ORIGINAL ARTICLE

*Cinnamomum verum* improved the functional properties of bioyogurts made from camel and cow milks

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Abstract The effects of *Cinnamomum verum* on the changes in antioxidant activities, proteolysis, total phenolic content and in vitro inhibition of α-amylase and α-glucosidase of bioyogurts prepared from cow- and camel-milks during 21 days of storage at 4 °C was investigated. The result shows that pH of cow-milk bioyogurt (cow-MY) decreased more than camel-milk bioyogurt (camel-MY) whereas, total titratable acidity increased to similar extent in both types of bioyogurts. The addition of *C. verum* in both type of bioyogurts enhanced the total phenolic content during the entire storage period. The antioxidant capacity of *C. verum*-bioyogurts was higher than plain-bioyogurts. Proteolysis was higher in camel-milk bioyogurt than cow-milk bioyogurt. The inhibition of α-amylase in fresh bioyogurts was stronger in camel-milk bioyogurt than cow-milk bioyogurt. The reverse was true for α-glucosidase. Conclusively, *C. verum* can enhance bioyogurt functional properties with potential therapeutic values for the diabetics.

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1. Introduction

Recent empirical researches have established the prevalence of diabetes across the globe; the present reported type2 diabetic patients are expected to increase at about 50% from 171 million to 366 million between years 2000 and 2030 (Wild et al., 2004). Based on the above account, earlier medical treatments are chemical oriented, however, the momentum has shifted from chemical medication to functional food. Thus, recently, researchers have encouraged the use of functional foods and herbal remedies in adjusting the health effects in an attempt to cure or even prevent diabetes. Recent researches have proved ineffectiveness of present medical treatments of diabetest. One of these researches is the work of Rao et al. (2008) which discovered the use of existing prescribed oral hypoglycemic agents and insulin are not without adverse effects. However, Morimoto et al. (1999) and Hansawasdi et al. (2000) ascertained that variety of foodstuffs have been shown effective in inhibiting glucosidase and, as well as McDougall...
Additional, α-glucosidase and α-amylase in plant extracts and some traditional foods has been cited to be significant in management of type 2 diabetes (Fujita et al., 2003; Djomeni et al., 2006).

Functional foods have been established as effective on diabetes (Fujita et al., 2003; Djomeni et al., 2006). Bioculture made by the natural bacterial fermentation of milk is no exemption, and had been established as healthy food. It involves culturing cream or milk with live and active bacterial cultures (Fiszman et al., 1999). There are several reports that indicate the usefulness of bioculture consumption in helping to manage diabetes (Apostolidis et al., 2006) and this could be partially attributed to its ability to inhibit α-amylase and α-glucosidase (Apostolidis et al., 2006).

Accordingly, several herbs and spices as well have potential to manage type 2 diabetes (Corzo-Martinez et al., 2007). Cinnamon (Cinnamomum verum) as a spice/herb has received wide acceptance as an important ingredient in food and traditional medicine since ancient times. Therefore, the objective of this research was to study the effects of C. verum-enriched camel- and cow-milk bioyogurts (in the subsequent discussions milk bioyogurt is identified as MY) on the changes in phenolic contents, proteolysis of milk protein, antioxidant activities and the inhibition of two enzymes (α-amylase and α-glucosidase) important in managing type-2 diabetes.

2. Materials and methods

2.1. Materials and chemicals

C. verum bark was purchased from a local store in Saudi Arabia. Commercial fresh and pasteurized cow milk (Dutch Lady) and camel milk (Al-Turath) were purchased from Malaysia and Saudi Arabia respectively. Other materials included in the present study were bioyogurt bacteria mixture (Chris-Hansen, Denmark) and probiotic mixture (Bio-Life, Malaysia) which have one capsule content 5 billion cfu of probiotic bacteria. Chemicals obtained from Sigma (St. Louis, MO) were 1,1-diphenyl-2-picrylhydrazyl radical (DPPH), Sodium tetraborate, sodium-dodecyl-sulfate, o-phthalaldehyde (OPA), β-mercaptoethanol, tryptone, α-amylase (porcine pancreatic α-amylase, A3176; Type VI-B, 10–30 units mg⁻¹ solids, contain lactose), Starch, dinitrosalicylic acid (DNSA), α-glucosidase (Type 1, Baker Yeast, G5003, 1KU), and p-nitrophenyl-α-D-glucopyranoside. Sodium–sodium tartrate-4-hydrate and Folin–Ciocalteu reagent were purchased from Merck (Darmstadt, Germany).

