The Effects of Processing and Ripening on the Quality of Pizza Cheese

(Pizza Cheese Quality - Effects of Processing and Ripening)

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Summary and Conclusions

The dramatic growth in the consumption of pizza cheese in recent years highlights the importance of functionaltiy as a major driving force in augmenting global cheese consumption. Despite the economic importance of cheese as an ingredient, little published information is available on the factors influencing the functionality of different cheeses or the comparative functionalities of different varieties. As an ingredient in foods, cheese is required to exhibit functional characteristics in the raw (e.g. sliceability, shreddability, grateability) and cooked (e.g. flowability, mouthfeel, flavour and/or stretchability) forms. Feedback from the market place suggests that the functional requirements of pizza cheese varies with region and that there is a growing demand for cheeses and/or cheese toppings with customised functional attributes in the pizza trade.

Hence, the main aims of this project were to quantify the changes in fuctionality during maturation of cheese and to develop an understanding of the factors which mediate the development of functionality. The approach to achieving these objectives involved the establishment of a suitable pilot plant production procedure for low moisture Mozzarella, developing and/or adapting existing methods for objective evaluation of the functional properties of pizza cheeses, and evaluating the effects of ripening and variations in cheesemaking conditions (e.g. pH at stretching) on the composition, yield and functionality of low moisture Mozzarella cheese.

The main conclusions were as follows:

- The technology for developing low moisture Mozzarella cheeses, with different compositions and functionalities, via alteration of cheesemaking parameters, has been developed.
- A database has been established on the storage-related changes that occur in texture, proteolysis and functionality of low moisture Mozzarella cheeses of different compositions. In addition an extensive database on the compositional, biochemical,

microstructural, rheological and/or functional properties of different commerical cheeses - low moisture Mozzarella, Cheddar and analogue pizza cheese, has been compiled.
- The functionality of low moisture Mozzarella changes markedly on storage/ripening at 4ºC. Initially, during the first 5-10 days of storage, the functionality of the baked cheese is poor but then improves on further storage as reflected by reductions in melt time and apparent viscosity (chewiness) and increases in stretchability and flowability. The changes in functionality are mediated by storage-related increases in pH, proteolysis, protein-bound water and free oil in the cheese. On prolonged storage (e.g. > 60 d at 4ºC), the cheese functionality becomes impaired as the shredded cheese develops an increased susceptibility to clumping/balling which makes it difficult to dispense the cheese onto the pizza pie and achieve a uniform surface distribution. Moreover, the baked cheese tends to exude excess free oil and loses its desired level of chewiness attaining a 'soupy' consistency.
- Novel methods were developed/adapted to objectively quantify functionality in the raw (susceptibility of shredded cheese to clump) and cooked (stretchability, chewiness, viscoelasticity) cheeses.

Commercial impacts

- Industry commissioned trials, in pilot plant and in-factory were successfully undertaken on development of:
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    - pizza-style cheeses using non-conventional technology
    - high moisture (520 - 540 g/kg) functional Mozzarella
    - flow resistant pizza-style cheeses for different applications
    - a customised functional heat-stable cheese as an ingredient

Research and Results

Developing of methods for quantifying functionality

Novel methods were developed to objectively quantify the stretchability of baked cheeses on pizza pie, the chewiness of melted cheese, and the tendency of shredded cheeses to clump or shatter on vibration under conditions which simulate conditions in pizza pie production.

Tests were also developed for monitoring the dynamic rheological and microstructural changes in the cheese during melting and for measuring the susceptibility of cheese to oiling-off or crusting/dehydrating during melting. While these tests would not be routinely used as a quality control tool, they would prove extremely useful in elucidating the causes of potential problems with functionality.

