Antioxidant activity and inhibition of key enzymes linked to type-2 diabetes and hypertension by *Azadirachta indica*-yogurt

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Abstract *Azadirachta indica* is widely used in traditional medicine to treat diabetes and hypertension. In the present study *A. indica*-yogurt was prepared and refrigerated up to 28 days. 

pH of *A. indica*-yogurt was lower whereas total titratable acid (TTA) was higher than plain-yogurt during storage. The total phenolic content (TPC) and antioxidant capacity increased during storage. *A. indica*-yogurt had highest TPC (74.9 ± 5.1 μgGAE/ml; p < 0.05) on day 28 and DPPH inhibition (53.1 ± 5.0%; p < 0.05) on day 14 compared to plain-yogurt (29.6 ± 1.1 μgGAE/ml and 35.9 ± 5.2%, respectively). The OPA values increased between day 7 and 21 of storage but reduced on the 4th week of storage with values for *A. indica*-yogurt being higher (p < 0.05) than plain-yogurts. Maximum inhibition of α-amylase (47.4 ± 5.8%), α-glucosidase (15.2 ± 2.5%) and angiotensin-1 converting enzyme (ACE, 48.4 ± 7.2%) by plain-yogurt water extract occurred on day 7, 14 and 0, respectively. *A. indica*-yogurt water extract increased the inhibition to maximal values for α-glucosidase and ACE on day 14 of storage (15.9 ± 10.1% and 79.70 ± 11.2%, respectively) and for α-amylase on day 21 of storage (54.8 ± 3.2%). *A. indica*-yogurt has higher TPC, antioxidant activities and enzymes inhibitory effects than plain-yogurt. Thus *A. indica*-yogurt may have the potential to serve as enhanced functional yogurt with anti-diabetic and anti-hypertension activities.

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1. Introduction

Yogurt is considered a healthy food due to high digestibility and bioavailability of its protein, energy and calcium. In addition, the yogurt microbial fermentative activities (e.g. proteolysis) during the making of yogurt resulted in modification of allergenic properties of milk (Viljoen et al., 2001) and the release of a range of bioactive peptides encrypted within the sequence of the native proteins (Gobbetti et al., 2004). Amongst the bioactive components detected in dairy products,
inhibitors of angiotensin I-converting enzyme (ACE), which has a central role in the regulation of blood pressure in mammals, have been studied extensively because of their potential use in the treatment of elevated blood pressure (Meisel, 1998).

In recent years, there has been increasing interest in the use of natural food additives and incorporation of health-promoting substances into the diet. Medicinal plants play an important role in the treatment of diabetes and hypertension, particularly in developing countries where most people have limited resources and access to modern treatments (Marles and Farnsworth, 1994). These plants have been investigated with respect to the suppression of glucose production from carbohydrates in the gut or glucose absorption from the intestine (Matsui et al., 1987), as well as the inhibition of ACE-I activities (Actis-Goreta et al., 2003; Kwon et al., 2005). The phenolic compounds, for instance, play a role in mediating anti-inflammatory and anti-diabetic effects (Clayton et al., 1996). Early studies showed that aqueous extract of neem leaves decreased blood glucose levels as well as glucose-induced hyperglycaemia (Shibata, 1955) whereas oral doses of neem leaf extracts significantly reduced insulin requirements for insulin dependent diabetes (McCue and Shetty, 2004). Phenolic compounds also have lower inhibitory effect against α-amylase activity but a stronger inhibition activity against α-glucosidase and therefore, can potentially be used as effective therapy for postprandial hyperglycaemia with minimal side effects (Kwon et al., 2006).

Neem (Azadirachta indica) has long been used to treat some pathological conditions linked to oxidative disorders which include treatment of fever, diabetes, and disorders that relate to arthritis and rheumatism (Van der Nat et al., 1991), skin diseases and inflammation (Clayton et al., 1996). Early studies showed that aqueous extract of neem leaves decreased blood adrenaline as well as glucose-induced hyperglycaemia (Shibata, 1955) whereas oral doses of neem leaf extracts significantly reduced insulin requirements for insulin dependent diabetes (Murthy and Sirsi, 1958). The biologically active components of dried A. indica leaves were found to be β-sitosterol, glucosides, nimbin, azadirones, azadirachtin and alkaloids (Schmutzer, 1995).

