

Price of milk for cheese factories



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Part 1:

Brown Swiss Cow's milk for cheesemaking

Introduction

The component (fat, protein, lactose) percentage of the milk is the most important factor. Casein plays a very important role in cheese production. Pure casein is a complex that consists of four individual proteins. One of them is k-Casein, which exists in different genetic variants (A, B, C, and E). A high proportion of k-Casein B is advantageous for milk coagulation and, therefore, for cheese yield. The proportions of the genetic variants can now be determined not only in milk from individual cows but also in mixed milk. As a result, milk producers, especially those with brown cattle, are demanding that cheese makers additionally reward high proportions of k-Casein B in the payment for milk content. This document addresses the milk price according to the milk components for the cheese factories.

Factors affecting yield

The yield of both cheese and butter is significantly influenced by the water content in the product. However, this is not primarily determined by the milk components, but rather by the production parameters. To reflect the true value of the milk components, the yield must be considered relative to the dry matter of the product.

When processing milk into cheese with standardized fat content, both cheese and butter yields must be taken into account, as they are directly related. For the cheesemaker, fat and protein are primarily important for yield, with only casein being relevant in cheese production. On average, casein constitutes about 77 % of the raw protein (depending on genetics/breed, feeding, cell count, and month of lactation or season).

The average casein content in mixed milk is about 25 g per kg of milk or 2,5 kg per 100 kg of milk. However, the variation is considerable: in June, casein levels in vat milk range between 22 and 26 g/kg, and in November, between 24 and 28 g/kg.

Influence of the milk components to cheese transfer

The proportion of the solids (fat, protein, lactose) present in the milk that transfers into the cheese depends on various factors such as coagulation, curd treatment, curd grain size, and so on. According to J. Kammerlehner [1], the following average values (transfer rates) apply:

- Fat ~ 90 %
- Raw protein ~ 75 %
- Ash ~ 35 %

Influence of the milk components to cheese transfer

Influence of Coagulation

The rennability (coagulation ability) of the milk is determined by the pH (which depends on cell count, month of lactation, milk cooling, and milk storage), as well as by the casein content and the genetic variants of caseins. However, the coagulation process—and thus the gel texture—is also influenced by factors such as water addition, rennet temperature, rennet time, and the "resting" of the milk.

Influence of Curd Preparation and Processing

The following factors influence the transfer of milk components into the cheese, particularly those of the milk fat:

- Technical equipment (e.g., type of cutting device)
- Timing of the cutting

Influence of the milk components to cheese transfer

- Speed of curd production (stirring speed = mechanical stress on the curd grains)
- Curd grain size

