Physicochemical, Rheological and Sensory Properties of Different Brands of Sesame Pastes

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Abstract: The chemical characteristics, rheological properties and sensory evaluation of nine different brands of the sesame pastes were investigated. The sesame pastes showed a significant difference for the crude fat, protein, crude fibre, total sugars, total ash, moisture content, and acid values \((p < 0.05)\). The fat content ranged from 51.80% to 61.56%, and the protein content varied between 16.08% and 18.97%. All sesame paste samples are pseudoplastic materials. The flow indexes lied between 0.67 and 0.81 for the tested sesame pastes \((p > 0.05)\). The consistency coefficient of the different sesame paste brands varied significantly \((p < 0.05)\), ranging from 4.48 to 24.21 Pa·s\(^*\), indicating that the consistency coefficient is a more sensitive parameter for measuring the flow behaviour of foodstuff. The areas of the hysteresis loops of the white-sesame paste of “Haoweisi” brand and the black-sesame paste of “A Yimeng couple” brand were higher than the other sesame pastes, indicating that these two samples were difficult to be restored to their original structures and such restoration required a longer time. Both Storage modulus \((G')\) and loss modulus \((G'')\) of the sesame pastes increased with increasing frequency, and \(G'\) values were greater than the \(G''\) values, exhibiting the typical properties of the viscoelastic solid, the results may provide the valuable reference for choosing the sesame pastes as the spreadable butters or salad dressings, and for further processing.

Key words: sesame paste, rheological properties, the consistency coefficient, proximate composition

1 INTRODUCTION

Sesame pastes, made of milling of the roasted sesame seeds, are widely popular in the East Asian and Middle Eastern countries, used as the spread on the steamed bread, the dressing, as an ingredient in foods or a base for developing new creamy products\(^1\). Sesame paste is a kind of colloidal suspension with hydrophilic solids suspended in sesame oil, behaving as non-Newtonian pseudo-plastic foodstuff\(^2\). Decreasing the particle size increases the tendency from elastic to viscous feature and decreased the magnitude of thixotropic area\(^1\). And the effect of temperature\(^3\), the dehulling\(^4\), the addition of the constituents\(^5, 3–11\) on the rheological properties of sesame paste have also been studied.

On the other hand, the sesame pastes are manufactured from natural products, it may be difficult to get chemically and physically uniform samples. Recent study indicated that the composition of different commercial sesame paste brands varies considerably\(^12\). However, in our knowledge, no study has been performed to characterize the rheological properties of the different sesame paste brands. Thus, the objective of the present work is to investigate the variance of the rheological properties of the commercial sesame paste, characterize the static flow properties and dynamic viscoelasticity of the different commercial sesame paste brands, and try to explore the relationship between the constituents, the rheological parameters and the sensory evaluations of the sesame pastes.

2 EXPERIMENTAL

2.1 Materials

During April 2016, the sesame butters of the nine different commercial brands (5 brand of white-sesame paste and 4 brand of black-sesame paste) were bought from the supermarket, or in the local market at Zhengzhou, China or through the internet to exhibit the most variation as far as possible. The brands of white-sesame pastes included “Cuizi” (Shandong Weifang Ruifu Oil Seasoning Co. Ltd, China), “Haoweisi” (Zhumadian Kangbo-huixin Agricultural Technology Co. Ltd, China), self-making sesame paste of the supermarket Dennis (Zhengzhou, China), and “Zhengdao” (Zhumadian Zhengdao Oil Industry Co. Ltd, China),

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which were referred to as W1, W2, W3, and W4, respectively. The brands of black-sesame pastes included "Cuizi", "Zhengdao", and self-making sesame paste of the supermarket Dennis, which were referred to as B1, B2, and B3, respectively. All these samples were bought in the supermarket in Zhengzhou, China. One white-sesame paste sample was bought in Chenzhai farmers market, Zhengzhou, China, and the black-sesame paste "A Yimeng couple" was bought from "Taobao" in the internet, which were referred to as W5, and B4, respectively. The samples were kept at 4°C and analysed during the shelf-life period.