The purpose of this present study was to assess the inhibitory potentials of A. indica-yogurt extract as anti-diabetic (i.e. against α-amylase and α-glucosidase) and anti-hypertensive (i.e. against angiotensin-I converting enzyme) agents. Quantitative measurements were also carried out on the A. indica-yogurt water extracts total phenolic content, antioxidant capacity and OPA values.

2. Materials and methods

2.1. Plant material

A. indica leaves were collected from an eighteen-year old tree in Petaling Jaya, Selangor, Malaysia. The leaves were washed and then oven dried (50 °C) for 72 h. The dried leaves were then ground to powder form, placed in an airtight container and stored at room temperature away from direct sunlight.

2.2. Water extraction of herb

Powdered A. indica leaves (10 g) were soaked in 100 ml of distilled water for 12 h in a water bath (70 °C) with occasional shaking, followed by centrifugation (2000 rpm, 15 min at 4 °C) and the supernatant was harvested. The clear solution obtained was refrigerated (4 °C) and used within 3 days as water herbal extract in the making of yogurt.

2.3. Preparation of starter culture

Pasteurized full cream milk (4% fat, 1 l) inoculated with a sachet of bacteria mixture with the following composition: Lactococcus acidophilus LA-5, Lactobacillus bulgaricus, Bifidobacterium bifidum Bb-12, Lactobacillus casei LC-01 and Streptococcus thermophilus Th-4 4 in the ratio of 4:4:1:1 and a capsule of probiotic mix containing L. bulgaricus, Lactobacillus rhamnosus, Bifidobacterium infantis and Bifidobacterium longum in the ratio of (1:1:1:1). The milk-bacteria mixture was incubated in a water bath (41 °C) for 12 h and the yoghurt formed was stored at 4 °C and used as starter culture within 7 days. Viable bacteria in the starter culture on day 7 of storage ranged 2.0–5.0 × 10⁹ cfu/g and 6.0–10.0 × 10⁸ cfu/g for Lactobacillus spp. and S. thermophilus, respectively.

2.4. Preparation of yoghurt

A. indica water extract (10 ml) was added into pre-warmed (41 °C) pasteurized full cream (4%) milk (85 ml) which has been previously mixed with starter culture (5 ml). The milk solid content was corrected to 15% g/ml by adding 2 g milk powder (4% fat). The mixture was thoroughly mixed and aliquoted (50 ml) into disposable plastic containers. Plain yoghurt was prepared as described for herbal-yoghurt but distilled water (10 ml) was used instead of herbal extract. Yogurts were incubated in water bath (41 °C) for 6 h and stored in a refrigerator (4 °C) for 2 h (fresh yoghurt or 0-day storage) up to 28 days.

2.5. pH and total titratable acid (TTA) determination

Yoghurt was homogenized in water (1:9) and the pH was read using a digital pH meter (Mettler-Toledo 320, Shanghai). Homogenised yoghurt was mixed with phenolphthalein (pH indicator, 0.1% w/v; 2–3 drops) and the TTA was determined by titration using NaOH as alkali. Titration with 0.1 N NaOH was carried out under continuous stirring until the development of a consistent pink colour. TTA (% lactic acid) produced after predetermined refrigeration was calculated as follows:

\[ \text{TTA}(% \text{Lactic Acid}) = \frac{V_{\text{NaOH}} \times 0.1N}{0.009 \times 100\%} \]

where \( V \) is volume of NaOH required to neutralize the acid and dilution factor = 10.