Losses

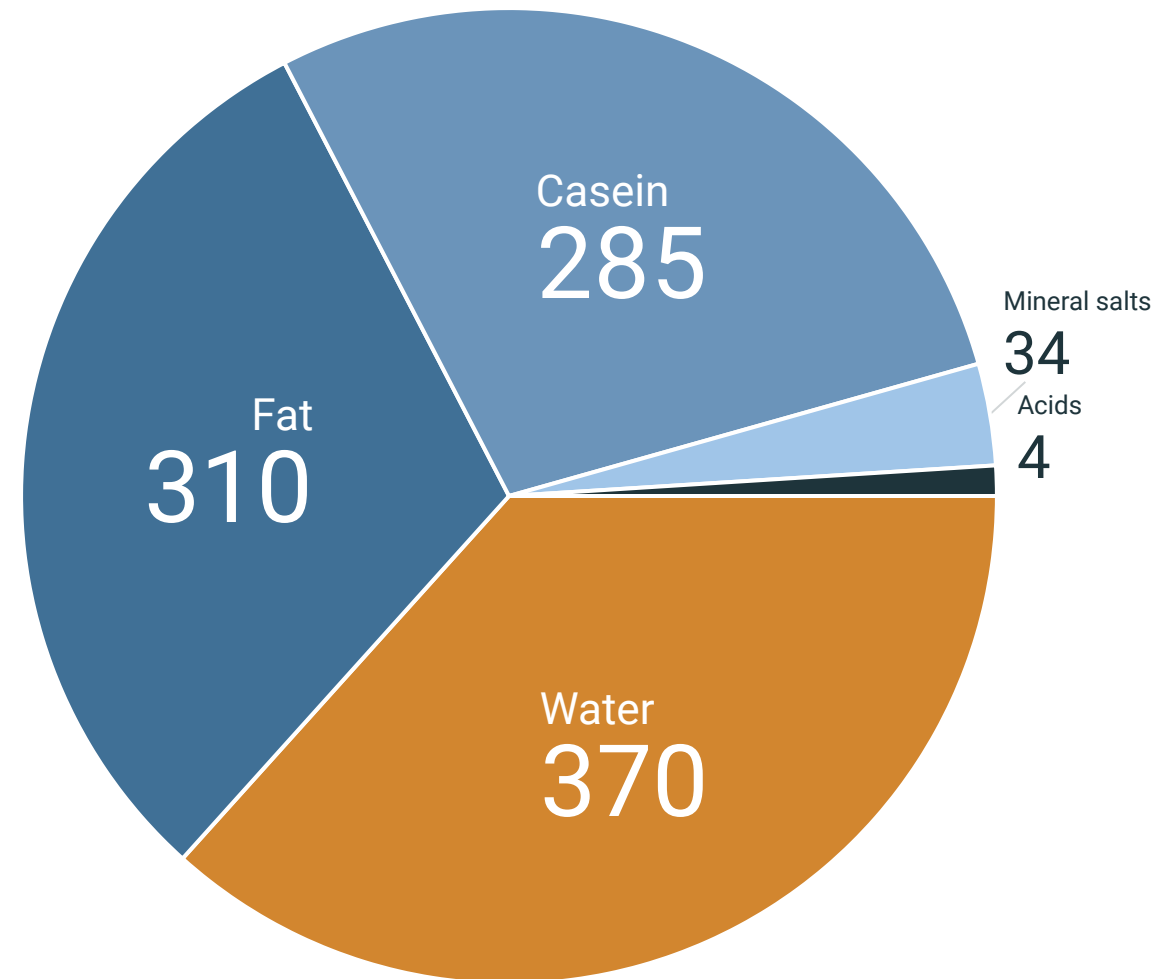
The fat present in the whey and cheese waste, as well as curd grain losses, lead to reduced yield. Although the fat is recovered as whey cream, it is more advantageous due to the price difference between milk cream and whey cream to extract as much milk fat as possible from the milk rather than recovering it from the whey.

Evaluation of milk components for cheese milk

Calculation Basics - Yield and Cheese Composition

We now want to investigate the additional value per kg of milk resulting from a 1 g/kg higher protein or fat content in the milk. Fundamentally, this additional value (not to be confused with the absolute value or milk price) depends on the price of the produced cheese, the cream price, and the yield, and therefore varies for each cheese type. For traditionally produced cheeses, we can approximately estimate the yield based on the protein content, which is 99 % casein and casein degradation products (**Figure 1**).

Composition of Emmental Cheese g/kg (ready for consumption)



Evaluation of milk components for cheese milk

Example of a yield calculation for Emmental cheese:

Cheese composition:

- Fat in dry matter (FiT): 49 %
- Water content: 370 g/kg
- Protein content: 285 g/kg
- Protein content of the milk: 32 g/kg
- Protein transfer rate (milk --> cheese): 74 %

Yield per 100 kg of milk:

- Protein in the milk:
 $\text{kg Protein in the milk} = 100 \text{ kg} \times 32 \text{ g/kg} = 3,2 \text{ kg Protein}$
- Protein (Casein) in the cheese:
 $\text{kg Protein (Casein) in the cheese} = 3,2 \text{ kg} \times 74 \% / 100 \% = 2,4 \text{ kg}$
- Estimated cheese yield:
 $\text{Estimated cheese yield} = 2,4 \text{ kg} \times 100 \% / 28,5 \% = 8,31 \text{ kg}$

This means that for every 1 g of milk protein, approximately 2,6 g of Emmental cheese is produced ($8,31 / 3,2 = 2,6 \text{ g of cheese}$), provided that the water content and fat in dry matter (FiT) remain unchanged.



Evaluation of milk components for cheese milk

Fat

Unless the cheese is made from whole milk, such as Walliser Raclette AOC, which is produced without skimming the milk, a higher fat content results in a higher cream yield. In this case, the added value of a higher milk fat content can be directly derived from the higher price for delivered cream. With a cream price of 9,32 CHF per kg of fat, the calculation is as follows:

Additional value for a fat content difference of +1 g/kg milk =
 $1 \text{ g} \times 9,32 \text{ CHF}/1000 \text{ g} = 0,0093 \text{ CHF}$ or 0,93 Rp/kg

Protein and Casein

The calculation of the value of a higher protein content in cheese milk is more complicated, as the added value depends on the cheese price, the cream price, and the specified water content of the cheese or cheese yield. For this reason, each cheese dairy must perform this calculation for its own operation.

