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FLAVOUR OF GOAT'S MILK: A REVIEW OF STUDIES ON THE SOURCES OF ITS VARIATIONS

TRYGVE SKJEVDAL

Department of Animal Nutrition, Agricultural University of Norway, 1432 Ås-NLH (Norway)

Present address: Norwegian Sheep and Goat Association, Parkveien 71, Oslo 2 (Norway)

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ABSTRACT

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The specific flavour of goat's milk is undesirable for direct consumption but for cheese production its presence can be advantageous.

Norwegian trials have shown that unclean handling of the milk reduces the true flavour. The flavour was not influenced by the presence of a buck.

The flavour is influenced by the free fatty acid content, especially the C_8 to C_{12} acids, and also may be affected by the KCl content and the presence of three different cresols. The flavour is negatively correlated to the organic substances in the milk. A strong flavour in the milk causes a strong flavour in the product when making brown whey cheese as well as ordinary white cheese.

In the Norwegian goat population there is a positive phenotypic, and maybe also a positive genetic, correlation between yield and strong flavour. The heritability for flavour is estimated to be about 0.25. A significant difference has been found between Norwegian and Swedish goat's milk, both in flavour intensity and free fatty acid content.

The flavour was less pronounced at the start and the end of lactation. Small differences were found in the flavour when comparing milk produced by goats fed on pasture and indoors. High feeding intensity by means of concentrates generally increased the flavour of the milk. In general the method of feeding and different feedstuffs have little influence on the true flavour of the goat's milk.

INTRODUCTION

Goat's milk is used for direct consumption as well as for cheese-making. The specific flavour of goat's milk may be of great importance when the milk is used for cheese production as long as the consumers are willing to pay higher prices for this cheese*. In contrast, milk free from the same specific flavour or odour is preferred when used for direct consumption.

* This refers to the normal cheeses as well as to the brown whey "cheese", which is rather popular in Norway and Sweden. The latter is produced from whey and cream from goat's milk, which is evaporated and then "browned" by heating.

The cause of the flavour of the goat's milk is not fully known. Several hypotheses and suggestions have been proposed, e.g. contamination of milk from hair and skin or from handling of the milk, and the odour from the buck, have all been said to cause this flavour (Winkler et al., 1930; Turner et al., 1937; Ford, 1968; Devendra and Burns, 1970). Norwegian investigations, however, indicate that unclean handling of milk reduces the intensity of the true flavour (Funtler, 1933), and the presence of a buck has no significant influence on odour or flavour of the goat's milk (Korvald, 1958). Mackenzie (1970) suggests changes in fat metabolism due to slight anaemia, acetonaemia, etc. as a possible cause.

Koestler and Wegmüller (1934) maintain that the specific flavour components of goat's milk originate from chemical substances synthesized in the udder and secreted from mamma, an explanation in agreement with Norwegian studies (Korvald, 1958; Brandsaeter and Abate, 1959, Svensen, 1968).

CHEMICAL BACKGROUND

The quantity of volatile fatty acids with 6 to 10 carbons is higher in goat's than in cow's milk (Ashworth et al., 1966; Parkash and Jennes, 1968). By adding C_8 to C_{12} fatty acids to the whey of cow's milk used for cheese making, Brandsaeter and Abate (1959) made whey cheeses with some of the typical goat flavour. The flavour was very "sharp, bitter and soapy". Also Koestler and Wegmüller (1934) obtained the characteristic "Bockgeruch" by mixing caproic and caprylic acids in certain ratios with butter fat from cow's milk.

Korvald (1958) found that the most pronounced flavour was in the cream and butter milk. Intensity of the flavour was also found to be positively related to the concentration of free fatty acids in goat's milk. This is in agreement with the fact that genuine goat's cheese contains more free fatty acids than cheese made from a mixture of goat's and cow's milk or cow's milk alone. Whey cheese made from cow's milk may even contain no free C_8 to C_{12} fatty acids (Brandsaeter and Abate, 1959), whereas goat's cheese with medium flavour was shown to have the highest free fatty acid content.

Test warm milk has a weak flavour (Korvald, 1958) and storing the milk up to 12 h was shown to increase the flavour in the milk (Skjevdal, 1974) as well as in the cheese (Fyksen and Steinsholt, 1974).

Lipoprotein lipase (LPL) activity may vary between individuals, the highest activity being in milk with a strong flavour (Bjørke, 1974). In French studies (Chilliard and Morand-Fehr, 1978) the variation of LPL activity seems to be similar to the variation of the flavour in goat's milk.