2.6. Preparation of yoghurt water extracts

Yogurts (10 g) were homogenized with 2.5 ml of sterile distilled water and the homogenates were acidified to pH 4.0 with HCl (0.1 M) followed by heating (water bath; 45 °C, 10 min) and centrifugation (5000g, 10 min, 4 °C). The pH of supernatants was brought to 7.0 using NaOH (0.1 M) and re-centrifuged (5000g, 10 min 4 °C) for further precipitation of proteins and salts. The supernatants were harvested and kept in the refrigerator (4 °C) and used within 12 h of preparation.
2.7. Total phenolic content assay

Yogurt water extract (1.0 ml) was mixed with ethanol (1.0 ml, 95% v/v) and 5 ml dH2O (Shetty et al., 1995). Folin–Ciocalteu reagent (0.5 ml, 50% v/v) was added to each sample and after a thorough mixing the solutions were allowed to stand for 5 min. at room temperature. Na2CO3 (1.0 ml, 5% g/100 ml) was then added and absorbance at 725 nm was read after another 60 min. incubation at room temperature. Known concentrations of gallic acid (Sigma–Aldrich, Germany; 5–60 μg/ml in ethanol) were treated in the same manner as for water extracts of yogurts and the regression of gallic acid standards was used to convert unknown samples to total phenolic content (μg gallic acid equivalent, (μgGAE)/ml).

2.8. Antioxidant activity by 1,1-diphenyl-2-picrylhydrazyl radical (DPPH) inhibition assay

DPPH inhibition was determined as described by Shetty et al. (1995). Briefly, DPPH (Sigma–Aldrich, Germany; 3 ml of 60 mmol/L in ethanol) were mixed with 250 μl yogurt extracts or 250 μl of water which serve as control. The mixture was shaken thoroughly and allowed to stand at room temperature. The constant absorbance readings at 517 nm were recorded after 5 min and the inhibition of DPPH oxidation (%) was calculated as follows (Apostolidis et al., 2007):

\[
\%\text{inhibition} = \frac{A_{517}^{\text{control}} - A_{517}^{\text{extract}}}{A_{517}^{\text{control}}} \times 100
\]

2.9. The o-pthalialdehyde (OPA) assay

This assay was used to evaluate proteolysis of milk proteins. The OPA reagent was prepared as described by Church et al. (1983). A small aliquot of yogurt extract (usually 10–50 μl containing 5–100 μg protein) was added directly into 1.0 ml of OPA reagent. The solution was mixed briefly by inversion and incubated for 2 min. at room temperature. The absorbance readings were, taken at 340 nm. The peptide concentration was estimated against the tryptone standard curve.

2.10. ACE inhibition assay

The ACE reagent was prepared as described by Vermeirssen et al. (2002). ACE reagent (500 μl) was added to 300 μl of water yogurt extracts in a cuvette and the contents were mixed and then incubated in a water bath (37 °C) for 2 min followed by the addition of 300 μl of rabbit lung extract. Absorbance was measured at 340 nm and the readings were compared to a control which had 300 μl of buffer solution instead of the extract. The rate of the reduction in ACE inhibition activity was calculated as follows:

\[
\text{ACEInhibition}(\%) = \frac{\text{ACE}_{\text{control}} - \text{ACE}_{\text{yogurt water extracts}} }{\text{ACE}_{\text{control}}} \times 100
\]

2.11. α-Amylase inhibition assay

The α-amylase inhibition assay was adapted from Apostolidis et al. (2006). Yogurt water extracts (500 μl) and 500 μl of 0.02 M sodium phosphate buffer, pH 6.9 with 0.006 M sodium chloride containing 0.5 mg/ml α-amylase solution were pre-incubated at 25 °C for 10 min. This was followed by the addition of 500 μl of a 1% starch solution in 0.02 M sodium phosphate buffer, pH 6.9 with 0.006 M sodium chloride to each tube at pre-determined time intervals. The reaction mixtures were incubated at 25 °C for 10 min. The reaction was stopped with 1.0 ml of dinitrosalicylic acid (DNSA) colour reagent. The test tubes were then incubated in a boiling water bath for 7 min. Then, 1.0 ml of 18.2% tartrate solution was added to each tube after the boiling prior to cooling to room temperature. The reaction mixture was then diluted by adding 10 ml of dH2O and the absorbance was read at 540 nm. The readings were compared to a control which had 500 μl of buffer solution instead of the extract. The enzyme inhibition was calculated as below:

\[
\text{Inhibition}\% = \frac{\text{Absorbance}_{\text{control}} - \text{Absorbance}_{\text{extracts}} }{\text{Absorbance}_{\text{control}}} \times 100
\]