2.2 Physicochemical characterization

The determination method of proximate composition was in accord with Hou\(^{[13]}\). Briefly, the proximate composition (crude fat, protein, moisture, and total ash) contents and the acid value were measured according to the methods of the Association of Official Analytical Chemists\(^{[10]}\).

The determination of crude fibre and total sugar contents were performed according to Van Soest et al.\(^{[15]}\) and Dubois et al.\(^{[16]}\), respectively.

2.3 Rheological properties

A Haake Rheostress60 rheometer equipped with a P35/Ti rotor and a TMP plate (diameter of 40 mm) was used to measure the rheological properties of the sesame pastes. A measurement distance of 1 mm was used for all rheological measurements.

The sesame paste samples were homogeneously mixed and placed on plates after calibration of the rheometer. The rotor was pressed down to scrape off excess sample. The rheological measurements were performed at 25°C.

Measurement of fluidity: The shear rate was increased gradually from 0.1 s\(^{-1}\) to 200 s\(^{-1}\) to study the changes in the apparent viscosity and stress; a power law model was used to fit the data as follows:

\[
\eta = k\gamma^{n-1}
\]

(Equation 1)

Where \(\eta\) is the apparent viscosity, Pa·s; \(\gamma\) is the shear rate, s\(^{-1}\); \(k\) is the consistency coefficient, Pa·s\(^{n}\); and \(n\) is the flow index.

Measurement of thixotropy: The shear rate was increased from 0.1 s\(^{-1}\) to 100 s\(^{-1}\) in 120 s, kept at 100 s\(^{-1}\) for 1 min, and then decreased from 100 s\(^{-1}\) to 0.1 s\(^{-1}\) in 120 s to obtain the hysteresis loop, and the hysteresis loop area was calculated using Rheowin Pro software (Haake).

Dynamic viscoelasticity: Within the viscoelastic range of the samples, the scan strain was 0.02% and the scan frequency was 0.1 Hz–10 Hz to record the variation patterns of the storage modulus and loss modulus with frequency.

2.4 Sensory evaluation

The sensory evaluation was determined by ten untrained panelists recruited from the graduate students and the staff. The sensory evaluation scoring standard for sesame paste was shown in Table 1. Statistical analysis was carried out using Microsoft Office Excel 2003, the confidence interval was set at 95%.

2.5 Data analysis

The HAAKE Rheowin Data Manager 4.63.000 was used to analyse all data collected in the rheological measurements; Origin 8.0, SPSS 16.0 and Excel 2003 were used to analyse the composition and sensory evaluation data. All measurements were performed in duplicate.

3 RESULTS AND DISCUSSION

3.1 Proximate composition and acid values

The commercial sesame pastes were chosen according to our previous study\(^{[17]}\) to represent the most wide range of products as possible. Significant differences were observed between the sesame pastes (\(p<0.05\)) (Table 2), and there existed the high coefficient of variation of 5.78% - 57.05% for the analyzed parameters (data not shown). The fat

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Sensory evaluation standards for sesame paste.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Descriptor</td>
<td>0~75</td>
</tr>
<tr>
<td>Colour and lustre (20%)</td>
<td>Abnormal colour and lustre; lacklustre</td>
</tr>
<tr>
<td>Smell (30%)</td>
<td>No aroma of sesame paste, burned taste or other bad smell</td>
</tr>
<tr>
<td>Texture (30%)</td>
<td>Poor fluidity, too dilute or viscous, no visual impurities, gritty</td>
</tr>
<tr>
<td>Taste (20%)</td>
<td>bad taste</td>
</tr>
</tbody>
</table>
Rheology of Different Brands of Sesame Paste

4.48 and 53.92 acid values had the highest coefficient of variation of -3.78 W2.

between 16.08 highest and W2 the lowest; and protein content varied to 61.56

varied for the sesame paste ported for the sesame paste

the sesame produced in Cameroon Syrian sesame seed

In general terms, our results were similar to those re-

The crude fibre, total sugars, and total ash contents were

content ranged from 51.80% to 61.56%, with W5 the

and protein content varied between 16.08% and 18.97%, in the decreasing order of

B1 > B2 > W4 > B4 > W5 > B3 > W3 > W1 > W2.

