



Note

Comparison between Holstein Cow's Milk and Japanese-Saanen Goat's Milk in Fatty Acid Composition, Lipid Digestibility and Protein Profile

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Received May 15, 2006; Accepted June 24, 2006; Online Publication, November 7, 2006

[doi:10.1271/bbb.60267]

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.¹⁾ 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.^{2,3)} 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."⁴⁾ The amount of α_{s1} -casein is also associated with the firmness of curd⁵⁾ 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.⁶⁾ Fatty acid methyl esters were prepared by the method of Alonso *et al.*⁷⁾ 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 $\times$ 0.25 mm, i.d. 0.25 μ m; 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 with 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,⁸⁾ 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

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Abbreviations: α_{s1} -c, α_{s1} -casein; α_{s2} -c, α_{s2} -casein; β -c, β -casein; κ -c, κ -casein; β -l, β -lactoglobulin; α -l, α -lactalbumin

Table 1. Fatty Acid Composition of Bovine and Caprine Milk Fat

	Bovine (n = 5)	Caprine 1 (n = 6)	Caprine 2 (n = 10)
	(%)		
C _{4:0}	0.2 ± 0.1 ^b	1.2 ± 0.3 ^a	0.4 ± 0.1 ^{b*}
C _{6:0}	1.8 ± 0.2 ^b	2.6 ± 0.1 ^a	2.0 ± 0.1 ^b
C _{8:0}	1.1 ± 0.1 ^c	3.3 ± 0.2 ^a	2.5 ± 0.1 ^{b*}
C _{10:0}	2.7 ± 0.4 ^c	12.6 ± 0.4 ^a	11.2 ± 0.2 ^{b*}
C _{12:0}	3.2 ± 0.5 ^b	5.6 ± 0.6 ^a	4.3 ± 0.1 ^{b*}
C _{14:0}	12.3 ± 1.5	12.9 ± 0.8	11.9 ± 0.3
C _{16:0}	45.7 ± 3.6 ^a	28.4 ± 2.0 ^b	32.7 ± 0.6 ^{b(*)}
C _{16:1}	2.2 ± 0.3 ^a	0.6 ± 0.0 ^b	0.6 ± 0.0 ^{b(*)}
C _{18:0}	7.7 ± 0.7 ^b	10.3 ± 1.1 ^a	11.0 ± 0.2 ^{a*}
C _{18:1}	21.8 ± 4.8	20.4 ± 1.7	21.3 ± 0.5
C _{18:2}	1.3 ± 0.2 ^b	2.2 ± 0.1 ^a	2.3 ± 0.1 ^{a*}

Each value is the means ± 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 higher than that for bovine milk ($P < 0.05$).

(*)The average values for caprine 1 and 2 are significantly lower than that for bovine milk ($P < 0.05$).

stacking gel of 4% acrylamide containing 5 M urea at pH 6.8. Each result is expressed as the mean ± SEM. The statistical significance of differences between values was analyzed by Student's *t* test or by a one-way analysis of variance and then by Duncan's multiple-range test.⁹⁾

The lipid contents of the bovine, caprine 1 and caprine 2 milk were 3.86 ± 0.48 , 1.78 ± 0.23 and 2.61 ± 0.14 g/100 g, respectively. As shown in Table 1, the composition of fatty acids in caprine milk was different from that in bovine milk. The percentages of decanoic (C_{10:0}) and octanoic (C_{8:0}) acids in caprine milk were markedly higher than those in bovine milk ($P < 0.05$). The contents of total short- and medium-chain fatty acids (C_{4:0}, C_{6:0}, C_{8:0}, and C_{10:0}) 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 (C_{16:0}), which was the major fatty acid in milk fat, was lower in caprine milk than that in bovine milk ($P < 0.05$). The lipid digestibility was determined as the amount 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 α_{s1} -casein, β -casein, κ -casein, β -lactoglobulin and α -lactalbumin were observed. In addition, α_{s2} -casein was identified by comparing with data from the literature.¹⁰⁾ 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 α_{s1} -casein in the caprine milk was very thin, while that for α_{s2} -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 α_{s1} - and α_{s2} -casein were $3.9 \pm 0.4\%$ and $13.6 \pm 0.5\%$, respectively, for the caprine milk, as compared to 33.7 ± 0.6 and $3.5 \pm 0.3\%$, respectively, for bovine milk. The respective values for β -casein were approximately $57.7 \pm 0.9\%$ and $35.7 \pm 1.1\%$ 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 $12.5 \pm 0.5\%$ and $5.9 \pm 0.3\%$ for the caprine milk, and $15.0 \pm 0.8\%$ and $4.7 \pm 0.6\%$ 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 α_{s2} -casein, while the profile for bovine casein showed the presence of two major bands corresponding to α_{s1} -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.*⁷⁾ Nevertheless, a significant difference was found in the C_{16:0} 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 middle-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.¹¹⁾ The values (caprine 1, 29.6; caprine 2, 24.1) as molecular percentages of short- and medium-chain fatty acids (C_{4:0}, C_{6:0}, C_{8:0}, and C_{10:0}) 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 (C_{4:0} to C_{10:0}) 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

