 h in a cabinet dryer (M/S Narang Scientific Works, New Delhi, India) (Sogi and Bawa 1998). Seeds were ground using a hammer mill (M/S Narang Scientific Works, New Delhi, India) to pass through a 50-mesh sieve to obtain a fine powder (de-oiled meal). Protein concentrates were prepared by dissolving de-oiled meal in NaOH (1.0%), distilled water, and NaCl (5%) at ambient temperature (20 to 24 °C) for 10 min, adding HCl to adjust the pH to 3.8, centrifugation (3000 x g, 10 min)(M/S Remi Instruments, Mumbai, India), vacuum drying (50 °C, 100 mm Hg) (M/S Narang Scientific Works, New Delhi, India) and grinding of flakes to pass a 100-mesh sieve.

Water/fat absorption

A sample (0.5 g) was taken in a test tube, then a thick slurry was prepared by mixing with water/refined groundnut (peanut) oil and centrifuged for 15 min at 750 x g. The supernatant was drained off for 30 min and the weight gain reported as water/oil absorption.

Bulk density

A sample was added gradually to a tared 100-mL cylinder and allowed to settle with constant tapping. Volume (mL) and weight (g) of the sample were recorded for computing bulk density (g/mL).

pH

Sample (0.8 g) was dissolved in double-distilled water (20 mL) to obtain a 3% suspension and its pH was determined using a
Functional properties of tomato seeds

Table 1—Water absorption, fat absorption, bulk density, and pH of tomato seed meal and protein concentrate (n = 3)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Whole</th>
<th>De-oiled</th>
<th>Alkali</th>
<th>Water</th>
<th>Salt</th>
<th>LSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water absorption, mL H2O/g</td>
<td>3.20 ± 0.04a</td>
<td>2.88 ± 0.01b</td>
<td>2.15 ± 0.03c</td>
<td>2.02 ± 0.01d</td>
<td>2.12 ± 0.09e</td>
<td>0.21</td>
</tr>
<tr>
<td>(mL H2O/g protein)</td>
<td>(13.15 ± 0.14)a</td>
<td>(8.47 ± 0.03)b</td>
<td>(3.91 ± 0.04)c</td>
<td>(2.79 ± 0.01)d</td>
<td>(3.04 ± 0.12)e</td>
<td>(0.24)</td>
</tr>
<tr>
<td>Fat absorption, mL oil/g</td>
<td>2.63 ± 0.21a</td>
<td>2.37 ± 0.18b</td>
<td>1.87 ± 0.03c</td>
<td>2.17 ± 0.05d</td>
<td>2.03 ± 0.06e</td>
<td>0.19</td>
</tr>
<tr>
<td>(mL oil/g protein)</td>
<td>(10.52 ± 0.84)a</td>
<td>(7.16 ± 0.54)b</td>
<td>(2.62 ± 0.04)c</td>
<td>(2.99 ± 0.06)d</td>
<td>(2.92 ± 0.08)e</td>
<td>(0.68)</td>
</tr>
<tr>
<td>Bulk density, g/mL</td>
<td>0.381 ± 0.00a</td>
<td>0.421 ± 0.00b</td>
<td>0.575 ± 0.00c</td>
<td>0.335 ± 0.00d</td>
<td>0.652 ± 0.01e</td>
<td>0.01</td>
</tr>
<tr>
<td>pH*</td>
<td>5.79 ± 0.02a</td>
<td>6.08 ± 0.09b</td>
<td>3.78 ± 0.02c</td>
<td>3.81 ± 0.03c</td>
<td>3.70 ± 0.02e</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Mean ± S.D. values superscripted with dissimilar letters in rows (a, b, c, d, e) are significantly different (p < 0.05)

*p% aqueous solution

pH meter (Model—LI 612; Elico Ltd., Hyderabad, India).

