Effects of Seasonal Variation in Milk Composition on the Quality of Pizza Cheese

(Pizza Cheese Quality - Effects of Seasonal Variation in

Milk Composition)

Armis No. 4246

Project Team:
T.P. Guinee (Leader)
B. O'Brien
P.M. Kelly
J.F. Connolly

The Dairy Products Research Centre

Moorepark, Fermoy, Co. Cork.

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Summary and Conclusions

Irish manufacturing milk is largely produced by Spring-calving herds, fed predominantly on pasture. Hence, the processing milk supply, like that of the individual cow, varies significantly in composition throughout the manufacturing season. This is reflected in inconsistencies in milk clotting properties, cheese composition, cheese yield and quality, especially in late lactation. It is generally accepted that these seasonal-related changes are attributable to many interactive influences such as stage of lactation, level and quality of feed, failure to dry off low yielding cows and extended storage of milk on the farm. Previous studies which have investigated the suitability of manufacturing milk in late lactation for cheesemaking have failed to isolate and characterise the relative contributions of the various factors involved and have not applied an objectively defined cheesemaking procedure to account for the changes in concentrations of cheese-recoverable components in the milk per se.

Hence, the main aims of this study were to investigate the effects of diet and lactation stage on the composition and cheesemaking quality of milk produced under controlled conditions.

The main conclusions were as follows:

- These studies clearly demonstrated that the Recommended Moorepark Milk Production System in conjunction with an objectively standardised cheesemaking process provides a model for year round production of quality Mozzarella cheese.
- Databases have been established on the effects of diet quantity and quality, and stage of lactation on the composition, processability and cheesemaking characteristics of milk from both Spring- and Autumn-calving herds.
- Increasing the daily herbage allowance from 16 to 24 kgs DM/cow/day during mid-lactation, resulted in increases in the level of milk casein and cheese yield but had little influence on cheese functionality. Similarily improving diet quality in mid-lactation

by reducing the stocking density from 4.3 to 3.8 cows/ha combined with concentrate supplementation (3 kgs/cow/day) had the same effect.

- Using milk from a Spring-calving herd, produced according to the Recommended Moorepark Milk Production System, in conjunction with an objectively-standardised Mozzarella cheesemaking process, no major problems were encountered during the lactation period 170 - 273 days from calving.
- Extending the lactation period of the Spring-calving herd from ~ 273 to 286 days resulted in higher cheese moisture (by ~ 2%), softer cheese, and lower chewiness in the melted cheese. A sharp decline in both total protein, casein and lactose in the milk was observed during this period. However the blending of this milk with milk of an Autumn-calving herd overcame these cheesemaking problems.
- The yield of low moisture Mozzarella cheese (using milks from Spring- or Autumn-calved herds) was positively correlated with milk casein level. The yield of cheese from the Spring-calved herd increased concomitantly with increasing casein level to day 273 of lactation and decreased thereafter as the casein concentration declined.
- In these studies it was found that easy-to-use tests such as lactose level in the milk and rennet coagulation properties as determined by Formagraph were useful indicators of the suitability of milk for cheesemaking.
- The Recommended Moorepark Milk Production System, as applied in the late lactation period, was characterised by a high plane of nutrition and a drying-off strategy which ensured a minimum daily milk yield per cow of 9 kg. It resulted in milk of good cheesemaking quality - lactose > 4.25%, and casein > 2.6% and satisfactory rennet coagulation properties - curd firming rate of > 0.15 min^{-1} curd firmness at 60 min of > 45mm - at the end of lactation.

Research and Results

In the next three investigations the effects of herbage allowance, stocking density and concentrate feed supplementation, and stage of lactation, on the composition of milk and its suitability for the manufacture of low-moisture Mozzarella cheese were evaluated.

Effect of Herbage Allowance in Mid-Lactation

Increasing the daily herbage allowance from 16 to 24 kg grass dry matter/cow/day significantly increased milk casein and cheese yield.

However, it had no significant effects on curd-forming properties, the suitability of milk for cheesemaking, or on cheese quality (Table 1).

Effect of Stocking Density and Concentrate Supplementation during Mid-Lactation

Improving diet quality through reduced stocking density from 4.3 to 3.8 cows/ha and concentrate supplementation with 3 kg/cow/day resulted in milk with higher concentrations of protein, casein and whey protein and superior curd-forming characteristics. The high quality diet milk resulted in significantly higher cheese yields and milk fat recoveries but had little effect on cheese quality. Hence these experiments indicate that the *Recommended Moorepark Milk Production System* can support efficient production of quality milk for cheesemaking when adequate grass is available.

