The fatty acid composition, the lipid digestibility and protein profile of Japanese-Saanen goat’s milk were characterized. Caprine milk contained substantial quantities of C_{4:0} to C_{10:0} fatty acids as compared with Holstein cow’s milk. The lipids of the former showed significantly higher digestibility in vitro by porcine lipase than those of the latter (P < 0.05). As determined by SDS–PAGE, the respective contents of α_{s1}-casein, one of the major allergens, were 3.9% and 33.7% in caprine and bovine milk.

Key words: caprine milk; fatty acid composition; fat digestibility; protein profile

There is a general agreement from a metabolic point of view that caprine milk is more easily digested than bovine milk. One important factor affecting digestibility is the size of the lipid globules. It has been reported that the mean size of the lipid globules was smaller in the former than in the latter. However, the digestibility of the lipids in caprine milk has not been determined in vitro. It has also been reported that caprine milk in some cases was less allergenic than bovine milk. This is probably due to the lower content of α_{s1}-casein in the former. Studies on the α_{s1}-casein content of caprine milk have revealed the presence of different phenotypes of α_{s1}-casein: “high type,” “middle type,” “low type” and “null type.” The amount of α_{s1}-casein is also associated with the firmness of curd which influences protein digestibility. It is therefore important to evaluate the content of α_{s1}-casein in milk from the Japanese-Saanen goat, a major species in Japan. The objectives of this study were to characterize the fatty acid composition, lipid digestibility and protein profile of Japanese-Saanen goat milk and to demonstrate the benefit of this for an infant diet.

Individual raw milk samples were obtained from Japanese-Saanen goats (age range of 2 to 5 years) at National Livestock Breeding Center Nagano Station. Individual raw milk samples from Holstein cows (age range of 3 to 5 years) were supplied by local farms. Sixteen samples of raw caprine milk, which were collected on different dates (caprine 1, n = 6, 5 March 2002; caprine 2, n = 10, 26 June 2002), and five samples of raw bovine milk (5 March 2002) were analyzed. Total lipids from the milk were extracted according to the method of Röse-Gottlieb. Fatty acid methyl esters were prepared by the method of Alonso et al. and analyzed by a gas-liquid chromatograph (GC-14B instrument Shimadzu, Kyoto, Japan) equipped with a flame ionization detector and using a capillary column (TC-FFAP, 30 m × 0.25 mm, i.d. 0.25 μm; GL Sciences, Tokyo, Japan). To investigate the lipid digestibility, fresh morning milk (caprine 1, n = 6; bovine, n = 5) was used. Five ml of a milk sample was mixed with 4 ml of a phosphate buffer (pH 8.7). Porcine pancreatic lipase (10 mg/ml, Sigma Chemical Co., St. Louis, MO, USA) was added to the mixtures to digest the lipid. The mixture was incubated for 30 min at 37 °C while being shaken. The digested formula was immediately heated at 75 °C for 5 min to inactivate the lipase. After filtration, the free fatty acids in the filtrate were measured according to a commercial kit (NEFA-Test Wako; Wako Pure Chemicals, Osaka, Japan). The lipid digestibility is defined as the amount of increase in free fatty acids (mEq/l) released by lipase. SDS–PAGE was performed according to the method of Laemmli using separation gel of 15% acrylamide. Quantitative analyses were performed with a gel scanner and Gel-Pro analyzer (Media Cybernetics, Silver Spring, MD, USA). Whole caseins were prepared from each milk sample by isoelectric precipitation with an acetate buffer. Alkaline urea-PAGE was performed with a separation gel of 15% acrylamide containing 5 M urea at pH 8.9 combined with...
The lipid digestibility was determined as the lipid digestibility and low allergenicity are now receiving considerable attention. The findings in this study in respect of these characteristics may offer additional evidence for the usefulness of caprine milk. First, the fatty acid composition of caprine milk showed characteristic features similar to those reported by Alonso et al. Nevertheless, a significant difference was found in the C16:0 content, this being lower in caprine milk than that in bovine milk (P < 0.05). Although it is well known that bovine milk contains substantial quantities of short or medium-chain fatty acids, we found that the contents of these fatty acids were higher in caprine milk than in bovine milk (P < 0.05). High variability of milk fatty acid composition among different animals has been observed by Garton. The values (caprine 1, 29.6; caprine 2, 24.1) as molecular percentages of short- and medium-chain fatty acids (C4:0, C6:0, C8:0, and C10:0) were higher in caprine milk (caprine 1, 19.7; caprine 2, 16.1) than that (5.8) in bovine milk (P < 0.05). The percentage of palmitic acid (C16:0), which was the major fatty acid in milk fat, was lower in caprine milk than in bovine milk (P < 0.05). The lipid digestibility was expressed as the percent of free fatty acids released in the reaction mixture. The values were 0.62 and 0.12 mEq/l for the caprine and bovine milk, respectively, indicating that the lipids of the former milk had significantly better digestibility by porcine lipase than those of the latter (P < 0.05). SDS–PAGE was performed on individual samples (bovine, n = 5; caprine 1, n = 6) (Fig. 1). The proteins from the bovine and caprine milk showed different profiles. In both samples, the five major bands corresponding to αs1-casein, β-casein, κ-casein, β-lactoglobulin and α-lactalbumin were observed. In addition, αs2-casein was identified by comparing with data from the literature. Although there was almost no difference in the profiles of β-casein, κ-casein, β-lactoglobulin and α-lactalbumin between the two samples of milk, the caprine milk showed a different pattern especially in the bands for α-caseins. The band for αs1-casein in the caprine milk was very thin, while that for αs2-casein was fairly thick. The opposite was true for bovine milk. The relative amounts of both milk proteins were determined by calculating the average density. The amounts of αs1- and αs2-casein were 3.9 ± 0.4% and 13.6 ± 0.5%, respectively, for the caprine milk, as compared to 33.7 ± 0.6 and 3.5 ± 0.3%, respectively, for bovine milk. The respective values for β-casein were approximately 56-7 ± 0.9% and 35.7 ± 1.1% for the former and latter. The contents of whey proteins were almost the same in the two kinds of milk. The respective values for β-lactoglobulin and α-lactalbumin were 12.5 ± 0.5% and 5.9 ± 0.3% for the caprine milk, and 15.0 ± 0.8% and 4.7 ± 0.6% for the bovine milk. The profiles for casein isolated by isoelectric precipitation on urea-PAGE are shown in Fig. 2. The caprine casein (caprine 1) had two major bands corresponding to β-casein and αs2-casein, while the profile for bovine casein showed the presence of two major bands corresponding to αs1-casein and β-casein.