Evaluation of milk components for cheese milk

- Example Emmental:**
- Fat in dry matter (FiT): 49 %
 - Water content: 37 %
 - Cheese price: 7,2 CHF/kg
 - Cream price (CHF per kg of fat): 9,32 CHF/kg



For each additional gram of protein per kg of milk, the calculation above results in an increased yield of **2,6 kg** of cheese per 1000 kg of milk (assuming constant water content and fat in dry matter). With a higher protein content, the milk fat content must also be increased by 0,08 % fat per 0,1 % protein, which results in correspondingly less cream being produced. The calculation is as follows:

Evaluation of milk components for cheese milk

	per 1000 kg of milk	
Additional profit from cheese	2.6 kg x CHF 7.2/kg	186 CHF / 1000 kg of milk
Reduced revenue from milk cream	100 x 0.8 % x CHF 9.32/kg	73 CHF / 1000 kg of milk
Net additional profit		113 CHF / 1000 kg of milk
		113 cents/kg of milk

The value of casein can now be derived based on the casein number (CnZ), which averages 77 %:
Added value of + 0,1 g casein/kg = Added value of protein × 100 % / CnZ = 1,47 cents/kg of milk

IR-Spectroscopic content determination

Testing Characteristics

Milk testing laboratories today routinely perform content analyses of milk using infrared spectroscopy. This is a highly efficient analytical technique. According to the manufacturer (FOSS Analytical), the latest MilkoScan devices can measure the following parameters with high accuracy:

- Fat
- Total protein
- Casein
- Lactose
- Fat-free dry matter

IR-Spectroscopic content determination

- Urea
- Free fatty acids
- Freezing point
- Citric acid
- pH value
- Degree of homogenization (fat globule size distribution)
- Polyunsaturated fatty acids
- Saturated and unsaturated fatty acids

IR-Spectroscopic content determination

Each parameter must be calibrated using reference materials (reference milk, etc.). Typically, the devices are calibrated for fat, protein, and lactose (freezing point and fat-free dry matter can also be calculated with this basic calibration). Determining casein requires additional calibration of the devices. However, this does not incur extra costs. This means that casein determination can be performed cost-effectively with increased demand. The sample throughput of the latest generation of devices ranges from 200 to 600 samples per hour (depending on the device configuration).

This gives the cheesemaker the opportunity to better align the payment for milk with its actual value for cheese production.



CDR FoodLab® Jr system

CDR FoodLab® Jr MUN consists of a thermostatically controlled analyser with photometric technology using LED emitters and kits of reagents that are pre-filled into vials and ready to use.

Analysis kits

The use of pre-filled reagents and the analytical methods, developed by the research laboratories of CDR, allow: quick and easy sample preparation, when needed at all, analytical methods extremely fast and easy, removing all needs for calibration procedures.



Reduced testing times

CDR FoodLab® Jr MUN allows accelerating analysis procedures. It is possible to analyze 3 samples at the same time and constantly monitor the production process, obtaining exact and accurate answers in just a few minutes.



Reliable

The measuring system guarantees high sensitivity, a wide measuring range, and an excellent repeatability of the test results thanks to the photometric technology based on state-of-the-art LED emitters at fixed wavelengths (from ultraviolet to the visible spectrum, up to 6 OD). The results of the analyses are correlated with the reference methods.



Easy to use

The system is designed to be used not only in a laboratory, but real time in the processing plant, even by staff with no previous specific lab tech experience.

The analysis methods are easier than the traditional ones and can be performed in few steps:

- 1 Adding the sample to the pre-filled reagent.
- 2 Following the displayed instructions and if there is ever a doubt, the HELP function will lead you through the process.
- 3 Results are automatically calculated, displayed and printed.



Pre-filled and disposable reagents are packaged in bags of 10 tests, developed and produced by the CDR research laboratories.