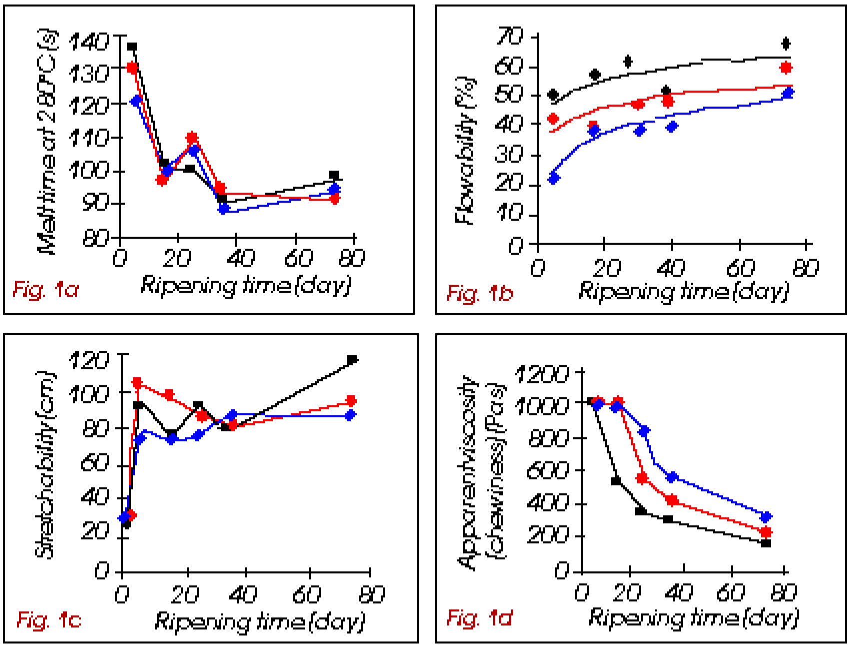

Fig. 1 (a,b,c,d) Changes in functionality during storage at 4°C of low moisture Mozzarella cheese salted using different methods: dry-salting curd before stretching (▬), brine-salting curd after stretching (▬), combined dry- and brine-salting of curd after stretching (▬).

Changes in biochemical and functional attributes during storage

A database has been established on the age-related changes that occur in texture, proteolysis and functionality of low moisture Mozzarella cheeses (LMMC) with different compositions, on storage at 4ºC.

The functionality of LMMC improves markedly during the first 2 weeks of ripening at 4ºC, as reflected by reductions in melt time and apparent viscosity and increases in flowability and stretchability, and maintains this status for up to 60 days (Fig. 1). The improved functionality is due to the increases in protein hydration and free fat during aging of the cheeses (Fig. 2 & 3).

These changes are mediated by physico-chemical changes including: the small increase in pH (from ~ 5.15 before texturisation to ~ 5.35 - 5.40 at 5 days), the increase in primary proteolysis *(Fig. 2)*, the solubilisation of casein bound calcium, and the slow coalescence of the partially denuded fat globules. The increase in protein hydration is paralleled by a swelling and loosening of the paracasein fibres, as revealed by confocal laser scanning microscopy *(Fig. 3).*

On prolonged storage, e.g. to 75 days, the unbaked cheese generally becomes too soft and sticky while the baked cheese attains excessive flowability, and a 'soupy' consistency, which lacks the desired chewiness (as reflected by the relatively low apparent viscosity). These changes in functionality are attributable to excessive proteolysis and protein hydration. However, the stretchability remains relatively constant even when the product is stored for prolonged periods of up to 4 months at 4ºC.

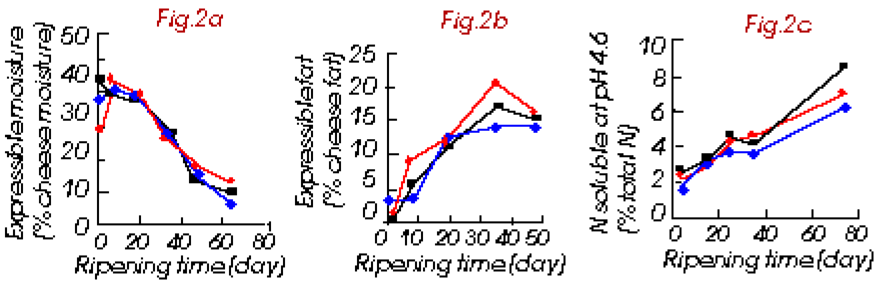

Fig. 2 (a,b,c) Biochemical changes, during storage at 4°C, in low moisture Mozzarella cheese salted using different methods: dry-salting curd before stretching (▬), brine-salting curd after stretching (▬), combined dry- and brine-salting of curd after stretching (▬).

Development of Mozzarella cheeses with customised functionalities

Technology has been developed for the production of low moisture Mozzarella cheeses, with different compositions and functionalities, via alteration of cheesemaking parameters. Cheese moisture and yield were increased by dry-salting of the curd before stretching, reducing the pH of the curd at stretching from 5.3 to 5.15-5.0 or increasing the curd temperature at stretching from 58 to 63ºC. The hardness of the unbaked cheeses and apparent viscosity (chewiness) of the baked cheese were reduced by lowering the milk protein level and the curd pH at stretching and by increasing the curd temperature at stretching and by dry-salting. The flowability of the melted cheese increased on raising the temperature of the curd at stretching and by using dry-salting (before stretching) as opposed to brine-salting after stretching.

The effects of cooking temperature, pH at whey drainage and pH at stretching on cheese composition and yield are interactive.