However, in the absence of adequate grass allowance (< 18-20 kg grass dry matter/cow/day), milk composition and processing characteristics and cheese yield are adversely affected. To correct this, grass allowance should be increased to at least 20 kg dry matter/cow/day if possible or concentrate supplementation introduced.

Table 1. The effect of daily herbage allowance on the composition of cheesemilk and its suitability for the production of low moisture part-skim Mozzarella cheese.

	Daily herbage allowance kg dry matter/cow			
Characteristic	16	20	24	
Milk composition				
Total protein, g/kg	31.6a	32.4b	32.5b	
Casein No.	72.7a	72.7a	73.4a	
Casein, g/kg	23.0a	23.6b	23.9c	
Cheese yield				
Actual, kg/1000 kg	87.64a	87.84a	90.7a	
MACY, kg/1000 kg *	83.64a	86.48ab	89.26b	
Recovery in cheese				
Milk fat, g/kg total	706a	720ab	749b	
Milk protein, g/kg total	743a	734a	738a	
Texture and functionality **				

Firmness, N	302a	310a	312a	
Flowability, %	49.9a	48.9a	50.8a	
Stretchability, cm	96.6a	109a	110a	
Apparent viscosity, Pas	472a	535a	456a	

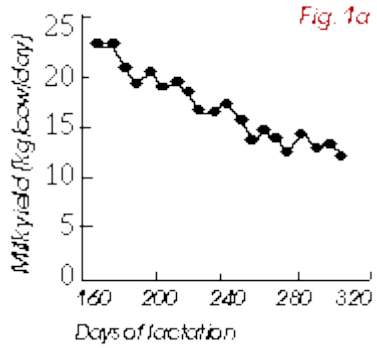
a, b, c, Values within a row without a common superscript were significantly different: P < 0.05.

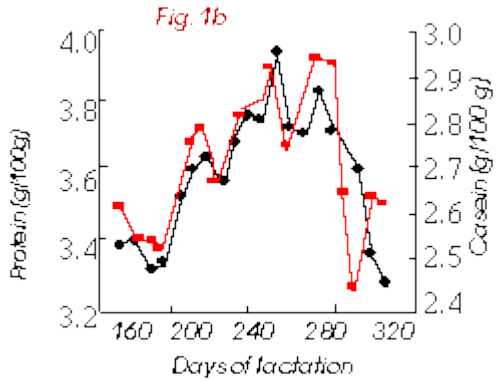
* MACY, moisture-adjusted (to 470 g/kg) cheese yield.

** Texture and functionality properties after 25d storage at 4°C.

Effect of Lactation Stage - August to December period

In the next two studies, three herds - a Spring (Spr)-calving (mean calving date February 22), Autumn (Aut)-calving (mean calving date September 28) and a mixed herd comprised of equal numbers of Spring- and Autumn-calving cows were evaluated during the period August - December. Each herd was managed in accordance with best Moorepark practices.





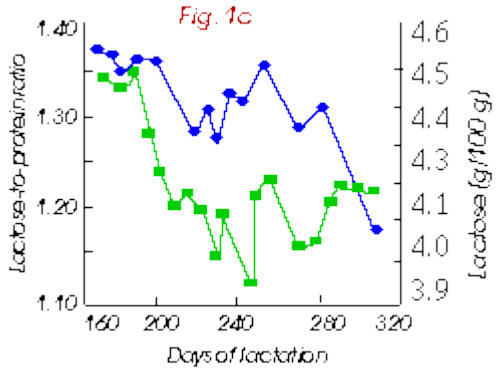


Fig. 1 a,b,c. Yield and composition of the milk from Spring-calved herds in mid-to-late lactation. Composition: protein (▬), casein (▬), lactose (▬), lactose-to-protein ratio (▬).

The changes in milk yield and composition are summarised in *Fig. 1a,b,c*. The decrease in milk yield with advancing stage of lactation coincided with increases in total protein and casein and a reduction in lactose level up to lactation day 270 approx. The trends in total protein and casein corroborate the similar trends reported for commercial milks (Banks et al., 1981; Phelan et al., 1982). The sharp decrease in the concentrations of casein, total protein and lactose toward the end of lactation - beyond day 270, confirmed in a repeat study, may be associated with some physiological changes accompanying the involution process at the end of lactation.

Using the *Recommended Moorepark Milk Production System* for quality milk production in conjunction with an objectively-standardised Mozzarella cheesemaking process, there were no notable effects of stage of lactation, during the lactation period 170 - 273 days (i.e. August 21 to November 21), on rennet coagulation properties or on the composition or functionality of low moisture Mozzarella when using milk from the Spring-calved herd.