1

Take the sample
to be analysed using the pipettes



2

Place the sample
in the test tube containing the



3

Insert the test tube
into the reading cell to obtain

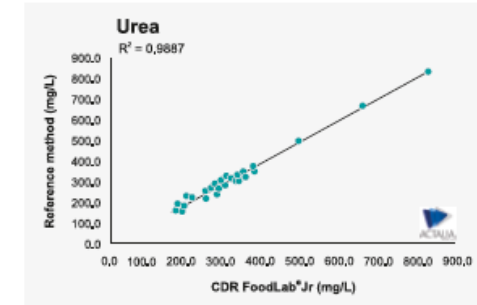
Milk Urea Nitrogen

Chemical tests carried out in whole, pasteurized and skimmed milk are becoming more important since they are used to control milk and dairy products quality, to monitor animal's health and to set up a correct diet, reducing production costs. The percentage of urea in whole milk is influenced by the amount of proteins contained in the diet of the animal and therefore its value is used to define adequate protein content in the fodder.

With this test, it is possible to identify additions of urea in milk made to increase the total percentage of nitrogen, which is normally used to determine the proteins content of milk. Therefore, urea test can be a useful tool, to differentiate between the content of urea and the real protein quantity, used by companies that process and package milk and dairy products, quality control units or research laboratories of milk industries. This test, due to its easiness and rapidity, can be carried out directly into the cowshed.

Comparative tests

The Poligny ACTALIA (France) reference laboratory, specialising in food analysis, performed an evaluation study: The analysis of urea on milk was performed with CDR FoodLab® and with the reference method in differential metric pH (NF EN ISO 14637). The correlation between the CDR FoodLab® method and the reference method is excellent ($R^2 = 0.9887$) considering the type of analysis and the difficulty of performing the reference method. Comparative tests, on samples of whole milk performed between the reference method (differential pH-metry instrument - EFA Instrument) and the CDR FoodLab® method, made in "Laboratorio Standard Latte" of the AJA (Italian Breeders Association) have confirmed a very good alignment between the two systems.



TESTS	Measuring range	Resolution	Repeatability
MUN	2.5 - 50 mg/dL	0.1 mg/dL	0.5 mg/dL
Urea	5.0 - 100 mg/dL	0.1 mg/dL	1 mg/dL

Technical specifications

Display	4.3" Wide TFT color LCD touchscreen
Connectivity	1 USB type B for technical service and PC connection - Bluetooth 2.1
Storage	4 GB internal memory to store the performed tests
Photometric module	37° C Thermostated block with 1 reading cell
Dimension and weight	15 x 22 x 8,3 cm (W x D x H) 0,80 Kg
Power supply	24 V or lithium battery (optional)