Hence, it is envisaged that customised products with different functional attributes within certain ranges are technically possible via alteration of make procedure and composition.

In summary there are dramatic changes in functionality during storage at 4ºC. Storage studies indicate that there is a time window (Fig. 4) within which functionality is optimum for a specific application. Within this window, biochemical parameters such as proteolysis and expressible moisture, and functional attributes such as flowability, chewiness and stretchability must fall within prescribed limits. The width of the window and the time at which it occurs (its location on the maturation time axis) are effected by cheese composition and cheesemaking procedure. Hence, alteration of the cheesemaking procedure enables the development of cheeses with customised functionalities.

Compositional and functional characteristics of different cheese types

A survey of different commercial cheese types such as Cheddar cheese (CC), low moisture Mozzarella (LMMC), and analogue pizza cheese (APC), revealed marked intra- and inter-variety differences in composition, microstructure, biochemical properties, functionality and viscoelastic changes on heating *(Table 1).*

Nevertheless, inter-category differences were clearly discernible. Compared to CC, LMMC had a higher mean pH, higher levels of expressible moisture (reflecting a lower water binding capacity of the paracasein) and lower mean levels of proteolysis, expressible fat and serum concentrations of N and Ca. While the LMMC and APC were comparable for many of the compositional variables, the APC had a significantly lower mean protein level and a higher fat level.

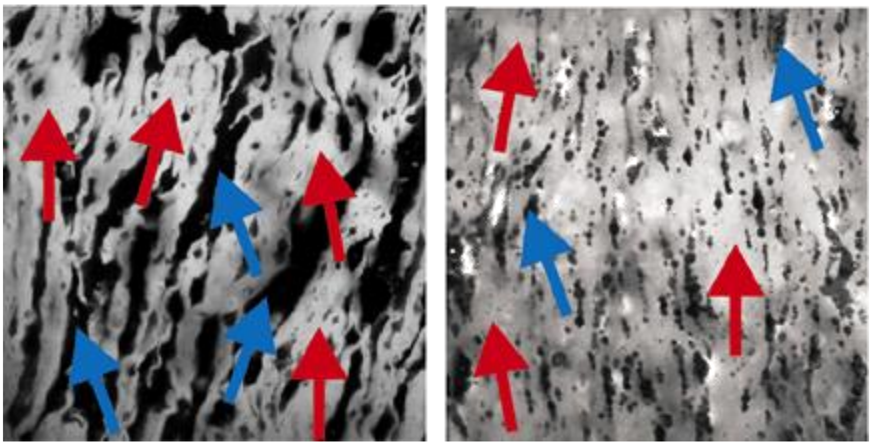

Fig. 3 Changes in microstructure of low moisture cheese during storage at 4°C for 1 (A) or 43 (B) days. The linearised parcasein fibres () enclose the fat phase (), which occurs in the form of pools exhibiting a similar orientation as the paracasein fibres. On storage the paracasein fibres present in the 1-day old sample swell as a consequence of hydration and become more voluminous, as in the 43-day old sample.

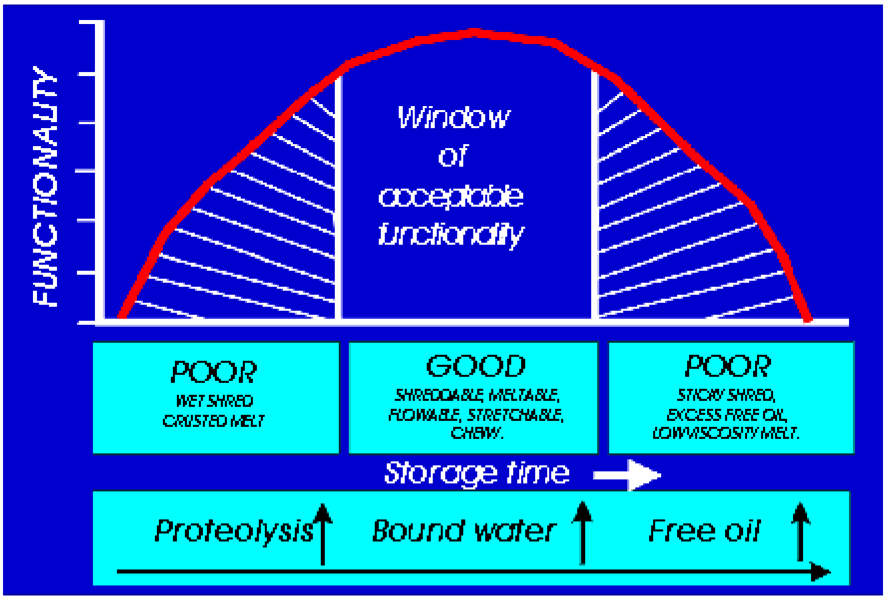

Fig. 4. Schematic of the changes in the overall functionality (red bellshaped curve) of low moisture Mozzarella on storage at 4°C. Functionality is poor (wet shred, crusted melt) initially, then becomes good (e.g. with desired degree of oiling-off, flow and chewiness), thereafter becoming poor again on prolonged storage (e.g. > 70 d). The storage-related changes in functionality are mediated by increases in proteolysis, protein bound water and free oil in the cheese.