Whipping quality

Whipping quality was determined over a range of different pH (5.0 to 9.0) values and in solutions of sodium chloride (0.5 to 1.5%) and sucrose (5 to 15%) maintained at pH 7.0. Sample (0.5 g) was taken in a blender (Usha Sriram (India), Noida) containing 50 mL of citrate buffer (0.1 M, pH 5.0 to 9.0 or 7.0) and the respective quantity of sodium chloride or sucrose. The mixture was blended for 2 min and immediately transferred to a 100-mL cylinder. The foam height was noted with respect to time until it collapsed; percent overrun was calculated as follows:

\[ \text{overrun} (%) = \frac{\text{volume of foam}}{\text{volume of solution}} \times 100 \]

Emulsification

Sample (0.5 g), citrate buffer (0.1 M, pH 7.0, 50 mL) and refined peanut oil (10 mL) were taken in a blender (Usha Sriram (India), Noida). The contents were blended for 2 min and then transferred to a 100-mL cylinder. Total cream heights were measured over a period of 50 h to determine emulsion stability, which is the resistance to change in cream volume with time. It can be expressed as percentage change in cream layer per unit time.

Statistical analysis

Data were statistically analyzed according to Gomez and Gomez (1984) using one- and two-way ANOVA to test the significance of differences among the values. Least significant difference (LSD) was also calculated in case of significant effects.

Results and Discussion

The functional properties of a meal and concentrate not only dictate its utilization but also the level of its incorporation into various food products. It might either improve or deteriorate the product quality as well as the storage behavior. Various functional properties of the meals and concentrates provide sufficient knowledge to predict their optimal utilization. The protein content of whole meal, de-oiled meal, alkali-, water-, and salt-extracted protein concentrates were 24.99, 33.07, 71.32, 72.45, and 69.56% (dry basis), respectively.

Water absorption capacity

The ability of whole and de-oiled meals to bind water (Table 1) was 3.20 and 2.88 mL H2O/g, while that of the concentrates from alkali, water, and salt extraction procedures was 2.15, 2.02, and 2.12 mL H2O/g, respectively. The water absorption (p < 0.05) of de-oiled meal was lower than that of whole meal, which could be attributed to the denaturation of protein during the processes of crushing and solvent extraction. Water absorption capacity of the concentrates was significantly lower than that of meals. It could be attributed to the fact that as the pH approaches the isoelectric point, the water holding capacity of protein is minimized. However, it was not affected by the extractants used, water and alkali or salt solutions. Earlier, Rahma and others (1986) reported a water absorption value of 2.53 mL H2O/g for de-oiled meal, which is slightly lower than the values obtained in the present study. The difference could be attributed to the variety of tomatoes used and oil extraction procedures. Liadakis and others (1998) reported water absorption capacity of 2.76 and 4.09 mL H2O/g of protein concentrates obtained through extraction with water and salt, respectively. The values obtained in the present study for similar parameters are slightly lower. These deviations could be due to variations in processing conditions during concentrate preparation; however, the difference in values was not significant and the lower values for concentrate from water extraction as compared to salt complement the present findings.

The water absorption capacity in terms of mLH2O/g protein for different products from tomato seed indicated that the protein in native form can bind more water. Various treatments in the preparation of other products altered the protein functionality resulting in significantly lower water absorption power.

Fat absorption capacity

The whole and de-oiled meals exhibited fat absorption values (Table 1) of 2.63 and 2.37 mL oil/g, while those for concentrates from alkali, water, and salt extraction were 1.87, 2.17, and 2.03 mL oil/g, respectively. The lower fat absorption value for de-oiled meal as compared to that for whole meal might be due to the protein denaturation effect as a result of temperature rise during grinding as well as the seed meal solvent extraction. Among the concentrates, the alkali-extracted showed the lowest fat absorption, which could be attributed to protein denaturation resulting in decreased binding sites for the fat molecules. The results of the present study agree with those of Rahma and others (1986) who reported similar values for de-oiled meal of tomato seeds. However, Liadakis and others (1998) reported the fat absorption values for water- and salt-extracted concentrates from tomato seeds to be 3.17 and 4.04 mL oil/g. The higher values observed by Liadakis and others (1998) could be attributed to differences in tomato variety used and oil extraction procedures.