The crude fibre, total sugars, and total ash contents were in the range of 2.53% - 3.78%, 6.23% - 18.57%, and 4.48% - 5.24%, respectively. The moisture content and acid values had the highest coefficient of variation of 57.05% and 53.92%, respectively.

In general terms, our results were similar to those re-

ported for the sesame paste 

reported the lower oil content and higher protein contents for

Korean sesame cultivars. In China, the sesame seeds for

production sesame pastes are from home and abroad in-

cluding Sudan, Nigeria, Ethiopia, Myanmar and so on. The various source of sesame seeds may contribute to the discrepancy.

3.2 Rheological properties of different commercial sesa-

3.2.1 Flow behaviour

Nine commercial sesame paste products were measured for rheological properties at 25°C. The flow curves showed the shear stress increased non-linearly with increasing shear rates for all samples (Fig. 1), indicating the sesame pastes behaved as non-Newtonian fluid.

It can be seen in Fig. 2 that for shear rates of 0.1 s^-1~ 200 s^-1, there was shear thinning for all sesame paste samples, i.e., the apparent viscosity decreases with increasing shear rate, but when the shear rate was greater than 50 s^-1, the apparent viscosities of the sesame paste samples showed the plateau of stability. The measured data fitted well into the power law model with R^2 values greater than 0.9648, and the fitting results were shown in Table 3. It can

### Table 2 Chemical composition and acid values of the sesame paste*

<table>
<thead>
<tr>
<th>Commercial samples</th>
<th>Crude fat (%)</th>
<th>Protein (%)</th>
<th>Crude fibre (%)</th>
<th>Total sugars (%)</th>
<th>Total ash (%)</th>
<th>Moisture content(%)</th>
<th>Acid values (mgKOH/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>W1</td>
<td>59.71 ± 0.26^a</td>
<td>17.00 ± 0.13^b</td>
<td>3.78 ± 0.10^c</td>
<td>7.70 ± 0.16^d</td>
<td>5.01 ± 0.01^e</td>
<td>0.12 ± 0.02^f</td>
<td>1.07 ± 0.10^g</td>
</tr>
<tr>
<td>W2</td>
<td>61.56 ± 0.50^a</td>
<td>16.08 ± 0.05^b</td>
<td>2.83 ± 0.05^c</td>
<td>6.23 ± 0.12^d</td>
<td>4.48 ± 0.01^e</td>
<td>0.47 ± 0.03^f</td>
<td>1.77 ± 0.04^g</td>
</tr>
<tr>
<td>W3</td>
<td>59.70 ± 0.30^a</td>
<td>17.21 ± 0.13^b</td>
<td>2.89 ± 0.04^c</td>
<td>8.96 ± 0.40^d</td>
<td>5.40 ± 0.03^e</td>
<td>0.64 ± 0.003^f</td>
<td>0.81 ± 0.02^g</td>
</tr>
<tr>
<td>W4</td>
<td>53.78 ± 2.71^a</td>
<td>18.04 ± 0.10^b</td>
<td>2.81 ± 0.07^c</td>
<td>10.35 ± 0.40^d</td>
<td>4.79 ± 0.03^e</td>
<td>0.20 ± 0.01^f</td>
<td>1.28 ± 0.01^i</td>
</tr>
<tr>
<td>W5</td>
<td>51.80 ± 1.20^a</td>
<td>17.96 ± 0.03^b</td>
<td>3.19 ± 0.06^c</td>
<td>10.87 ± 0.02^d</td>
<td>5.10 ± 0.03^e</td>
<td>0.34 ± 0.003^f</td>
<td>1.36 ± 0.01^i</td>
</tr>
<tr>
<td>B1</td>
<td>56.84 ± 0.70^a</td>
<td>20.10 ± 0.09^b</td>
<td>2.94 ± 0.09^c</td>
<td>18.57 ± 0.14^d</td>
<td>5.70 ± 0.02^e</td>
<td>0.50 ± 0.01^f</td>
<td>2.51 ± 0.09^i</td>
</tr>
<tr>
<td>B2</td>
<td>55.71 ± 3.22^a</td>
<td>18.97 ± 0.02^b</td>
<td>2.53 ± 0.05^c</td>
<td>12.38 ± 0.13^d</td>
<td>5.10 ± 0.03^e</td>
<td>0.63 ± 0.01^f</td>
<td>2.94 ± 0.03^i</td>
</tr>
<tr>
<td>B3</td>
<td>55.38 ± 2.10^a</td>
<td>17.49 ± 0.20^b</td>
<td>3.43 ± 0.08^c</td>
<td>12.90 ± 0.08^f</td>
<td>5.24 ± 0.02^d</td>
<td>1.10 ± 0.02^e</td>
<td>4.26 ± 0.08^f</td>
</tr>
<tr>
<td>B4</td>
<td>55.91 ± 0.26^a</td>
<td>17.3 ± 0.21^b</td>
<td>3.05 ± 0.11^c</td>
<td>13.31 ± 0.03^f</td>
<td>4.50 ± 0.03^g</td>
<td>0.93 ± 0.04^d</td>
<td>1.77 ± 0.07^g</td>
</tr>
</tbody>
</table>