Microstructural analysis of the cheeses indicated that the paracasein in the LMMC was in the form of longitudinally aligned protein fibres with entrapped fat columns, consisting of coalesced and discrete globules *(Fig. 5)*. Less orientation of the paracasein (into fibres) and a lower degree of fat coalescnce was evident in the CC. The microstructure of the APC was distinctly different from that of the LMMC or APC, with a more uniformly distributed paracasein matrix and more discrete uniformly-sized fat globules. The inter-category compositional and microstructural differences, were associated with differences in functionality *(Table 1)*.

A smaller number of other commercial cheese-types were also evaluated. In general the *pasta-filata* cheeses (e.g. Mozzarella, Kackaval, string cheese) had superior stretchability and chewiness and moderate flowability. Several inter-variety correlations between cheese composition and functionality were noted, e.g. stretchability was negatively correlated with levels of fat, fat-in-dry matter and the level of primary proteolysis, and positively correlated with moisture content. It is envisaged that the findings of the survey would prove extremely valuable to the manufacturers of cheese blends for pizza toppings.

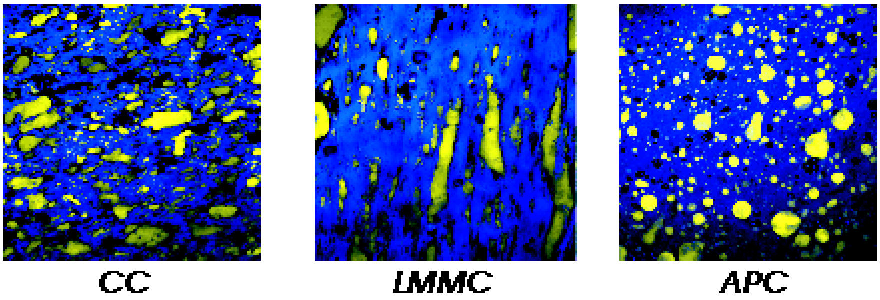

Fig. 5. Microstructures of different cheeses used in pizza pie: Cheddar (CC), low moisture Mozzarella (LMMC) and analogue pizza cheese (APC). Microstructural differences are reflected in different distributions of the paracasein (in blue) and fat (in yellow) phases.

Table 1. Compositional and functional characteristics of commercial cheeses used on pizza pie§

		Cheddar	**Cheese Type Low moisture Mozzarella**	**Analogue pizza cheese**
1.	Cheese composition			
	Moisture (g/kg)	372^{a}	464^{b}	488^{b}
	Protein (g/kg)	254^{a}	260^{a}	184^{b}
	Fat (g/kg)	331a	232^{b}	250^{b}
	pH	5.14^{a}	5.53^{b}	6.30^{c}
	Nitrogen soluble at pH 4.6(% Total N)	20.3^{a}	4.7^{b}	2.3^{b}

	Nitrogen soluble in 5% phosphotungstic acid (% Total N)	4.6[a]	0.5[b]	0.2[b]
2.	Cheese juice composition			
	Expressible serum			
	(% cheese moisture)	8.8[a]	18.8[b]	21.8[b]
	Serum N (% cheese N)	16.8[a]	6.3[b]	6.0[b]
	Serum Ca (% cheese Ca)	38.2[a]	22.7[b]	4.7[c]
	Expressible fat (% cheese fat)	18.2[a]	4.1[b]	6.2[b]
3.	Functionality			
	Aggregation index (-)*	4.04[a]	3.95[a]	3.74[a]
	Melt time (s)	101[a]	108[a]	105[a]
	Flowability (%)	70[a]	53[b]	42[b]
	Stretchability (cm)	23[a]	87[b]	27[a]
	Apparent viscosity (Pas)**	375[a]	390[a]	410[a]

§ Samples were of Irish, UK or Danish origin; for each cheese type the sample size (n) was 8.

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

* Aggregation index is a measure of the susceptibility of the shredded cheese to clump.

** Apparent viscosity is a measure of the chewiness of the melted cheese.

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