The fat absorption capacity in terms of mL oil/g protein for different products from tomato seed showed the highest value for the whole meal indicating that the protein in native can bind more fat. Subsequent treatments in the preparation of de-oiled meal and concentrates significantly lowered the fat absorption ability.
Table 2—Foaming capacity (%) of tomato seed meals and protein concentrates under different pH, salt, and sugar levels (n = 3)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Whole</th>
<th>De-oiled</th>
<th>Alkali</th>
<th>Water</th>
<th>Salt</th>
<th>LSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>3.0</td>
<td>2.62 ± 0.77</td>
<td>5.28 ± 0.89</td>
<td>9.54 ± 2.34</td>
<td>9.65 ± 1.54</td>
<td>4.19 ± 0.11</td>
<td>NS</td>
</tr>
<tr>
<td>5.0</td>
<td>2.01 ± 0.03</td>
<td>4.00 ± 0.41</td>
<td>5.47 ± 1.49</td>
<td>5.88 ± 0.64</td>
<td>5.68 ± 0.65</td>
<td>LSD</td>
</tr>
<tr>
<td>7.0</td>
<td>6.54 ± 0.75</td>
<td>8.00 ± 0.23</td>
<td>7.43 ± 1.17</td>
<td>4.27 ± 0.26</td>
<td>11.63 ± 0.32</td>
<td>NS</td>
</tr>
<tr>
<td>Salt 0.5%</td>
<td>10.76 ± 0.16</td>
<td>9.25 ± 1.63</td>
<td>8.08 ± 0.83</td>
<td>10.22 ± 1.31</td>
<td>10.20 ± 2.41</td>
<td>9.30</td>
</tr>
<tr>
<td>1.0%</td>
<td>24.97 ± 1.30</td>
<td>11.63 ± 1.57</td>
<td>3.88 ± 0.53</td>
<td>6.84 ± 0.60</td>
<td>12.50 ± 1.50</td>
<td>9.30</td>
</tr>
<tr>
<td>1.5%</td>
<td>28.84 ± 0.62</td>
<td>15.64 ± 0.94</td>
<td>3.65 ± 0.60</td>
<td>6.91 ± 0.59</td>
<td>10.14 ± 1.57</td>
<td>9.30</td>
</tr>
<tr>
<td>LSD</td>
<td>NS</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>5%</td>
<td>11.32 ± 1.00</td>
<td>15.59 ± 2.71</td>
<td>9.09 ± 0.48</td>
<td>4.61 ± 1.09</td>
<td>6.69 ± 1.02</td>
<td>3.25</td>
</tr>
<tr>
<td>Sugar 10%</td>
<td>11.87 ± 1.29</td>
<td>19.36 ± 2.30</td>
<td>15.45 ± 1.67</td>
<td>10.89 ± 2.39</td>
<td>7.50 ± 1.17</td>
<td>3.25</td>
</tr>
<tr>
<td>15%</td>
<td>14.36 ± 1.20</td>
<td>22.55 ± 2.67</td>
<td>13.47 ± 2.87</td>
<td>12.59 ± 4.42</td>
<td>8.75 ± 1.72</td>
<td>2.51</td>
</tr>
</tbody>
</table>

Mean ± S.D. values superscripted with dissimilar letters in rows (a, b, c, d, e) and columns (p, q, r) are significantly different (p < 0.05), NS—nonsignificant
*Solute:solvent, 1:100

Table 3—Foam stability (half-life) of tomato seed meal and concentrate under different pH, salt, and sugar levels (n = 3)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Whole</th>
<th>De-oiled</th>
<th>Alkali</th>
<th>Water</th>
<th>Salt</th>
<th>LSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td>7.06°</td>
<td>23.06°</td>
<td>120.26°</td>
<td>27.06°</td>
<td>4.30°</td>
<td>71.0</td>
</tr>
<tr>
<td>5.0</td>
<td>0.56°</td>
<td>0.56°</td>
<td>7.06°</td>
<td>7.06°</td>
<td>2.06°</td>
<td></td>
</tr>
<tr>
<td>7.0</td>
<td>55.0°</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salt 0.5%</td>
<td>15.0°</td>
<td>19.7°</td>
<td>2.0°</td>
<td>5.8°</td>
<td>2.4°</td>
<td></td>
</tr>
<tr>
<td>1.0%</td>
<td>50.5°</td>
<td>33.0°</td>
<td>1.0°</td>
<td>3.0°</td>
<td>1.5°</td>
<td>NS</td>
</tr>
<tr>
<td>1.5%</td>
<td>207°</td>
<td>25.5°</td>
<td>1.0°</td>
<td>2.3°</td>
<td>1.5°</td>
<td></td>
</tr>
<tr>
<td>LSD</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5%</td>
<td>5.0°</td>
<td>37.5°</td>
<td>6.25°</td>
<td>0.5°</td>
<td>0.5°</td>
<td></td>
</tr>
<tr>
<td>Sugar 10%</td>
<td>38.4°</td>
<td>40.0°</td>
<td>10.0°</td>
<td>1.0°</td>
<td>1.75°</td>
<td>16.29</td>
</tr>
<tr>
<td>15%</td>
<td>43.0°</td>
<td>45.0°</td>
<td>7.5°</td>
<td>10.0°</td>
<td>2.25°</td>
<td></td>
</tr>
<tr>
<td>LSD</td>
<td>NS</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Means superscripted with dissimilar letters in rows (a, b, c, d, e) and columns (p, q, r) are significantly different (p < 0.05), NS—nonsignificant
*Solute:solvent, 1:100