2.12. α-Glucosidase inhibition assay

The α-glucosidase inhibition assay was performed in reference to the method of Apostolidis et al. (2006). Yogurt water extract (500 μl) and 1000 μl of 0.1 M potassium phosphate buffer (pH 6.90) containing α-glucosidase solution (1.0 U/ml) was incubated in water bath at 25 °C for 10 min. After 10 min., 500 μl of 5 mM p-nitrophenyl-α-glucopyranoside solution in 0.1 M potassium phosphate buffer (pH 6.90) was added to each tube at predetermined time intervals. The reaction mixtures were incubated at 25 °C for 5 min. prior to the reading of absorbance at 405 nm. The readings were compared to a control which had 500 μl of buffer solution instead of the extract. The α-glucosidase inhibitory activity was expressed as inhibition% as follows:

\[
\text{Inhibition}\% = \frac{\text{Absorbance}_{\text{control}} - \text{Absorbance}_{\text{extracts}} }{\text{Absorbance}_{\text{control}}} \times 100
\]

2.13. Sensory analysis

Sensory analyses were carried out by 15 untrained panels aged between 20 and 41 years old. Each panel was presented with four coded yogurt samples (10 ml) of the following treatments: A. indica-yogurt, A. indica-yogurt + sugar (10 g/100 g yogurt), plain-yogurt and commercially available organic strawberry-yogurt containing sugar (10 g/100 g yogurt). The evaluation was scored on 1–10 point hedonic scale (1–2 = extremely poor, 3–4 = poor, 5–6 = fair, 7–8 = good, 9–10 = excellent) according to texture (presence of whey), consistency (grainy, lumpy and firmness), taste (sour, sweet and bitter), aroma and overall preference.

2.14. Statistical analysis

Three separate experiments were carried out and replicate assays from the same experiment were performed. Data were expressed as mean ± SEM. (standard error of the mean). The statistical analysis was performed using one way analysis of variance (ANOVA, SPSS 14.0), followed by Duncan’s post hoc test for mean comparison. The criterion for statistical significance was p < 0.05.
3. Results and discussions

3.1. pH and TTA in yogurt

The pH at the end of fermentation was lower for A. indica-yogurt than that for plain-yogurt (4.11 ± 0.03 and 4.50 ± 0.04, respectively, p < 0.05, Fig. 1). Refrigerated storage for 28 days resulted in further reduction of pH towards 4.25 for plain-yogurt whereas A. indica-yogurt increased to 4.22 during the first week followed by gradual decrease towards 4.05. Post-acidification of yogurt during storage at 4 °C is a common feature associated with small but measurable microbial metabolic activity (Saint-Eve et al., 2008). Fluctuations in pH during storage may be explained by the relative changes in the formation of organic acids and alkaline nature of milk protein breakdown products (Sefa-Dedeh et al., 2001; Papadimitriou et al., 2007). The consistently higher TTA in A. indica-yogurt than in plain-yogurt, both at the end of fermentation and during storage may indicate differential microbial population during fermentation and possibly storage. This is not surprising since TTA measures organic acids (lactic, citric, formic, acetic and butyric acids), with the exception of those bound to alkaline ions, accumulated in the yogurt (Ostlie et al., 2003).