2.2. C. verum water extracts preparation

In this study, ground C. verum bark was mixed thoroughly with distilled H₂O in the ratio of 1:10 with concentration 0.1 g mL⁻¹. The mixture was incubated overnight in a hot water bath at 70 °C (Julabo, Model Sw-21c or Haake Model SWD 20), followed by centrifugation at 4 °C (6708g, for 15 min) by using centrifuge machine (Eppendorf 5804 R), and the supernatant was harvested (Behrad et al., 2009). The clear solution obtained was used as C. verum water extract in the preparation of bioyogurt.

2.3. Preparation of starter culture

Full cream milk 1 L (content 3% and 4% fat, for both camel and cow-milk respectively) was initially pre-heated to 41 °C. A mixture of bioyogurt bacteria mix consisting of Lactobacillus acidophilus LA-5, Bifidobacterium bifidum Bb-12, Lactobacillus casei LC-01 and Streptococcus thermophilus Th-4 in the ratio of 4:4:1:1 and a capsule of probiotic mix containing Lactobacillus bulgaricus, Lactobacillus rhamnosus, Bifidobacterium infantis and Bifidobacterium longum in the ratio of (1:1:1:1) were mixed thoroughly with the preheated milk followed by incubation overnight at 41 °C in a hot water bath. The bioyogurt formed was kept refrigerated at 4°C and used as bioyogurt starter culture within 7 days (Rashid et al., 2007).

2.4. Preparation of bioyogurt

Preparation of C. verum-bioyogurts was by mixing 10 mL of C. verum water extract (0.1 g mL⁻¹) with 85 mL of commercial pasteurized full cream milk and 5 g of starter culture (Shah, 2003). The mixture was, mixed thoroughly and incubated at 41 °C. The pH of the mixture was determined every 30 min by using pH meter (Cyper Scan 510), and the incubation was terminated at pH 4.5 by placing the C. verum-bioyogurts in ice-bath for 60 min. BioYogurts were, then placed in the refrigerator for up to 21 days. The same procedures were carried out to prepare plain bioyogurt (control) except that 10 mL of distilled H₂O was used in place of C. verum-water extract.

2.5. Preparation of bioyogurt water extract

Bioyogurt water extract was prepared by mixing bioyogurt with distilled H₂O in the ratio of 1:0.25 and the pH was acidified to 4.0 with 1 M HCl prior to being incubated in hot water bath at 45 °C for 10 min followed by centrifugation at 4 °C (6708g, for 10 min). Thereafter, NaOH (0.5 M) was added to neutralize the supernatant to pH 7.0. After centrifugation at 4 °C (6708g, for 10 min) the supernatant was harvested and used as bioyogurt water extract in relevant assays within 12 h of preparation (Behrad et al., 2009).

2.6. Measurement of pH and determination of total titratable acid (TTA)

The pH of bioyogurt was measured by using a digital Metler Toledo 320 pH meter (Kailasapathy, 2006) which has been calibrated to pH 4.0 and 7.0 using standard solutions. TTA was determined by titration using 0.1 N NaOH as alkali and phenolphthalein (0.1% w/v, 2–3 drops) as the indicator. The amount of acid produced during fermentation was calculated (Sadler and Murphy, 1998) as following:

\[
\text{TCA} = \text{Dilution factor (10)} \times V_{\text{NaOH}} \times 0.1N \times 0.009 \times 100%
\]

2.7. Total phenolic assay

The total phenolic content (TPC) was determined according to Shetty et al. (1995) technical specification. Bioyogurt water extracts (1 mL) were initially mixed with 1 mL, 95% ethanol and distilled H₂O (5 mL) in a test tube. Thereafter, 0.5 mL
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Folin–Ciocalteu reagent 50% v/v was added to each sample followed by a brief thorough mixing and then standing at room temperature. 1 mL of 5% Na₂CO₃ was added after 5 min and the reaction mixture was allowed to stand for another 60 min. The absorbance of the resulting blue color was measured at 725 nm using Spectrophotometer (Shimadzu UV Mini 1240). Various gallic acid concentrations 10–60 μg mL⁻¹ were used as standard and subjected to TPC assay as described for bioyogurt samples. The values were converted to total phenolics, expressed in micrograms equivalents of gallic acid per gram (μgGAE g⁻¹) sample.