The characteristics of caprine milk with its good digestibility and low allergenicity are now receiving considerable attention. The findings in this study in respect of these characteristics may offer additional evidence for the usefulness of caprine milk. First, the fatty acid composition of caprine milk showed characteristic features similar to those reported by Alonso et al. Nevertheless, a significant difference was found in the C16:0 content, this being lower in caprine milk than that in bovine milk (P < 0.05). Although it is well known that bovine milk contains substantial quantities of short or medium-chain fatty acids, we found that the contents of these fatty acids were higher in caprine milk than in bovine milk (P < 0.05). High variability of milk fatty acid composition among different animals has been observed by Garton. The values (caprine 1, 29.6; caprine 2, 24.1) as molecular percentages of short- and medium-chain fatty acids (C4:0, C6:0, C8:0, and C10:0) were similar to the values (29.3) reported in Garton’s study. The short- and medium-chain fatty acids pass into the portal vein and are then carried to the liver where they are quickly oxidized, providing energy. It seems likely that caprine milk lipid, which contains a substantial amount of short- and medium-chain fatty acids, has better absorbability than conventional animal fat which contains mainly long-chain saturated fatty acids. We also found that the lipids of caprine milk were digested better in vitro than those of bovine milk. Several researchers have reported that porcine pancreatic lipases showed sn-1 and sn-3 positional selectivity for glycerides.12,13) Ha and Lindsay have reported that a large proportion of volatile n-chain fatty acids (C4:0 to C10:0) in bovine and caprine milk lipid were located at the sn-3 position of the glycerides.14) Marai et al. have also reported that the milk fats of sheep and goat are rich in short-chain fatty acids and are largely esterified at the sn-3 position.15) The difference in fatty acid composition