Bulk density

Bulk density (Table 1) of whole and de-oiled meal was 0.381 and 0.421 g/mL, while the alkali- and salt-extracted concentrates had 0.575, 0.335, and 0.652 g/mL, respectively. The significantly (p < 0.05) higher bulk density of de-oiled meal, as compared to that of whole meal, might be due to the finer particle size of the former. Among the concentrates, the water-extracted one had lower bulk density as compared to that of the salt-extracted one, which was significantly (p < 0.05) higher. Kramer and Kwee (1977b) had reported the bulk density of protein concentrates prepared from whole tomato canning waste to be in the range of 0.076 to 0.101 g/mL. However, in the present study, the concentrate prepared through water extraction showed a similar value, while the concentrate prepared through salt extraction gave higher value as compared to Liadakis and others (1998), who reported 0.27 g/mL. The difference in these values might be as a result of reasons like variation in raw material, processing, and analytical procedures. The bulk density is an important character as it determines the behavior of a material in dry mixes as well as volume occupied while packaging.

pH

The pH values (Table 1) indicated that whole (5.79) and de-oiled (6.06) meals were nearly neutral while the concentrates had pH (3.70 to 3.81) in the acidic pH range. The pH of the de-oiled meal was significantly higher (p < 0.05) than that of the whole meal. It could be attributed to the removal of free fatty acids and fat during oil extraction. The lower pH of the concentrates was due to the HCl used for the precipitation of isolated proteins.

Whipping properties

The foaming capacities (Table 2) of whole meal, de-oiled meal, and alkali-extracted concentrate indicated lower values at pH 5 as compared to pH 3 and 7 (solute to solvent ratio 1:100, 20 to 24 °C). The results further revealed that with the increase in pH from 3 to 7, the foaming capacity changed from 9.65 to 4.27 and 4.19 to 11.63% for concentrates prepared through water and salt extraction procedures, respectively. It may be due to extraction of different types of proteins with different extraction solvents as reported by Canella and Castriotta (1980). Two-way ANOVA did not show any significant (p > 0.05) effect of pH and type of product on the formability. It might be due to negligible effect of pH on the intrinsic properties of the protein like size, surface hydrophobicity, and structural flexibility that are responsible for foaming capacity.

With the addition of 0.5, 1.0, and 1.5% salt, foaming capacity of the meal was 10.76, 24.97, and 28.84% for whole meal, while the de-oiled meal gave values as 9.25, 11.63, and 15.64% which might be due to extraction of globulin which has a higher foaming capacity under neutral pH conditions. The foaming capacity of the alkali- and water-extracted concentrates decreased with the increase in salt concentration; however, the salt-extracted concentrate did not show much change. The lower foam capacity of the alkali- and water-extracted concentrate might be due to lower extraction of salt-soluble proteins. Salt-extracted concentrate did not show any significant change in foam capacity since it mainly contained globulin. Addition of sugar improved the foaming capacity of meals and concentrates; however, the de-oiled meal exhibited the highest response. The alkali-extracted concentrates showed higher foaming capacity than those extracted with salt and water.