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

The DPPH inhibition was determined by measuring the free radical scavenging ability of bioyogurt water extracts (Shetty et al., 1995). Three mL of DPPH in 95% ethanol (60 mM) was added to 250 μL of water bioyogurt extracts. The absorbance was measured at 517 nm against controls, which contained 250 μL of distilled H₂O instead of the extract. The percentage of inhibition was calculated (Shetty et al., 1995) as follows:

\[
\text{Inhibition} \% = \left(1 - \frac{A_{517}^{\text{extract}}}{A_{517}^{\text{control}}}\right) \times 100
\]

2.9. The assessment of proteolysis by o-pthalaldehyde (OPA) assay

The OPA reagent was prepared as described by Church et al. (1985). The OPA solution composed of the following reagents: Sodium tetraborate 25 mL of 100 mM, sodium-dodecyl-sulfate 2.5 mL of 20% wt⁻¹, and 40 mg of OPA was dissolved in 1 mL of methanol and 100 μL of β-mercaptoethanol and the mixture was diluted to a final volume of 50 mL with distilled H₂O. This derived reagent was prepared fresh and used within 2 h of preparation. A small aliquot (usually 10–50 μL containing 5–100 μg protein) of bioyogurt water extract and added directly into 1.0 mL of OPA reagent and the solution was mixed briefly by inversion followed by incubation for 2 min at room temperature and absorbance readings at 340 nm. The OPA values were estimated against tryptone standard curve constructed from a range of tryptone concentrations from 0.25–1.50 μg mL⁻¹.

2.10. β-Amylase inhibition assay

The β-amylase inhibition assay was adopted from Apostolidis et al. (2006) technical specification. Briefly, 500 μL of bioyogurt water extract was mixed with 500 μL of 0.02 M sodium phosphate buffer, pH6.9 with 0.006 M sodium chloride containing 0.5 mg mL⁻¹ β-amylase solution and pre-incubated in water bath at 25 °C for 10 min. Starch solution (1% g mL⁻¹, 500 μL) in 0.02 M sodium phosphate buffer, pH6.9 with 0.006 M sodium chloride was added to each tube at pre-determined time intervals. Starch hydrolysis was activated by incubation at 25 °C for 10 min and was terminated by adding 1.0 mL of dinitrosalicylic acid color reagent. The test tubes were incubated in a boiling water bath at 90 °C for 7 min followed by the addition of 1.0 mL tartrate solution 18.2% to each tube prior to cooling to room temperature. The reaction mixture was diluted by adding 10 mL of distilled H₂O and the absorbance was read at 540 nm. Control was treated as described above except that buffer solution (500 μL) was used in place of the bioyogurt water extract. The enzyme inhibition was calculated (Apostolidis et al., 2006) as follows:

\[
\text{Inhibition} \% = \left(1 - \frac{A_{540}^{\text{control}} - A_{540}^{\text{extract}}}{A_{540}^{\text{control}}}\right) \times 100
\]

2.11. α-Glucosidase inhibition assay

The α-glucosidase inhibition assay was as described by Apostolidis et al. (2006) technical specification. Briefly, bioyogurt water extract (500 μL) was added into test tubes containing α-glucosidase solution 1.0 U mL⁻¹ in potassium phosphate buffer (0.1 M, pH 6.90). Thereafter, pre-incubation in water bath at 25 °C for 10 min was carried prior to the addition of 500 μL of 5 mM-p-nitrophenyl-α-D-glucopyranoside solution in 0.1 M potassium phosphate buffer (pH 6.90) at pre-determined time intervals. The tubes were then re-incubated in water bath at 25 °C for 5 min followed by absorbance readings at 405 nm. Control was treated as described above except that buffer solution (500 μL) was used in place of the bioyogurt water extracts. The α-glucosidase inhibitory activity (%) was calculated (Apostolidis et al., 2006) as follows:

\[
\text{Inhibition} \% = \left(1 - \frac{A_{405}^{\text{control}} - A_{405}^{\text{extract}}}{A_{405}^{\text{control}}}\right) \times 100
\]

2.12. Statistical analysis

The experiments were carried out in three different batches of biobios (n = 3). Data were expressed as mean ± SME (standard mean error), by using the software SPSS® version 17.0 (SPSS Inc., 2008), and Microsoft® Excel 2007. The statistical analysis was performed using one way analysis of variance (ANOVA) with confidence interval of 95%. The criterion for statistical significance was p < 0.05.