* The components are expressed on dry weight basis except moisture content; Values within the same column with different letters differ significantly (p < 0.05).

- Fig. 1 Relationship between the shear rate and shear stress for the nine commercial sesame paste brands at 25°C.

- Fig. 2 Apparent viscosity-shear rate relationship for different sesame pastes at 25°C.
be seen that the flow behavior index n values were less than 1, indicating that all sesame paste samples are pseu-
doplastic materials. The finding was similar with that re-
ported for hulled and unhulled sesame pastes\(^3\), milled
sesame\(^2\), and sweetened sesame paste\(^3\). The flow behavior
index reflects the degree of pseudoplasticity of a fluid, and
the further the n values to 1, the greater deviation from
Newtonian flow behaviour. The n values lied between 0.67
and 0.81 for the tested sesame pastes, and there were no
significant difference among those of the different brands
\((p>0.05)\). The reported n values at 25°C for sweetened
sesame paste was 0.44\(^{11}\), that for milled sesame was 0.95\(^2\),
and our results fell within the range of the reported values.

The initial apparent viscosities of the 9 sesame paste
samples lied between 6.46 and 28.06 Pa\(\cdot\)s. The consistency
indexes k of the different sesame paste brands varied sig-
nificantly \((p<0.05)\), ranging from 4.48 to 24.21 Pa\(\cdot\)s\(^2\), in
the descending order of B4 > W2 > W1 > B3 > B1 > W4 > W5
> W3 > B2, and indicating that the consistency index is a
more sensitive parameter for measuring the flow behaviour
of foodstuff. Our results were higher than 1.71 Pa\(\cdot\)s\(^2\) re-
ported for milled sesame\(^2\), and Razavi et al.\(^7\) reported that
the consistency index of 108 for sesame paste/ date syrup
blends, and the consistency indexes increased to 201.4-240
Pa\(\cdot\)s\(^2\) after incorporating the starch, or xanthan, or guar
gum into the blends as the fat replacer. In China, the
tesame pastes are produced using the various equipment
and techniques. The sesame seeds roasting temperature
ranged from 130°C to 170°C. And the common equipment
used includes the stone mill and colloid mill, and the fluid
high energy medium mill is put into use in small scale. The
diversity may lead to the different particle sizes and
account for discrepancy in the flow behavior index and the
consistency indexes between the different commercial
brands.

Many researchers reported the rheological properties of
the various food samples\(^{23-26}\). And the reported consistency
index k and flow behaviour index n at 25°C for commercial
lactic beverages were 0.102 - 0.44 Pa\(\cdot\)s\(^2\) and 0.510 – 0.671 respectively\(^{27}\), those for Lebasese locust bean
gum were 0.90 – 9.25 Pa\(\cdot\)s\(^2\) and 0.47 – 0.70 respectively\(^{28}\),
those for creamed honey were 63.0 Pa\(\cdot\)s\(^2\) and 0.7885 re-
spectively\(^{29}\), and those for mayonnaise samples were
26.05–81.38 Pa\(\cdot\)s\(^2\) and 0.16–0.33 respectively\(^{10}\).