Kramer and Kwee (1977b) reported that the overrun for the protein concentrates...
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from tomato canning waste and soybean proteins (Supro 610) were 100 to 118 and 40%, respectively, at pH 7.0, and the addition of sugar further improved it. Rahma and others (1986) observed that the de-oiled meal had poor foaming properties. The present study has indicated that with the addition of salt and sugars the foaming ability of the meal and concentrates from tomato seeds improved, which is similar to the finding by Kramer and Kwee (1977b).

Foam stability is equally important since food products are generally stored under ambient or refrigeration conditions until consumed. There are many criteria for measuring the foam stability, such as volume, drained liquid, conductivity, density, but in the current study the former was used with half-life units considering its merits (Wilde and Clark 1996). Whole and de-oiled meal gave negligible foam stability (0.5 min) at pH 5.0 which improved as the pH was increased to 7.0 or decreased to 3.0 (Table 3). The foam stability was 23 and 95 min at pH values of 3.0 and 7.0 in the case of de-oiled meal, which was higher than that for the whole meal, possibly due to the higher protein content of the former. Alkali-extracted concentrate showed a half-life of 120 min at pH 3.0 followed by 27 and 4.3 min for concentrates prepared through water and salt extraction, respectively. De-oiled meal and alkali-extracted concentrate showed a significant ($p < 0.05$) effect of increase in pH while others did not exhibit any such effect.

The data showed that with 0.5, 1.0, and 1.5% salt, half-lives were 15, 50.5, and 207 min for the whole meal and 19.7, 33, and 25.5 min for the de-oiled meal, respectively. The concentrates showed poor stability at all salt concentrations. Statistical analysis did not indicate any significant change with the addition of salt, and among the meals as well as concentrates. The foam stability values with 5, 10, and 15% sugar addition were 37.5, 40.0, and 45.0 min for the de-oiled meal and 5.0, 38.5, and 43.0 min for the whole meal, respectively. However, protein concentrates exhibited poor stability in the range of 0.5 to 10 min under similar conditions. Statistical analysis revealed significant differences among the meals and concentrates with the addition of sugar ($p < 0.05$), however, sugar level did not improve the stability significantly.

Rahma and others (1986) reported that the foam structure was very weak and stability at room temperature was only 15 min (half-life). Kramer and Kwee (1977b) reported that tomato waste protein concentrates, with or without the addition of sugar, produced a more stable foam as compared to the salt-extracted one.

Emulsification properties

Figure 1 and 2 reveal that whole and de-
Concentrate:oil:water, 1:20:100

perature (20 to 24 °C), while, among the
and de-oiled meals were stable as evident
emulsifying capacities. The higher emulsi-
oiled meals had good emulsion capacity
protein concentrates prepared by alkali, wa-
ter, and salt extractions exhibited nearly 25, 27,
and 30% cream formation under similar
conditions (Figure 3 to 5). The whole meal
gave higher values as compared to the de-
oiled one, while concentrates showed lower
emulsifying capacities. The higher emulsi-
ying capacity of the whole meal may be
attributed to its higher emulsifier content
than that of de-oiled meal and concen-
trates. Emulsions formed by the whole
and de-oiled meals were stable as evident
from the thickness of the cream layer over
a retention period of 50 h at ambient tem-
perature (20 to 24 °C), while, among the
protein concentrates, stability of water-
and salt-extracted ones gave higher values.
The alkali-extracted concentrate showed
poor stability since the thickness of the
cream layer gradually reduced with the
breakdown of emulsion. A negligible
quantity of foam was produced in all the
cases, which collapsed after 1.5 h.
The emulsification capacity of 46.90 mL of
oil/g has been reported for de-oiled meal
(Rahma and others 1986) which is similar
to the one reported in the present study. Liadakis
and others (1998) reported that emulsion ac-
civity and stability of water- and salt-extracted
concentrates were comparable to those for
soybean. The present study confirms the
good emulsion capacity and stability of the
water- and salt-extracted concentrates.

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Conclusions
The functional properties of tomato seed meals and concentrates were evaluated to assess their effective use in food systems. Foaming properties were found to be poor; however, emulsion properties were adequate to form a good emulsion in a food system. The emulsifying capacity and stability of meal was better; however, water-
and salt-extracted protein concentrates may be better suited for food systems due to the absence of cellular matter.