3. Results and discussions

3.1. Determined pH and total titratable acid

During 21 days of refrigerated storage the results showed cow-MY has lower pH values than camel-MY (p < 0.05 for day 14 and 21, Fig. 1A). No differences in pH were observed for cow-MY and camel-MY in the presence of C. verum. Likewise, in the presence or absence of C. verum TTA showed no differences in both camel- and cow-MYs during storage (Fig. 1B). The measurement of pH indicates free H⁺ concentration, generated through the production of organic acids by lactic acid bacteria (LAB). Accordingly, 21 days of refrigeration decreased the pH of bioyogurts to lower pH values (3.5–4.4). Probably, the decreasing of pH resulted in accumulation of acetic acid, citric acid, butyric acid, acetaldehyde, formic acid and lactic acid (Ostlie et al., 2003) by the breakdown of sugar (e.g. lactose) and protein products (Lourens-Hattingh and Viljoen, 2001; Papadimitriou et al., 2007). Early study reported that organic acids were linearly related to accumulation of TTA (Billard et al., 2007). However, TTA, reflects the total
amount of hydrogen ions present in the fermented milk sample with the exception of those bound to alkaline ions, nevertheless, TTA was suggested more relevant in the evaluation of fermentation capacity of microbes (Geidam et al., 2007). Thus, the addition of *C. verum* appeared not to affect microbial fermentation of cow and camel milks.

3.2. Total phenolic content in cow and camel milk bioyogurts

The TPC in camel-MY was higher ($p < 0.05$) than in cow-MY (Fig. 2). The presence of *C. verum* in fresh cow- and camel-MYs resulted in higher TPC (39.6 ± 2.0 & 67.3 ± 0.7 μg GAE ml⁻¹ respectively, 0 day) compared to their respective control. However, during refrigerated storage the presence or absence of *C. verum* had no significant effect on TPC, which elevated it to similar manner in both types of bioyogurts. An increase in TPC during storage occurred in all bioyogurts but was only significant on day 14 in *C. verum*-camel-MY. Prasad et al. (2009) found that *C. verum* contained high level of TPC that may contribute to the increase of TPC in *C. verum*-cow and camel-MYs. Additionally, the differences in TPC in both types of bioyogurts could be explained by the formation/degradation of polymeric phenolics by lactic acid bacteria (Dalling, 1986).

3.3. Inhibition of 1,1-diphenyl-2-picrylhydrazyl radical (DPPH) by bioyogurts

The antioxidant activities of fresh camel-MY (15.4 ± 1.3%) were not significantly different from fresh cow-MY (26.4 ± 0.7%; 0 day). Accordingly, the antioxidant activities increased (not significant) in the presence of *C. verum* in both cow- and camel-MYs with 35.3 ± 1.0% and 27.1 ± 1.1% respectively. Likewise, refrigerated storage increased antioxidant activities ($p < 0.05$) in both cow-MY (day 7) and camel-MY (day 14) compared to fresh bioyogurts. The antioxidant activities remained elevated on day 21 for cow- and camel-MYs in the absence or presence of *C. verum*. Despite the higher concentration of vitamin C in fresh camel milk as reported by Yeh et al. (2003) in this present study, fresh camel-MY had no significant difference from fresh cow-MY. Importantly, during storage period the antioxidant activities increased in camel-MY, an attribute which is not found in cow-MY. It is pertinent to note that the presence of *C. verum* increased antioxidant activities for both types of bioyogurts during storage. Cinnamon bark was reported to have high antioxidant activities (>60%) associated with polymeric phenolics (Prasad et al., 2009; Ranilla et al., 2010). Similarly, higher antioxidant activities in *C. verum*-MYs during storage may be indicated as a desirable characteristic that may enhance the therapeutic values of bioyogurt (Fig. 3).