### 3.2.2 Thixotropy

Thixotropy is the ability of a food system to return to its
original structure after it is subjected to external forces,
and thixotropy test is desired for the development of
texture for edible applications. On the premise of not dam-
aging the structure of samples, the shear stress reaches its
maximum with increasing shear rates, and the process is
recovered after decreasing the shear rate, thus forming a
closed hysteresis loop. The area of the hysteresis loop rep-
resents the energy required for a sample to eliminate the
effect of time on flow behaviour\(^{11}\).

It can be seen from Fig. 3 that except for W5, the other
sesame butter samples all exhibit the thixotropy behaviour,
and the areas of hysteresis loops were calculated, as shown
in Table 4.

It can be seen from Table 4 that the areas of the hystere-
sis loops of the sesame paste W2 and B4 were higher than
those of the other sesame pastes, indicating that it was dif-
ficult for these two samples to be restored to their original
structures and that such restoration requires a longer time.
The area of the hysteresis loop of the white sesame paste
W5 was 0 Pa/s, indicating that this samples has no thixot-
ropy. The pseudoplastic and thixotropic behaviour have
the impact on the spreadability of sesame paste\(^3\), and thus
the results may provide the valuable reference for choosing
the sesame pastes as the spreadable butters.

### Table 3  Fitting parameters of the law power model for the sesame paste at 25°C.

<table>
<thead>
<tr>
<th>Sample</th>
<th>W1</th>
<th>W2</th>
<th>W3</th>
<th>W4</th>
<th>W5</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>B4</th>
</tr>
</thead>
<tbody>
<tr>
<td>k (Consistency coefficient)</td>
<td>12.87 ± 0.52(^a)</td>
<td>13.68 ± 0.69(^b)</td>
<td>5.09 ± 1.06(^a)</td>
<td>7.72 ± 0.61(^a)</td>
<td>7.53 ± 1.47(^a)</td>
<td>11.78 ± 0.64(^a)</td>
<td>4.48 ± 0.68(^a)</td>
<td>11.97 ± 1.75(^a)</td>
<td>24.21 ± 0.07(^a)</td>
</tr>
<tr>
<td>n (flow behavior index)</td>
<td>0.73 ± 0.02</td>
<td>0.77 ± 0.06</td>
<td>0.80 ± 0.06</td>
<td>0.77 ± 0.02</td>
<td>0.75 ± 0.05</td>
<td>0.76 ± 0.02</td>
<td>0.81 ± 0.04</td>
<td>0.71 ± 0.04</td>
<td>0.67 ± 0.00 (^a)</td>
</tr>
<tr>
<td>R(^2)</td>
<td>0.9993 ± 0.0095</td>
<td>0.9972 ± 0.0028</td>
<td>0.9648 ± 0.0350</td>
<td>0.9839 ± 0.0159</td>
<td>0.9797 ± 0.0217</td>
<td>0.9896 ± 0.0094</td>
<td>0.9657 ± 0.0343</td>
<td>0.9816 ± 0.0179</td>
<td>0.9890 ± 0.0070</td>
</tr>
</tbody>
</table>

**Fig. 3** Thixotropy measurements of the nine sesame paste brands at 25°C.

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3.2.3 Dynamic viscoelasticity

Storage modulus ($G'$) and loss modulus ($G''$) are important parameters for the evaluation of food raw materials and products quality as well as for the prediction of processing performance. If $G' \geq G''$, the samples will exhibit characteristics of gels and behave as the viscoelastic solids, and if $G' \leq G''$, the samples will exhibit characteristics of fluids and behave as the elastic liquids. In a frequency sweep, characteristics of the high frequency area can represent the short-term properties of the samples, while characteristics of the low frequency area can reflect the long-term properties of samples (storage stability).