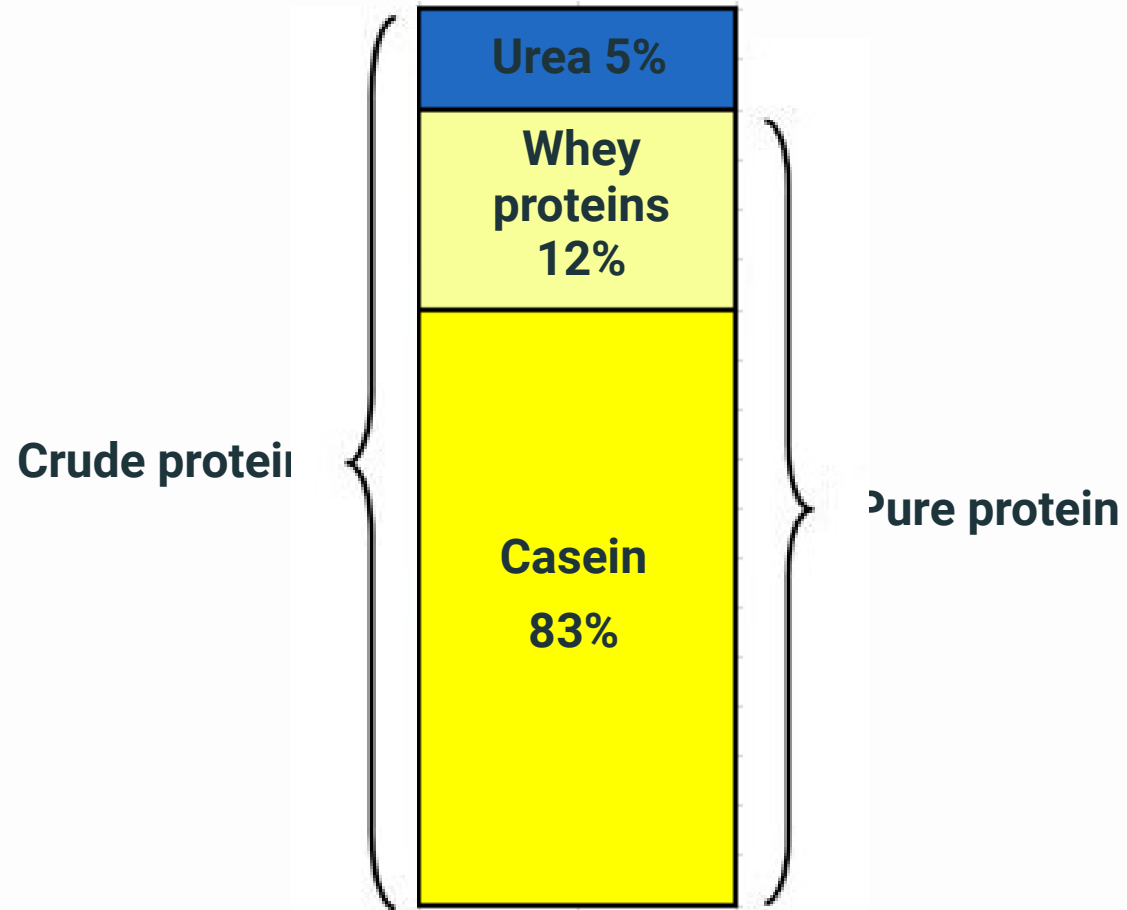


Distribution of the proteins in cow milk

Total Proteins		Average values		
			%	Relative values
Proteins			3.2	100.0
1. Casein			2.5	78.0
	Casein a		1.0	40.0
	Casein b		0.75	30.0
	Casein k		0.38	15.0
	Casein c & other in small quantities		0.37	15.0
2. Whey proteins			0.54	100.0
	b-1 alboumines			
		b-lactoglobulin	0.27	50.0
		a-lactoglobulin	0.12	22.0
		albumin ορού	0.02	5.0
	b-2 anosogloboulines		0.07	12.0
	b-3 peptones		0.06	10.0
NPN			0.16	5.0

Cheese yield obtained from poorly coagulating and well-coagulating milk samples

	gr of cheese/100gr of milk	gr of dry cheese solids/100gr of milk
Poorly coagulating milk (n=38)	7.69+-0.19	3.03+-0.07
Well-coagulating milk (n=81)	8.14+-0.13	3.17+-0.05



Composition of Nitrogen and Protein Fractions in Milk.



Part 2:

Sheep's milk for cheesemaking

Sheep milk urea & crude protein

The relationship between sheep milk Urea and the Crude Protein of the ration (Cannas 1998)

Urea (mg/dl)	15.4	17.6	19.8	22.0	24.2	26.4	28.6	30.8	33.0
CP (%DM)	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0
Urea (mg/dl)	35.2	37.4	39.6	41.8	44.0	46.2	48.4	50.6	52.8
CP (%DM)	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0	20.5

*CP = Crude Protein

Data & Trial Method

- **Country:** Bulgaria, 2011
- **Population:** 40 ewes, Synthetic population Bulgarian milk (SPBM), IAS – Kostinbrod, Bulgaria.
- **Duration:** 180 days
- **Trial Groups:** 2 x 20 ewes
- **Feeding System:** In groups, with constant access to water
- **Milk Yield Inspection:** bi-monthly for 120 days

INGREDIENTS (%)	CONTROL	SOYPASS
Corn	12,0	12,0
Wheat	12,0	12,0
Triticale	36,8	36,8
DDGS	21,5	21,5
Soya bean meal	15,0	---
Sunflower meal	--	7,5
Soypass	--	7,5
Calcium carbonate	1,2	1,2
Dicalcium phosphate	0,7	0,7
Salt	0,7	0,7
PREMIX	0,1	0,1

Trial Data & Soypass[®] Performance

Group A (Soya extr. 44%)

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=====
:                               Master                               (527311734424276086) =====
:                               :                               :                               :
: Single-Mix                    (RUN)  ** ACME Feeds **              {1} 2018                    CUSTOMISED FORMULA          13:28 20/10/23 0007
: 2209.1/2.0                    (    1) Plant=0088                sibbicks
=====