3.4. Proteolysis of milk protein in bioyogurts

The values of OPA on day 0 were higher in the following respectively in *C. verum*-camel-MY (397.1 ± 4.9 mg g⁻¹), in camel-MY (368.2 ± 14.8 mg g⁻¹), in *C. verum*-cow-MY (172.9 ± 3.2 mg g⁻¹), and cow-MY (80.1 ± 3.2 mg g⁻¹). The OPA values during refrigerated storage of the bioyogurts decreased slightly (not significantly different) for camel-MY

![Figure 1](image1.png)  Changes in (A) pH and (B) TTA during refrigerated (4 °C) storage. ■ plain-cow milk bioyogurt (control) ■ *C. verum*-cow milk bioyogurt □ plain-camel milk bioyogurt (control) ■ *C. verum*-camel milk bioyogurt respectively. Values are presented as mean ± SEM ($n = 3$).

![Figure 2](image2.png)  Changes in Total phenolic content (μg mL⁻¹) in bioyogurt during refrigerated (4 °C) storage. ■ plain-cow milk bioyogurt (control) ■ *C. verum*-cow milk bioyogurt ■ plain-camel milk bioyogurt (control) ■ *C. verum*-camel milk bioyogurt respectively. Values are presented as mean ± SEM ($n = 3$).

![Figure 3](image3.png)  Changes in Antioxidant activity in bioyogurt (inhibition %) during refrigerated (4 °C) storage. ■ plain-cow milk bioyogurt (control) ■ *C. verum*-cow milk bioyogurt ■ plain-camel milk bioyogurt (control) ■ *C. verum*-camel milk bioyogurt respectively. Values are presented as mean ± SEM ($n = 3$).
and *C. verum*-cow-MY. However, it increased significantly \((p < 0.05)\) for cow-MY and *C. verum*-camel-MY. Generally, the proteolysis activity of starter cultures on proteins of milk is expressed as the amount of free amino groups measured as difference in absorbance values at 340 nm. The proteolysis in milk biyo yogurts in this present study may relate to types of biyo yogurt bacteria and their metabolic activity as demonstrated by Tamime and Robinson (1999) which reported high level of proteolysis in biokefir after storage compared to other fermented milks. Additionally, could be related to initial proteolysis in camel milk biyo yogurts which resulted in active proteolytic enzymes than cow milk biyo yogurts (Abu-Tarboush, 1994). Furthermore, camel-MY showed 2–3 folds higher OPA values than cow-MY and this may attribute to the differences in the ease and extent of proteolysis of difference in immunology of both camel and cow milk proteins, besides, the peptides in camel milk could be more easily attacked by starter culture than cow milk (Abu-Tarboush, 1996; El-Agamy et al., 2009). Mehaia and Al-Kanhal (1992), Taha and Kielwcin (1989) found that higher amounts of free amino acids in camel milk than cow milk. This could explain differences in milk protein from both sources which also appeared to influence how *C. verum* affected proteolysis, where, the increase in OPA values during the first week of storage for *C. verum*-cow-MY was in contrast to *C. verum*-camel-MY, which occurred during the last two weeks of storage (Fig. 4).

### 3.5. In vitro inhibition of \(\alpha\)-amylase

In this study, fresh camel-MY had higher mean inhibitory effect \((\text{not significantly different})\) with 33.2 \(\pm\) 1.4\% than cow-MY at 26.4 \(\pm\) 1.5\% on \(\alpha\)-amylase activity (Fig. 5). The refrigerated storage resulted in increased \((p < 0.05)\) the inhibitory effects of biyo yogurts for camel-MY and decreased \((p < 0.05)\) for cow-MY by day 14 (48.8 \(\pm\) 1.2 and 15.3 \(\pm\) 2.4\% respectively). The addition of *C. verum* increased biyo yogurts inhibition of \(\alpha\)-amylase activity to 55.8 \(\pm\) 3.8\% for cow-MY and 58.5 \(\pm\) 2.6\% for camel-MY. However, refrigerated storage decreased both biyo yogurts ability to inhibit \(\alpha\)-amylase activity to about 35\% and 50\% by *C. verum*-cow-MY and *C. verum*-camel-MY respectively. The present study showed that camel-MY not only inhibit but also develop a more enhanced inhibitory effects on \(\alpha\)-amylase during refrigerated storage than could cow-MY. The cow-MY may also increase its ability to inhibit \(\alpha\)-amylase at par with camel-MY, provided *C. verum* is also present. Strong *C. verum* inhibitory effects on \(\alpha\)-amylase activity at 51\% for 5 mg extract was reported by Ranilla et al. (2010) coupled with increased amount of GLUT4 protein levels as stated by Cao et al. (2007) which make this herb potentially beneficial for diabetic patients. The latter (GLUT4) was suggested because of the ability of procyanidin oligomers of the catechins and/or epicatechins in cinnamon to mimic insulin effects which eventually help improve glucose utilization (Cao et al., 2010).