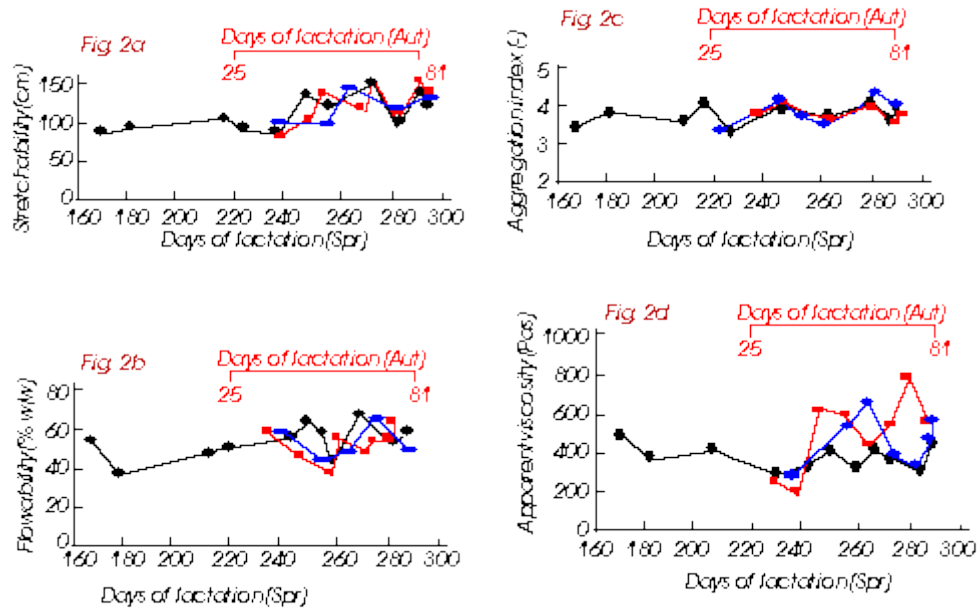


Fig. 2 (a,b,c,d). Functional parameters of low moisture part skim Mozzarella cheeses made from milks from the Moorepark Spring-calved (▬, lactation period 170 - 286 days), Autumn-calved (▬, lacation period 25 - 81 days) or mixed-calved (equal mumbers of Spring- and Autumn-calving cows (▬) herds in 1996, after storage for 1 month at 4°C. The aggregation index and apparent viscosity are indices of the susceptibility of the raw cheese to clump and of the chewiness of the melted cheese, respectively.

However, extending the lactation period of the Spring-calved herd from ~ 273 to 286 days (November 21 to December 4) resulted in higher cheese moisture of 2% approx., softer cheese and lower chewiness in the melted cheese. The use of early lactation milk from the Autumn-calved herd (60 - 73 days lactation), or the blending of this milk with late-lactation milk (273 - 286 days) from the Spring-calved herd overcame the cheesemaking problems associated with the milk exclusively from the Spring-calved herd in late November/early December. The trends in the latter study were confirmed by a repeat study a year later (1997).