<table>
<thead>
<tr>
<th></th>
<th>Bovine (n = 5)</th>
<th>Caprine 1 (n = 6)</th>
<th>Caprine 2 (n = 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C4:0</td>
<td>0.2 ± 0.1</td>
<td>1.2 ± 0.3</td>
<td>0.4 ± 0.1</td>
</tr>
<tr>
<td>C6:0</td>
<td>1.8 ± 0.2</td>
<td>2.6 ± 0.1</td>
<td>2.0 ± 0.1</td>
</tr>
<tr>
<td>C8:0</td>
<td>1.1 ± 0.1</td>
<td>3.3 ± 0.2</td>
<td>2.5 ± 0.1</td>
</tr>
<tr>
<td>C10:0</td>
<td>2.7 ± 0.4</td>
<td>12.6 ± 0.4</td>
<td>11.2 ± 0.2</td>
</tr>
<tr>
<td>C12:0</td>
<td>3.2 ± 0.5</td>
<td>5.6 ± 0.6</td>
<td>4.3 ± 0.1</td>
</tr>
<tr>
<td>C14:0</td>
<td>12.5 ± 1.5</td>
<td>12.9 ± 0.8</td>
<td>11.9 ± 0.3</td>
</tr>
<tr>
<td>C16:0</td>
<td>45.7 ± 3.6</td>
<td>28.4 ± 2.0</td>
<td>32.7 ± 0.6</td>
</tr>
<tr>
<td>C16:1</td>
<td>2.2 ± 0.3</td>
<td>0.6 ± 0.0</td>
<td>0.6 ± 0.0</td>
</tr>
<tr>
<td>C18:0</td>
<td>7.7 ± 0.7</td>
<td>10.3 ± 1.1</td>
<td>11.0 ± 0.2</td>
</tr>
<tr>
<td>C20:2</td>
<td>21.8 ± 4.8</td>
<td>20.4 ± 1.7</td>
<td>21.3 ± 0.5</td>
</tr>
<tr>
<td>C24:2</td>
<td>1.3 ± 0.2</td>
<td>2.2 ± 0.1</td>
<td>2.3 ± 0.1</td>
</tr>
</tbody>
</table>

Each value is the mean ± SEM.

Means with different superscript letters within a row are significantly different by Duncan’s multiple-range test (P < 0.05).

The average values for caprine 1 and 2 are significantly lower than that for bovine milk (P < 0.05).
and polymorphic fat structure might be one of the factors responsible for the higher digestibility of caprine milk fat. Several researchers have shown that the size of lipid globules in bovine milk was larger than that in caprine milk.\(^1\) In general, smaller lipid globules are better dispersed and produce a more homogeneous texture of lipid in milk. Thus, the difference in physicochemical properties may influence the activity of lipase.

We also have showed that caprine milk contained a smaller amount of \(\alpha_{s1}\)-casein, the major allergen in bovine milk. Although \(\beta\)-lactoglobulin in whey proteins is considered to be the most important allergen in bovine milk, the casein fraction also has potent antigenic potential.\(^{10}\) The antigenicity of \(\beta\)-lactoglobulin can be partially eliminated by certain treatments, but caseins maintain the capability of binding to IgEs even after a strong denaturating process.\(^2\) Caseins amount to nearly 80% of the proteins and form colloidal particles in a ruminant’s milk.\(^2\) Bovine caseins consist of four polypeptides: \(\alpha_{s1}\)-, \(\alpha_{s2}\)-, \(\beta\)- and \(\kappa\)-casein. Although these four polypeptides constitute caprine caseins, they have been shown to have quantitative allelic variability, particularly with \(\alpha_{s1}\)-casein.\(^{17}\) In caprine breeds, four types of \(\alpha_{s1}\)-casein alleles have been identified, resulting in various amounts of this protein in the milk from different caprine breeds.\(^4\) However, there have been few studies on the caseins in milk from the Japanese-Saanen goat, which is a major species in Japan. In the present study, we have demonstrated by SDS–PAGE that the amount of \(\alpha_{s1}\)-casein in the milk from the Japanese-Saanen goat was very low, implying that the caprine milk samples tested in this study belong to the “low type of milk.” These findings are worth noting because the Japanese-Saanen goat may be employed to produce milk for allergic subjects. Urea-PAGE has been used to identify milk protein phenotypes. The isolated caseins were well separated in the following order: \(\beta\)-casein, \(\alpha_{s2}\)-casein and \(\alpha_{s1}\)-casein. These profiles are similar to those described by Van Hekken and Tompson.\(^{18}\) As shown by the SDS–PAGE and urea-PAGE profiles, bovine casein had two major bands corresponding to \(\alpha_{s1}\)-casein and \(\beta\)-casein, while caprine casein had two major bands corresponding to \(\beta\)-casein and \(\alpha_{s2}\)-casein. The absence in the urea-PAGE profiles of the \(\alpha_{s1}\)-casein band in caprine milk, the \(\alpha_{s2}\)-casein band in bovine milk.
and the κ-casein band in both kinds of milk was probably due to its low content in each sample. It is worth noting that urea-PAGE can be used for screening the content of αs1-casein in a number of milk samples. Taken together, these results show that caprine milk may be a new protein source for allergic children and may also be used for modified formulas.

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References