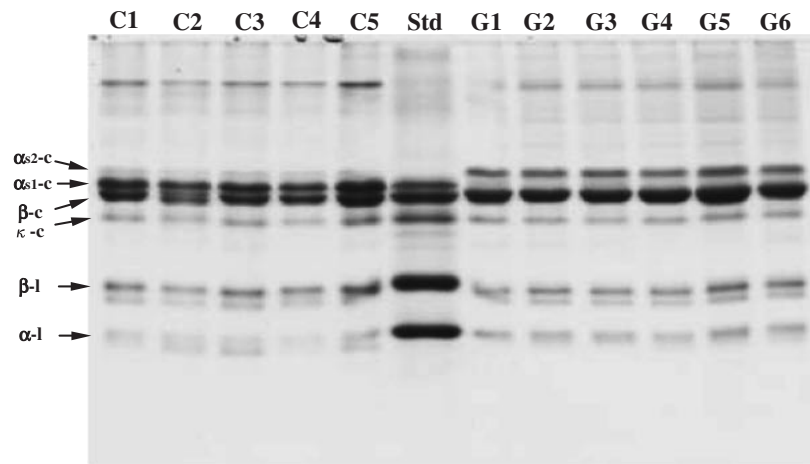


Fig. 1. SDS-PAGE Patterns of Bovine and Caprine Milk Proteins.

Lanes C1–C5, bovine milk; lane Std, standard milk proteins; lanes G1–G6, caprine 1 milk. $\alpha_{s1}\text{-c}$, α_{s1} -casein; $\alpha_{s2}\text{-c}$, α_{s2} -casein; $\beta\text{-c}$, β -casein; $\kappa\text{-c}$, κ -casein; $\beta\text{-l}$, β -lactoglobulin; $\alpha\text{-l}$, α -lactalbumin.

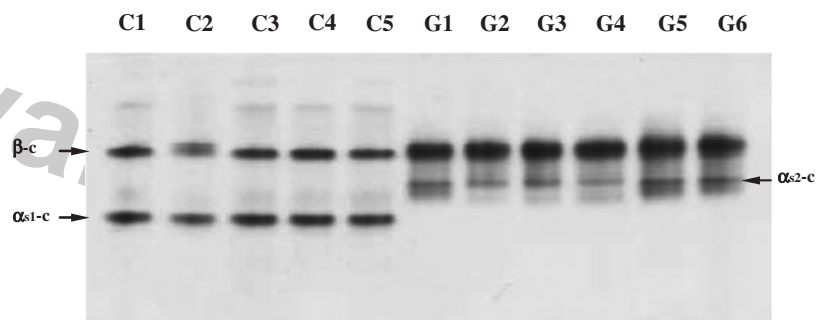


Fig. 2. Urea-PAGE Patterns of Bovine and Caprine Milk Proteins.

Lanes C1–C5, bovine milk; lanes G1–G6, caprine 1 milk. $\alpha_{s1}\text{-c}$, α_{s1} -casein; $\alpha_{s2}\text{-c}$, α_{s2} -casein; $\beta\text{-c}$, β -casein.

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 α_{s1} -casein, the major allergen in bovine milk. Although β -lactoglobulin in whey proteins is considered to be the most important allergen in bovine milk, the casein fraction also has potent antigenic potential.¹⁶⁾ The antigenicity of β -lactoglobulin can be partially eliminated by certain treatments, but caseins maintain the capability of binding to IgEs even after a strong denaturing 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: α_{s1} -, α_{s2} -, β - and κ -casein. Although these four polypeptides constitute caprine caseins, they have been shown to have quantitative allelic variability,

particularly with α_{s1} -casein.¹⁷⁾ In caprine breeds, four types of α_{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-Saen goat, which is a major species in Japan. In the present study, we have demonstrated by SDS-PAGE that the amount of α_{s1} -casein in the milk from the Japanese-Saen 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-Saen 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: β -casein, α_{s2} -casein and α_{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 α_{s1} -casein and β -casein, while caprine casein had two major bands corresponding to β -casein and α_{s2} -casein. The absence in the urea-PAGE profiles of the α_{s1} -casein band in caprine milk, the α_{s2} -casein band in bovine milk

and the κ -casein band in both kinds milk was probably due to its low content in each sample. It is worth nothing that urea-PAGE can be used for screening the content of α_{s1} -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.

Acknowledgment

This work was supported in part by grant-aid for young scientists (B, 16700533) from the Ministry of Education, Culture, Sports, Science and Technology of Japan.

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