Our preliminary experiments showed that Linear viscoelastic region (LVR) was observed for the sesame pastes at strain of 0.001%~0.02%, and a strain of 0.02% was selected for further frequency sweep. Figure 4 shows the frequency sweep chart of the 9 sesame paste products. Both $G'$ and $G''$ of the sesame pastes increased with increasing frequency, and $G'$ values were greater than the $G''$ values, exhibiting the typical properties of the viscoelastic solid, which agrees with previous reports.

The sesame paste samples having fine particles tend to show the viscous characters, rather than the elastic characters, and those having coarse particles have the higher $G'$ values and the stronger particle-particle interactions. The $G'$ and $G''$ values of the 9 sesame paste products were all different, and B4 had the greatest $G'$ and $G''$ values, while those for W2 were the smallest. Thus it can be referred that all the tested sesame pastes may have the coarse particles, and the variance in the particle size may contribute to the difference.

3.3 Sensory evaluation

The sensory evaluation was performed for the nine commercial sesame butters, and the results were shown in Table 5.

It can be seen that there existed the difference in color and lustre, smell, taste and texture between the different brands, but not significant ($p > 0.05$). Sample W1 was brownish yellow, had characteristic aroma of sesame paste, proper viscosity, and received the highest total score, followed by B2. Akbulut et al. found that sesame paste/pine honey blends obtained the highest overall acceptance when pine honey level was 9%, and there were the significantly positive correlations between spreadibility, mouth coating and overall acceptability. The sensory characterics of the sesame pastes was influenced by many factors, such as grinding and roasting. It was reported that comparing with that from steamed or microwaved, sesame paste made from roasted sesame was acceptable, the flavor of the products was dependent on the roasting condition.

3.4 Relationship / Correlation between the different evaluation parameters

Pearson’s correlation analysis was performed, and the results were shown in Table 6.

Significant positive relationship was observed between protein content and sugar content, and between moisture content and acid values. And there existed the significant negative relationship between the ash content and the area of hysteresis loops. Altay & Ak reported that the tahin oil behaved like a Newtonian liquid, but incorporating up to 30% solid particles presented a significant increase in viscosity and a shift to pseudoplastic property. There was a significantly negative correlation between the fat content and protein content.

**Table 4 Areas of the hysteresis loops of the sesame paste.**

<table>
<thead>
<tr>
<th>Sample</th>
<th>W1</th>
<th>W2</th>
<th>W3</th>
<th>W4</th>
<th>W5</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>B4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of hysteresis loop (Pa/s)**</td>
<td>500</td>
<td>3400</td>
<td>100</td>
<td>500</td>
<td>0</td>
<td>600</td>
<td>200</td>
<td>700</td>
<td>3700</td>
</tr>
</tbody>
</table>

**Areas of hysteresis loops were calculated using HaakeRheowin Pro software 4.7.**

![Fig. 4 Frequency sweep chart (a, storage modulus; and b, loss modulus) of the nine sesame paste brands at 25°C.](image)
and the yield stress, and viscosity of salad dressing\(^{35}\). Lindner & Kinsella\(^{36}\) found the apparent viscosity of the sesame paste was 3.75, reached the high value when the water content was 6\%, and the viscosity decreased when the water content exceeded 40\%. The mechanism behind the relationship between the flow behaviour parameters and the components such as the moisture and ash content needs to be further elucidated.

### 4 Conclusions

The commercial sesame pastes presented physicochemical characteristics (crude fat, protein, crude fibre, total sugars, total ash, moisture content, and acid values) with significant differences (\(p<0.05\)), indicating heterogeneity of brands found in the Chinese market. All tested sesame pastes exhibited pseudoplastic behaviour. There existed significant difference between the consistency coefficients of the different sesame paste brands. The white-sesame paste of "Haoweisi" brand and the black-sesame paste of "A Yimeng couple" brand had the larger areas of the hysteresis loops than the other sesame pastes, indicating that these two samples were difficult to be restored to their original structures and such restoration required a longer time. All the tested sesame pastes behaved in the same way as gel-like structured materials in which storage modulus (\(G'\)) was greater than loss modulus (\(G''\)). Sample W1 is brownish yellow, had characteristic aroma of sesame paste, proper viscosity, and received the highest total score. The physicochemical, rheological and sensory properties of the different brands of sesame paste might be valuable for product improvement, processing and transportation in the food industry.