3.2. Antioxidant activity

DPPH inhibition of day 0 yogurt in the presence of A. indica was higher than plain-yogurt (30.1 ± 5.1% and 23.5 ± 5.0%, respectively, Fig. 2). Refrigerated storage increased DPPH inhibition in both yogurts with A. indica-yogurt showing consistently stronger effect than plain-yogurt. Highest DPPH inhibitions were shown by both yogurts on days 7 and 14 with extended storage to 28 days resulted in a loss of DPPH inhibition to values lower than day 0 by plain-yogurt but not by A. indica-yogurt. A. indica has been previously reported to show antioxidant activities properties (Sithisarn et al., 2005; Madhi et al., 2003) which may be explained by its high concentration of vitamin C and riboflavin (Atangwho et al., 2009). Other possible sources of DPPH inhibitors attributed to yogurt may be derived from milk protein proteolysis (Lourens-Hattingh and Viljoen, 2001) and organic acids (Correia et al., 2004) as a result of fermentation and post-acidification during storage. Proteolysis and TTA for instance were also shown to increase during storage in the presence of A. indica (Figs. 4 and 1b, respectively). Higher yogurt antioxidant activity in the presence of A. indica is beneficial in two respects, firstly to delay the oxidation process of lipids in yogurt that are responsible for the formation of off-flavours and undesirable chemical compounds (Berset et al., 1994) and secondly, to increase dietary antioxidants which are crucial in preventing the progressive impairment of pancreatic beta-cell function due to oxidative stress (Liu et al., 2005). The presence of A. indica in yogurts may thus be viewed advantageous in prolonging the shelf life of yogurt and the consumption of which in reducing the occurrence of type 2 diabetes.

3.3. Total phenolic content

The TPC in A. indica-yogurt was higher (p < 0.05) than plain-yogurt both after fermentation and during storage (Fig. 3). Refrigerated plain- and A. indica-yogurts showed transient reduction in TPC by day 14 (17.5 ± 3.1 and 38.5 ± 7.2 µgGAE/ml, respectively), but increased to highest values (29.6 ± 2.5 and 74.9 ± 6.2 µgGAE/ml, respectively; p < 0.05) by day 28. The transient decrease and increase in TPC in both yogurts may be explained by the action of yogurt
bacteria during refrigerated storage to further break down the polymeric phenolics in the presence of A. indica (Dalling, 1986). Elevated TPC in food was commonly associated with increased antioxidant activities (Veligolu et al., 1998) despite some disagreements (Kahkonen et al., 1999). In the present study A. indica-yogurt showed higher antioxidant activity than plain-yogurt, although not all of these activities can be attributed to A. indica (Fig. 2). Further studies are required to characterize the phytochemicals in A. indica which may be responsible for the elevated TPC and sustained antioxidant activities in A. indica-yogurt during refrigerated storage.

3.4. Proteolysis in yogurt

OPA values of yogurt in the presence of A. indica was higher than plain-yogurt during the 28 days of storage (Fig. 4). OPA values after day 14 of storage tended to reduce for plain-yogurt but the opposite was true for A. indica-yogurt. OPA values were highest for A. indica-yogurt (30 ± 0.02 mg/g) on day 21 of storage but lowest for plain-yogurt (10.2 ± 0.03 mg/g) on day 28. Proteolysis in fermented milks is related to the activity of yogurt bacteria (Wood, 1981). The proteinase of L. bulgaricus for instance hydrolyses casein to yield polypeptides (Tamine and Robinson, 1985) which may be broken down further by the peptidases of S. thermophilus. On the other hand, S. thermophilus metabolizes excess amino acids liberated by L. bulgaricus. Therefore, the balance between amino acid liberation and utilization was suggested (Rasic and Kurmann, 1978) to explain the degree of proteolysis.