In the study of Skjevdal (Astrup et al., 1972a, b; Skjevdal, 1974) there was shown to be a significant negative correlation between the flavour and polyenoic acid content of the milk from individual goats ($r = -0.53$).

Examination of the various positions of the fatty acids in milk triglycerides has revealed no difference between species like goat, sheep, cattle and buffalo (Freeman et al., 1965).

The high KCl content of goat's milk (Parkash and Jennes, 1968) may influence the intensity of the flavour (Fyksen and Steinsholt, 1974). The same may be true for other compounds found in milk. In Norwegian studies, two isomeric compounds, ortho- and metacresols (Svensen, 1968) were identified in whey cheese from goat's milk, but not found in whey cheese made from cow's milk. Paracresol, a derivative of tyrosine decomposition, is found in milk from cows as well as from goats. The cresols have a bitter taste and may thus influence milk flavour. The hypothesis can be made that there is a certain correlation between the hormone thyroxine, through the amino acid tyrosine and the cresols, and the flavour of the goat's milk.

FLAVOUR INTENSITY IN RELATION TO MILK COMPOSITION AND YIELD

In Norway there is a demand for the goat flavour in whey cheese. Investigations are therefore made to study the phenotypic correlations between the flavour intensity score of goat's milk and its chemical composition (Table I).

TABLE I

Phenotypic correlation between the flavour intensity score and different components in milk (on the basis of lactation)

Component		Author		
		Opstvedt (1968)	Rønningen (1965a)	Skjevdal (1974)
Dry matter	(%)	-0.16^{T}	—	−0.23
Fat	(%)	0.35^{T}	-0.20^{*}	−0.04 and -0.35^{*}
Protein	(%)	-0.31^{T}	-0.35^{*}	0.28
Lactose	(%)	-0.21^{*}	-0.20^{*}	0.13
Ash	(%)	−0.22		+ 0.10

[T]Significant figures.

In all three studies negative correlations were found between the main organic substances and the flavour intensity score of the milk. This is in agreement with the results from the selection experiment for the flavour of goat's milk (Steine, 1978). Thus, when milk with a high fat content was used, the resulting cheese had a low flavour intensity score (Opstvedt, 1968). Logically milk with a weak or strong flavour also produces cheese with a low or high flavour intensity score, respectively. The same relationship is found in white cheese (Fyksen and Steinsholt, 1974) as well as in brown whey cheese (Bakkene and Steinsholt, 1975).

In the study of Rønningen (1965b) a positive genetic correlation was found between milk yield and flavour intensity ($r = 0.77$), but the results from the selection experiment (Steine, 1978) tend to give a negative genetic correlation

between the flavour intensity score and milk yield. A phenotypically positive correlation has been found in other studies (Rønningen, 1965a; Stjevdal, 1974). This finding agrees well with the observation by Opstvedt (1963) that the highest flavour score of cheese was found in the North of Norway where the milk yield per goat was highest but the content of fat was lowest.

GENETIC BACKGROUND

Rønningen (1965b) investigated the flavour of the milk from 457 goats by a monthly sample from each individual from February to October 1964. The flavour intensity scores were examined by three judges. The repeatability of the determination was rather low and indicates that several samples per goat distributed throughout lactation are needed to evaluate the genetic variations between animals. In the study concerned, the heritability of the flavour intensity score of milk was estimated at 0.25, when the mean score for all samples within each animal was used.

It is well known that differences exist between individuals and also between breeds. This was shown with regard to milk quality when comparing Saanen goats imported to Norway with the native breed (Bakke et al., 1976; Table II).

TABLE II

Flavour intensity score and free fatty acids content in milk from Saanen goats, Norwegian goats and crosses between them

	Saanen			Saanen × Norwegian			Norwegian		
	no.	$\bar{x}$	s	no.	$\bar{x}$	s	no.	$\bar{x}$	s
Flavour score	16	1.05	0.11	15	1.15	0.73	23	1.83	0.54
Free fatty acids, meq/l	16	1.10	1.17	15	3.25	3.65	23	4.59	6.32

The Saanen goats were shown to produce milk with a flavour intensity score near to that of cow's milk (1.0), with a slightly higher free fatty acid content than that of the cow's milk (0.6—0.7). The native goats produced milk with a significantly higher flavour intensity score.