### 3.6. In vitro inhibition of \(\alpha\)-glucosidase

The inhibition of \(\alpha\)-glucosidase for *C. verum*-cow-MY \((15.5 \pm 0.5\%)\) was higher than by cow-MY \((11.3 \pm 0.4\%, p < 0.05)\) by 0 day. However, these values decreased gradually to the lowest \((8.7 \pm 0.5\%\) and 5.5 \(\pm\) 0.2\%, \(p < 0.05)\) for *C. verum*-cow-MY (14 days) and Cow-MY (21 days) respectively. The *C. verum*-camel-MY also had a higher \(\alpha\)-glucosidase inhibition than camel-MY \((11.7 \pm 0.2\%\) and 8.4 \(\pm\) 0.2\% respectively, \(p < 0.05)\) but both increased steadily to the highest values \((17.0 \pm 0.6\%\) and 13.7 \(\pm\) 0.7\% respectively, \(p < 0.05)\) by day 21 of storage. Increase in \(\alpha\)-glucosidase inhibitory activities in camel-MY during refrigerated storage was noted both in the absence or presence of *C. verum*, nevertheless, it was opposite to that seen in cow-MYs. To the best knowledge of the researchers, this is the first time such differences was reported and it suggests \(\alpha\)-glucosidase inhibitors

![Figure 4](image4.png)  Changes in OPA values (mg g\(^{-1}\)) in biyo yogurt during refrigerated (4 °C) storage. **plain-cow milk biyo yogurt (control)** ■ *C. verum*-cow milk biyo yogurt ■ *C. verum*-camel milk biyo yogurt (control) ■ *C. verum*-camel milk biyo yogurt respectively. Values are presented as mean \(\pm\) SEM \((n = 3)\).

![Figure 5](image5.png)  Changes in \(\alpha\)-amylase inhibitory activity (%) in biyo yogurt during refrigerated (4 °C) storage. **plain-cow milk biyo yogurt (control)** ■ *C. verum*-cow milk biyo yogurt ■ plain-camel milk biyo yogurt (control) ■ *C. verum*-camel milk biyo yogurt respectively. Values are presented as mean \(\pm\) SEM \((n = 3)\).

![Figure 6](image6.png)  Changes in \(\alpha\)-glucosidase inhibitory activity (%) in biyo yogurt during refrigerated (4 °C) storage. **plain-cow milk biyo yogurt (control)** ■ *C. verum*-cow milk biyo yogurt ■ plain-camel milk biyo yogurt (control) ■ *C. verum*-camel milk biyo yogurt respectively. Values are presented as mean \(\pm\) SEM \((n = 3)\).
were continually produced in camel-MY during storage. Studies related to alpha-glucosidase inhibition has involved mostly on the use of plant extracts and some traditional foods (Fujita et al., 2003; Djomeni et al., 2006). The C. verum has received major attention due to its high inhibitory activity of alpha-glucosidase (Ranilla et al., 2010) which helps to lower blood glucose concentrations in patients with diabetes type2 (Pham et al., 2007) (Fig. 6).

The present study illustrates that biyogurt inhibition of enzymes relevant to diabetes may be enhanced by refrigerated storage and fortified with C. verum, taken together the consumption of C. verum or food-containing C. verum such as cow- or camel-MYs may thus offer direct anti-diabetic effects via inhibition of amylase in the intestine, hence slowing the absorption of glucose, and improving insulin sensitivity by enhancing utilization of glucose in peripheral tissues.

4. Conclusion
Conclusively, camel-MY tends to undergo more extensive fermentation during post-acidification than cow-MY, both in the absence and presence of C. verum. This resulted in sustained or increased inhibition of enzymes such as alpha-amylase and alpha-glucosidase, which linked to diabetes. Thus, C. verum can enhance functional properties of biyogurts in relation to acidification, proteolysis, total phenolic content, and antioxidant activities.

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