3.5. Inhibition of angiotensin-1 converting enzyme (ACE) by yogurts

Fresh plain-yogurt inhibited about 50% ACE activity but this reduced to about 20% by the 3rd week of storage (Fig. 5). A. indica-yogurt had higher ACE inhibition than plain-yogurt with maximal inhibition of 79.7 ± 11.1% occurring on day 14 of storage. Both plain- and A. indica-yogurts recorded similar values on day 28 of storage (23.1 ± 0.3%). Pripp et al. (2005) showed that a high ACE-inhibitory potential is accompanied by a high degree of proteolysis (OPA values), which is shown as higher OPA values in A. indica-yogurt than in plain-yogurt in the present studies (Fig. 5). The exopeptidase activities on milk proteins are regarded responsible for the formation of many fragmented peptides with anti-ACE activity (FitzGerald et al., 2004). The changes in ACE activity in relation to OPA values with storage time for both plain- and A. indica-yogurts (Figs. 4 and 5) suggest that the relatively less specific peptides produced during fermentation were further cleaved to smaller and possibly more bioactive proteins during the first 7 days of refrigeration. However, extensive proteolysis of these proteins during extended storage may yield much smaller and less bioactive proteins (Fig. 5). The addition of A. indica into yogurt may thus change the manner in which the microbial enzymes affected proteolysis and subsequently the formation and deactivation of proteins with anti-ACE activities.

3.6. α-Amylase inhibitory potentials in yogurt

Fresh A. indica-yogurt (44.4 ± 3.0%, day 0) had higher (p < 0.05) inhibitory effects on α-amylase than plain-yogurt (29.8 ± 5.3%, Fig. 6). Refrigerated storage increased plain-yogurt α-amylase inhibition during the first 14 days to 47% but this reduced (p < 0.05) to 23–28% between the 3rd and 4th week of storage. In contrast, α-amylase inhibition of A. indica-yogurt increased to 55.0 ± 2.5% by day 21 of storage with small reduction to 42.0 ± 3.0% by day 28 of storage. The consumption of yogurt was reported effective to check rapid postprandial increase in blood glucose (Djomeni et al., 2006; Fujita et al., 2003). This may be explained by the inhibition of carbohydrate digestive enzymes (pancreatic α-amylase) important in causing postprandial hyperglycaemia commonly found in type-2 diabetes (McDougall and Stewart, 2005). A non-sustained increase in α-amylase inhibition with storage may, also be related to proteolysis as described earlier for ACE. Our findings showed that A. indica did not only enhance but may also increase the yogurt α-amylase inhibitory capacity with storage. To our best knowledge, this has not been previously

![Figure 5](image5.png) Changes in inhibition (%) of angiotensin-I converting enzyme (ACE) by yogurt refrigerated (4 °C) up to 28 days. ■ Plain-yogurt (control). ■ A. indica-yogurt. Values are presented as mean ± SEM (n = 3).

![Figure 6](image6.png) Changes in α-amylase inhibitory activity (%) in yogurt during refrigerated (4 °C) storage. ■ Plain-yogurt (control). ■ A. indica-yogurt. Values are presented as mean ± SEM (n = 3).
reported and the apparent strong inhibition of α-amylase activity even as long as 28 days of storage should be taken to advantage. This is because plant phenolic compounds which bind to the reactive sites of enzymes thus altering its catalytic activity (McCue and Shetty, 2004) in general are considered potent and safe inhibitors of carbohydrate hydrolysing enzymes (Lee et al., 2008).

### 3.7. α-Glucosidase inhibitory potentials in yogurt

*A. indica*-yogurt has higher mean α-glucosidase inhibition activity than plain-yogurt (p > 0.05; Fig. 7) but both yogurts showed similar changes in α-glucosidase inhibition activity during refrigerated storage with highest inhibition (15%) recorded on day 14. Therefore, refrigeration of yogurts for two weeks resulted in maximum increase of α-glucosidase inhibition but *A. indica* per se was not affecting α-glucosidase as it affected α-amylase.