Unpublished results from milk samples taken from Saanen goats in the Federal Republic of Germany have confirmed the results in Table I, but a few of these goats resembled the Norwegian goats with regard to free fatty acids in the milk.

At the Agricultural University of Norway a selection experiment for goat's milk flavour using Norwegian dairy goats started in 1969 (Steine, 1978; Bakke et al., 1977). A herd of approximately 90 goats was divided into two lines. In one line selection was carried out for high flavour intensity in the milk (HF), and in the other line for low flavour intensity (LF). In 1977 this selection

experiment was ended after approximately five generations of selection.

The selection response in the flavour intensity score, estimated as the difference between the selection lines can be seen in Fig.1.

The heritability estimates for flavour intensity scores decreased with increasing generation intervals as can be seen in Table III.

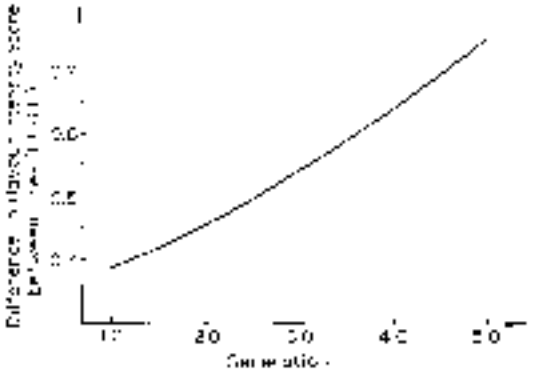

Fig.1 Selection response in the flavour intensity score estimated as the difference between selection lines (Steine, 1978).

TABLE III

Heritability estimates for flavour intensity scores (Steine, 1978)

Generation interval	Number of				h^2 ± S.E.	
	Tests	Lactations	Goats	Sires		
0	1761	282	105	37	0.37	0.37
1.0 - 2.5	2004	283	104	42	0.19	0.22
> 2.5	1677	223	115	42	0.07	0.15

In these analyses the flavour intensity scores were adjusted for significant effects of year, age and stage in lactation.

The selection has also significantly decreased the content of lauric acid as a percentage of milk fat and increased palmitic acid and the free fatty acid content in the HF selection line compared with the LF line.

ENVIRONMENTAL FACTORS AND FEEDING

Rönningen (1965b) found a stronger flavour in the milk from young than from old goats, a finding which was not confirmed by Steine (1978). The milk produced at the start and towards the end of lactation is found to have a less pronounced flavour than that produced during mid-lactation (Rönningen,

1965a; Skjevdal, 1974; Steine, 1975), and cheese produced during the latter part of lactation is shown to have a rather weak flavour (Korvald, 1958; Opstvedt, 1963).

In the study of Opstvedt (1967) supplements of browse resulted in a small and inconsistent effect on the flavour, whereas the study by Korvald (1958) indicates that goats in herds feeding on browse gave milk with a weaker flavour than other herds gave.

The flavour of the cheese produced when the goats were fed indoors during late autumn, was less pronounced than that produced when the goats were grazing (Korvald, 1958; Opstvedt, 1963). However, only minor differences in flavour intensity have been observed between milk produced during the first 2 to 4 months of lactation when the goats are stall fed and when they are fed on pasture (Rønningen, 1965a; Opstvedt, 1963). In some studies a tendency has been noted to lower flavour intensity scores produced by pasture than indoor feeding (Opstvedt, 1963; Rønningen, 1965b; Skjevdal, 1972b).

Feeding intensity studies have shown that the flavour of goat's milk is favourably affected by high concentrate and high intensity of feeding (Opstvedt, 1967; Skjevdal, 1974) and the effect is apparently very distinct on mountain pasture (Skjevdal, 1972b).

Feeding hay rather than grass silage apparently has tended to give milk with a stronger flavour (Opstvedt, 1967; Skjevdal, 1972a). Supplements of swedes have also tended to increase milk flavour (Skjevdal, 1974), although not significantly, whereas potato feeding had no apparent effect.

Supplements of coated linoleic acid have significantly increased the polyenoic acid content of goat's milk, with a slight decrease in the flavour (Astrup et al., 1972a). In the cow the same feeding caused a strong oxidation flavour of the milk (Astrup et al., 1972b). Recent unpublished studies with goats at the Agricultural University of Norway have shown that supplements of palmitic and stearic acids significantly increased milk fat content, but lowered milk quantity and flavour. For the cow the addition of palmitic acid resulted in more rancid milk (Astrup et al., 1977). Supplements of cholesterol caused no difference when compared to the control. The studies using supplements of fatty acids clearly indicate that the goat flavour is not identical with the so-called rancid milk defect and oxidation flavour in cow's milk.