Time period: 2018                Plant name:                Optimization date: 20/10/2023
-----

LP code:      4141      Description: Bulgaria trial Control      LP Solution: OPTIMAL
-----

RM code      Description      Kgs      %      LP_min LP_max RMcost LCost HCost      Nutrient  Units      LP_min      Actual      LP_max
-----
55 Triticale      368.0  36.8      320.0
45 DOGS, maize    215.0  21.5      320.0
13 Soya extr. 44% 150.0  15.0      620.0
2 Maize           121.0  12.1      270.0
51 Wheat          120.0  12.0      320.0
31 Limestone      12.0   1.2      210.0
44 Salt           7.0    0.7      110.0
29 DCP 18%        7.0    0.7      400.0
-----
Total: 1000.0 100.0      356.72
-----
Batch cost: 356.72

[VOLUME] % 100.0
DRY MATTER % 87.967
PROTEIN % 18.741
FAT % 4.0728
FIBER % 4.0769
NDF % 16.4275
ADF % 5.8666
STARCH % 38.2495
SUGAR % 2.0446
ASH % 5.56115
CALCIUM % 0.73216
PHOS % 0.5783
SODIUM % 0.32773
SALT % 0.85473
POTASS % 0.76873
LYSINE % 0.77148
METHIONINE % 0.30998
MER MJ/kg 11.7223
PDIA g/kg 56.885
PDIN g/kg 130.918
UDP g/kg 28.1957
GROSS ENER MJ/kg 16.26745

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Group B (SoyPass & Sunflower)

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===== Master (527311734424276086) =====
:
: Single-Mix (RUN) ** ACME Feeds ** {1} 2018 CUSTOMISED FORMULA 13:30 20/10/23 0008 :
: 2209.1/2.0 ( 1) Plant=0088 sibbicks :
=====
Time period: 2018 Plant name: Optimization date: 20/10/2023
-----
LP code: 4141 Description: Bulgaria trial Control LP Solution: OPTIMAL
-----
RM code Description Kgs % LP_min LP_max RMcost L0cost H0cost Nutrient Units LP_min Actual LP_max
-----
55 Triticale 368.0 36.8 320.0 [VOLUME] % 100.0
45 DOGS, maize 215.0 21.5 320.0 DRY MATTER % 87.8159
2 Maize 159.05 15.905 270.0 PROTEIN % 16.7425
51 Wheat 120.0 12.0 320.0 FAT % 4.09607
39 Soyabass 75.0 7.5 800.0 FIBER % 4.411075
41 Sunflower extr. 28% 36.95 3.695 280.0 NDF % 18.3438
31 Limestone 12.0 1.2 210.0 ADF % 6.4287
44 Salt 7.0 0.7 110.0 STARCH % 40.0
29 DCP 18% 7.0 0.7 400.0 SUGAR % 2.556755
Total: 1000.0 100.0 344.34 ASH % 5.383997
Batch cost: 344.34 CALCIUM % 0.723734
PHOS % 0.595143
SODIUM % 0.326589
SALT % 0.856197
POTASS % 0.688669
LYSINE % 0.414823
METHIONINE % 0.250847
MER MJ/kg 11.615475
PDIA g/kg 60.9957
PDIN g/kg 121.14005
UDP g/kg 32.774855
GROSS ENER MJ/kg 14.922823

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Trial Data & Soypass[®] Performance

	Group A (Soya extr. 44%)	Group B (SoyPass & Sunflower)
Crude protein (%)	18.7	16.7
Urea (mg/dl)	44.0 - 46.2	35.2 - 37.4

*the SoyPass group has significantly lower urea levels

Composition of sheep milk

Breed /Average	Fat (%)	Total Protein (%)	Casein (%)	Whey Protein (%)	Lactose (%)	Dry matter (%)	Ash (%)
Lacaune	7.0	6.0	4.0	1.0	5.0	20.0	1.0
Friesian	7.0	6.0	4.0	1.0	4.0	19.0	1.0
Chios	8.0	6.0	5.0	2.0	5.0	20.0	1.0
Assaf	6.0	5.0	4.0	1.0	5.0	19.0	1.0
Karagouniki	9.0	7.0	5.0	2.0	5.0	20.0	1.0
Frisarta	6.0	6.0	5.0	1.0	5.0	18.0	1.0

Composition of Feta Cheese g/kg (ready for consumption)