### 3.8. Organoleptic properties

*A. indica*-yogurt was not different from plain-yogurt for all characteristics except for higher score for bitterness (4.3 ± 0.7 and 1.9 ± 0.3, respectively, p < 0.05). The addition of sugar increased the sweetness (p < 0.05), aroma and overall preference scores (p > 0.05) for *A. indica*-yogurt compared to plain-yogurt. However, when compared with strawberry-yogurt, sweetened *A. indica*-yogurt had lower sourness but higher sweetness scores (p < 0.05). Despite its bitterness, *A. indica* is consumed together with fish and sweet sauce in order to promote good health (Clayton et al., 1996). Yogurt may become a good carrier for *A. indica* extract because its presence did not markedly change yogurt organoleptic properties except for its bitterness. The addition of natural non-caloric sweetener such as *Stevia rebaudiana* leaves may increase the acceptability of *A. indica*-yogurt without causing concern to diabetic consumers (Table 1).

Toxicology studies was not attempted, but published reports indicate the application of *A. indica* water extract ranging from 10 to 500 mg/kg body weight (Boeke et al., 2004) did not produce toxic effects. An example of extreme administration of *A. indica* was reported by Chandra et al. (2007) whereby diabetic rats survived after a 30 days oral administration of water extracts of dried *A. indica* leaves (500 mg/kg/animal) with significant decrease (53%) in blood glucose levels, reactivation of the antioxidant enzymes, and recovery of the original body weight. The amount used was 170 times stronger than the dosage used in the present studies (i.e. 145 mg/100 ml *A. indica*-yogurt, equivalent to a daily dosage of 2.9 mg/kg body weight for a 50 kg person). As such, it is anticipated that the amount of *A. indica* water extract used in the preparation of *A. indica*-yogurt was in the range of safety dose and it is assumed to be safe for human consumption.

### 4. Conclusions

The addition of *A. indica* into yogurt enhanced the acidification, total phenolic content and antioxidant activities of yogurt. *A. indica*-yogurt also has higher inhibitory effects on *in vitro* α-amylase and ACE activities. Given the existing medicinal values of *A. indica* and evidence of improved *A. indica*-yogurt with respect to acidification, anti-oxidant and inhibition of enzymes related to diabetes and hypertension in the present study, *A. indica*-yogurt has the potential to be further developed as a functional yogurt for consumers with diabetes and hypertension.

### Acknowledgement

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### References


### Table 1 Mean taste panel scores for samples of yogurt.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Plain-yogurt</th>
<th><em>A. indica</em>-yogurt</th>
<th><em>A. indica</em>-yogurt + sugar</th>
<th>Strawberry-yogurt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texture</td>
<td>5.9 ± 0.6</td>
<td>5.8 ± 0.6</td>
<td>5.7 ± 1.1</td>
<td>5.9 ± 1.2</td>
</tr>
<tr>
<td>Consistency</td>
<td>6.3 ± 0.7</td>
<td>6.1 ± 0.4</td>
<td>6.8 ± 0.9</td>
<td>7.5 ± 0.4</td>
</tr>
<tr>
<td>Soursness</td>
<td>4.4 ± 0.9</td>
<td>4.2 ± 0.5</td>
<td>3.1 ± 1.1</td>
<td>6.2 ± 1.0</td>
</tr>
<tr>
<td>Sweetness</td>
<td>2.5 ± 0.7</td>
<td>2.9 ± 0.5</td>
<td>7.7 ± 0.5</td>
<td>5.3 ± 0.6</td>
</tr>
<tr>
<td>Bitterness</td>
<td>1.9 ± 0.3</td>
<td>4.3 ± 0.7</td>
<td>2.9 ± 0.4</td>
<td>1.9 ± 0.1</td>
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<td>Aroma</td>
<td>5.1 ± 0.6</td>
<td>5.5 ± 0.9</td>
<td>6.5 ± 0.8</td>
<td>7.8 ± 0.3</td>
</tr>
<tr>
<td>Overall preference</td>
<td>5.6 ± 0.1</td>
<td>5.4 ± 0.7</td>
<td>6.5 ± 0.7</td>
<td>7.4 ± 0.3</td>
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</table>

*Values are presented as mean ± SEM, n = 12.

*A 1–10 point hedonic scale (1–2 = extremely poor, 3–4 = poor, 5–6 = fair, 7–8 = good, 9–10 = excellent).
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