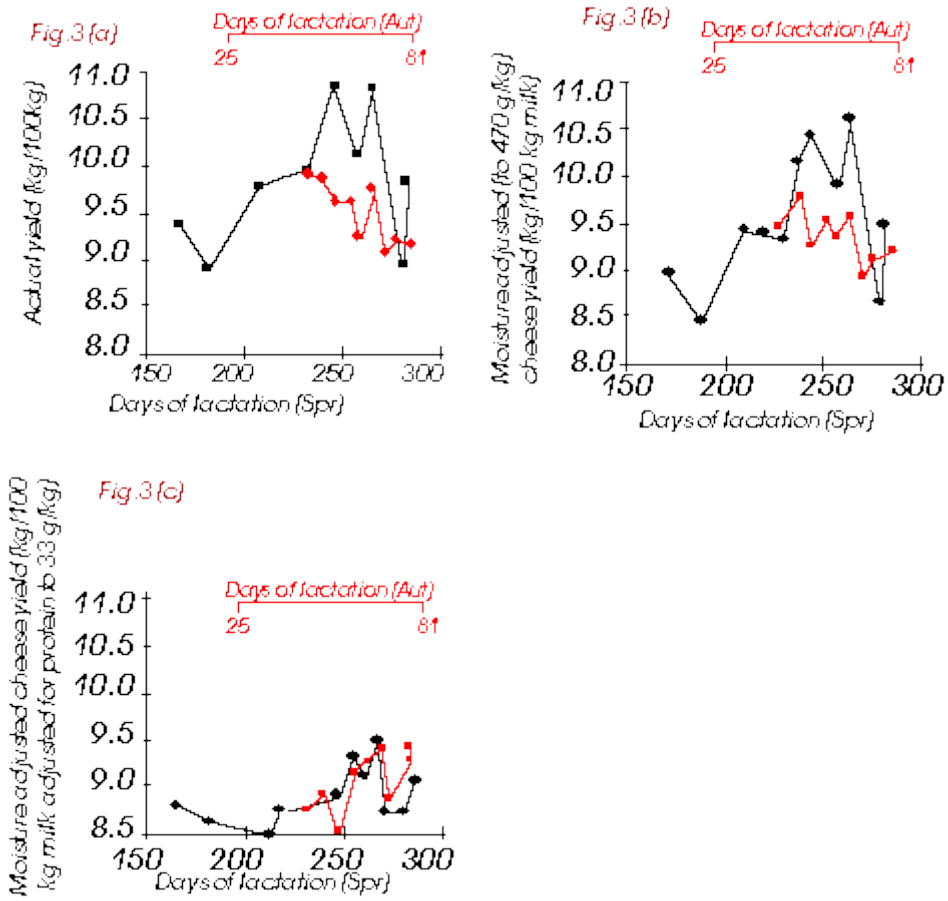


Fig.3 (a) Yields of cheese from the Spring-calved herd (▬ ,Spr) in the lactation period 170 to 286 days and Autumn-calved (▬ , Aut) herd in the lactation period 25 - 81 days. Yield was expressed as actual yield, (kg cheese, at actual moisture content/100 kg of milk), (b) moisture-adjusted cheese yield (kg of cheese, with moisture-adjusted to a common level of 470 g/kg, /100 kg milk), or (c) moisture-adjusted cheese yield (kg of cheese, with moisture adjusted to a level of 470 g/kg/100 kg milk adjusted to standard protein content 3.3 g/100 g and fat content 2.75 g/100 g).

The effects of stage lactation on the yields of cheese from the Spring- and Autumn-calved herds are presented in *Fig. 3a,b,c.* The actual and moisture-adjusted yields of cheese from the Spring-calved herd showed the same trend as casein *(Figs. 1 and 3)*, corroborating previous studies (Guinee et al., 1996, 1998; Walsh et al., 1996) that found casein to be a major determinant of cheese yield. Similar trends were noted for the Autumn-calved and mixed herds, hence the Spring-calved herd milk gave higher actual, and moisture-adjusted yields than the Autumn-calved milks over much of the lactation period when their casein levels were higher.

To eliminate the contribution of variations in milk composition, (i.e. casein and fat) to cheese yield, and hence to observe the effects of lactation other than gross composition, the yield was also expressed as MACYPAM - the moisture-adjusted yield/100 kg milk adjusted for protein (3.3 g/100g) and fat (2.75 g/100g).

The absence of significant differences between the MACYPAM for the Spring- and Autumn-calved herds (Fig. 3.) suggest that, with the Recommended Moorepark Milk Production System, the effects of stage of lactation per se on actual and moisture-adjusted cheese yield ensue from differences in gross composition and not to other effects (e.g. state of casein as effected by Somatic Cell Count).

The lactation studies show that the cheese manufacturing season using milk from Spring-calving herds can be extended successfully into the late Autumn/Winter period (beyond 270 days lactation) by effective managment of late-lactation milk production and by the blending with early lactation Autumn milk.

Effect of Lactation Stage - May to July Period

This lactation study on the suitability of milk for the production of low moisture Mozzarella was undertaken in the period May - July 1997, when the Spring-calving herd was in mid-lactation and the Autumn-calving herd was in late-lactation (i.e. 245 - 280 days into lactation). The late-lactation milk from the Autumn-calving herd generally had non-significantly higher levels of milk fat, protein, casein and whey protein throughout the period and these milk compositional differences appeared to be reflected in non-significantly higher actual cheese yield from lactation day 252 to the end of the investigation period - lactation day 280.

The low moisture Mozzarella cheese from the late-lactation milk of the Autumn-calving herd had higher levels of primary proteolysis, was softer and had a lower apparent viscosity (chewiness) on melting, at most ripening times throughout most of the investigation period. However, the differences in texture and functionality were small and probably would not markedly impact on quality.

Effect of Freezing Mozzarella

Freezing was studied so as to evaluate its effect on low moisture Mozzarella functionality in the event where frozen storage of cheese, produced from good quality mid-lactation milk, was envisaged as the most opportune means of ensuring a continuous supply of acceptable cheese to the market during the winter period. Freezing was achieved by placing diced cheese (2.5 cm cubes) in a blast cooler at -40°C for 48 h and then holding at -18°C.

Storage of the frozen cheese at -18°C for 15 days or 30 days, either immediately after production (before subsequent ripening at 4°C for 15 days), or after ripening at 4°C for 15 days, had no notable effects on its functionality.

For further information, please contact:

Dr. T.P. Guinee

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