CONCLUSION

The true flavour of goat's milk seems to be due to a complex of chemical substances and is not caused by milk contamination. The flavour intensity is negatively correlated with fat, protein and lactose content of milk. Significant differences exist between breeds as well as between individuals within breeds. In the Norwegian goat breed the heritability of milk flavour is estimated to be 0.25.

The flavour intensity is apparently related to the time of lactation, being lowest at the start and toward the end of the lactation cycle. High feeding in-

lously by means of concentrate increases the flavour of the milk. Otherwise, feeding in general has only a minor influence on the intensity of the flavour in goat's milk.

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RÉSUMÉ

Skjevdal, T., 1979. Flaveur du lait de chèvre, synthèse d'études sur les sources de variation. *Livest. Prod. Sci.*, 6: 397 - 405 (en anglais).

La flaveur spécifique du lait de chèvre est indésirable pour la consommation directe, mais elle peut être utile pour la production de fromage.

Les divers essais norvégiens montrent qu'un traitement non hygiénique du lait réduit la flaveur spécifique du lait mais que celle-ci n'est pas influencée par le bruit.

Elle dépend de la teneur des acides gras libres, spécialement des acides en C6 à C10 et peut-être aussi de la teneur en KCl et en trois crésols différents. Elle est en corrélation négative étroite avec la teneur en substances organiques du lait. Une forte flaveur du lait se retrouve dans les produits, qu'il s'agisse du fromage brun de sérum ou du fromage blanc fermenté.

Dans la population de chèvres norvégiennes il y a une corrélation positive phénotypique, et peut-être aussi génétique, entre la production et la flaveur forte. L'héritabilité de la flaveur peut être estimée à 0,25 environ. On a trouvé une différence significative entre les chèvres norvégiennes et les saanen, à la fois dans l'intensité de la flaveur et dans la teneur en acides gras libres du lait.

La flaveur est moins prononcée au début et à la fin de la lactation. Elle présente de petites différences entre les périodes de pâturage et d'alimentation en stabulation. Elle est généralement accrue par l'alimentation intensive avec des aliments concentrés. D'une façon générale elle est peu sensible aux facteurs alimentaires.

KURZFASSUNG

Skjevdal, T., 1979. Übersicht der Ursachen für die Variation des Geschmacks der Ziegenmilch. *Livest. Prod. Sci.*, 6: 397–405 (in Englisch).

Bei direktem Verzehr von Ziegenmilch ist deren Geschmack unerwünscht, für die Käseproduktion kann dieser jedoch von Vorzug sein.

Norwegische Untersuchungen ergaben, dass unsaubere Behandlung den eigentlichen Ziegengeschmack der Milch reduziert; der Bock hatte keinen Einfluss auf den Geschmack.

Der Geschmack wird durch den Gehalt an freien Fettsäuren beeinflusst, besonders durch die C_6- bis C_{12}-Säuren, weiterhin möglicherweise durch KCl und drei verschiedene Kresole. Durch die organischen Bestandteile der Milch wird der Geschmack negativ beeinflusst. Wird Käse, ob brauner Molkenkäse oder gewöhnlicher weisser Käse, aus Milch mit strengem Geschmack hergestellt, nimmt dieses Produkt den spezifischen Geschmack an.

In dem Norwegischen Ziegenbestand besteht sowohl eine positive phänotypische und möglicherweise auch positive genetische Beziehung zwischen Leistung und strengem spezifischen Geschmack. Der Heritabilitätswert für Geschmack wird auf etwa 0.25 veranschlagt. Es wurde ein grosser Unterschied zwischen Norwegischen und Saanen Ziegen gefunden, sowohl in Bezug auf die Geschmacksintensität als auch den Gehalt an freien Fettsäuren.

Der Geschmack ist zu Beginn und am Ende der Laktation weniger ausgeprägt. Die Milch von im Stall gefütterten Ziegen hat fast den gleichen Geschmack wie die von Weidetieren. Ein hoher Einsatz von Kraftfuttermitteln erhöht allgemein den spezifischen Geschmack der Milch. In der Regel haben Fütterung und verschiedene Futtermittel wenig Einfluss auf den natürlichen Ziegenmilchgeschmack.