### Table 5  Sensory evaluation for the sesame paste.

<table>
<thead>
<tr>
<th>Commercial samples</th>
<th>Color and lustre</th>
<th>Smell</th>
<th>Taste</th>
<th>Texture</th>
<th>Total score</th>
</tr>
</thead>
<tbody>
<tr>
<td>W1</td>
<td>17.00 ± 0.51</td>
<td>26.15 ± 1.36</td>
<td>27.08 ± 2.01</td>
<td>17.00 ± 0.69</td>
<td>87.23 ± 1.57</td>
</tr>
<tr>
<td>W2</td>
<td>16.08 ± 0.68</td>
<td>25.08 ± 1.52</td>
<td>23.38 ± 1.62</td>
<td>15.38 ± 0.71</td>
<td>79.92 ± 1.53</td>
</tr>
<tr>
<td>W3</td>
<td>15.77 ± 1.22</td>
<td>24.46 ± 1.47</td>
<td>23.92 ± 1.89</td>
<td>14.54 ± 0.85</td>
<td>78.69 ± 0.43</td>
</tr>
<tr>
<td>W4</td>
<td>14.52 ± 1.30</td>
<td>24.18 ± 2.11</td>
<td>23.05 ± 1.43</td>
<td>15.40 ± 0.69</td>
<td>77.15 ± 1.53</td>
</tr>
<tr>
<td>W5</td>
<td>15.92 ± 0.59</td>
<td>24.31 ± 1.63</td>
<td>25.00 ± 2.41</td>
<td>16.15 ± 1.01</td>
<td>81.38 ± 0.64</td>
</tr>
<tr>
<td>B1</td>
<td>16.54 ± 0.87</td>
<td>24.69 ± 1.45</td>
<td>26.15 ± 2.32</td>
<td>16.77 ± 1.52</td>
<td>84.15 ± 1.16</td>
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<tr>
<td>B2</td>
<td>15.64 ± 0.36</td>
<td>23.03 ± 2.02</td>
<td>25.48 ± 1.08</td>
<td>15.22 ± 0.87</td>
<td>79.37 ± 0.59</td>
</tr>
<tr>
<td>B3</td>
<td>15.46 ± 0.75</td>
<td>21.85 ± 1.88</td>
<td>24.08 ± 1.45</td>
<td>13.85 ± 0.65</td>
<td>75.24 ± 0.73</td>
</tr>
<tr>
<td>B4</td>
<td>16.15 ± 0.26</td>
<td>23.15 ± 1.26</td>
<td>25.77 ± 2.33</td>
<td>15.54 ± 0.78</td>
<td>80.61 ± 1.63</td>
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### Table 6  Pearson’s coefficients of correlation between the composition, flow behavior parameters and texture of the sesame paste.

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<thead>
<tr>
<th></th>
<th>Crude fat</th>
<th>Protein</th>
<th>Crude fiber</th>
<th>Total sugars</th>
<th>Total ash</th>
<th>Moisture content</th>
<th>Acid value</th>
<th>n</th>
<th>k</th>
<th>Hysteresis loop area</th>
<th>Texture</th>
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</thead>
<tbody>
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<td>-0.023</td>
<td>-0.526</td>
<td>-0.213</td>
<td>-0.231</td>
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<td>0.245</td>
<td>0.075</td>
<td>-0.750*</td>
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<td>0.582</td>
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<td>0.040</td>
<td>0.240</td>
<td>0.341</td>
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<td>-0.750*</td>
<td>0.138</td>
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</table>

* Significant at \(p < 0.05\), ** Significant at \(p < 0.01\) (\(n=9\)).
Rheology of Different Brands of Sesame Paste

References:
(2014).


