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Dairy Ingredients for Chocolate and Confectionery

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High free-fat, spray-dried powders were successfully produced at a lower fat content (40% rather than 56%) using ultrafiltration. Chocolates made from these powders had improved flow properties and superior quality.
The stability, viscosity and firmness of toffees were improved by optimising the casein, whey protein and lactose levels of skim milk powders used in their manufacture.

Dairy Ingredients for Chocolate and Confectionery Products

(Dairy Ingredients for Chocolate and Confectionery)

Armis No. 4519

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Summary and Conclusions

Chocolate

Powders produced by spray-drying have been found not to perform as well in chocolate manufacture as roller-dried powders. This is attributed mainly to the free-fat levels of roller dried powders which have up to 90% free-fat, compared to less than 10% in regular spray-dried powder. In a previous study (DPRC No. 13) it was shown that high fat spray-dried powders had the necessary free-fat level (up to 95%) for chocolate, although free-fat levels were lower in powders produced in the January - March period. It was also shown that the properties of the high fat powders important for chocolate were affected by milk composition. The effects of the powder properties on the flow properties and hardness of chocolate were also clarified and quantified.

The key objectives of these studies were:

** to produce high free-fat spray-dried powders for chocolate at a lower fat content (40% fat) and to reduce the flowability problems associated with high free-fat powders.*

** to determine the predictive ability of raw milk composition (milk protein and solid fat content at 10ºC) to control the functional properties of spray-dried milk powders (free-fat, particle size and vacuole volume) important for chocolate.*

** to determine the ability of the milk powder properties to predict the chocolate properties.*

** to make recombined powders using milk fats of varying solid fat content in order to quantify the effects of solid fat content on the flow properties of the chocolate.*

Toffee

Reconstituted milk powder or sweetened condensed milk is used in confectionery products such as toffees, caramels and fudges, but their role is poorly understood. Because of the high solids contents of these confectionery products, the concentration of ingredients in the available moisture is very high. The functionality of milk protein ingredients, in particular in a high-solids product is unknown. A better knowledge of the role of each ingredient component could lead to development of specific ingredients to meet individual customer requirements.

Hence, the key objective of this study was to evaluate the effects of milk powder composition on the processability, flow properties and firmness of low moisture confectionery using toffee as an example.

Main Conclusions and Achievements

Milk Powder for Chocolate

- By using ultrafiltration to raise the protein content of the powders, it was possible to produce high free-fat powders at a lower fat content than previously (40% rather than 56% fat).

- The flow properties of high fat powders (40% and 56% fat) were poorer than commercial whole milk powders (26% fat). There was no significant effect of fat content (40 - 56%) and free-fat content (39% - 100%) on the flow properties. The flow properties disimproved as the temperature increased from 5 to 25ºC.

- Confirmatory trials showed that the free-fat of the milk powders was predicted well by the protein and solid fat content at 10ºC of the milks. However, the size of the powder particles was predicted less well. The vacuole volume of the powders was not related to milk composition.

- It was possible to predict the viscosity and final hardness of the chocolates from the free-fat and particle size of the powders but the yield value of the chocolates was predicted less well from the solid fat at 10ºC and vacuole volume of the powders.

- The free-fat level of recombined powders was unaffected by the solid fat content of the fat. There were no differences in the flow properties of chocolates made with recombined powders with milk fats of different solid fat content, that is, the expected decrease in yield value did not occur with increasing solid fat content.

Milk Powder for Low Moisture Confectionery (Toffee)

- The firmness of cooked toffee at 90ºC was increased by the casein content and decreased by the lactose content of the skim milk powders.

- The hardness of the final toffees was increased both by the casein content and the lactose content of the skim milk powders.

- Toffee firmness, hardness and colour were affected by the casein:whey protein ratio of milk powders. Pre-heat treatment of the reconstituted milk at low milk solids concentration was necessary for the production of toffees stable to heat.

- Microscopic examination of the toffees showed that the casein:whey protein ratio affected the size of the fat pools and protein aggregates in the toffees and that the degree of whey protein denaturation was responsible for toffee structure.

Confirmatory trials for powders in chocolate

A previous project was very successful in understanding and defining the effect of the selected milk components (milk protein and solid fat content at 10ºC) on the functional properties of high fat (56%) spray-dried milk powders (free-fat, particle size and vacuole volume) important for chocolate (see DPRC No. 13).

In the current project, five trial powders made for confirmatory purposes showed that the properties of the milk powders were predicted by the protein and solid fat content at 10ºC of the milks.

Five chocolates were then made to demonstrate that it was possible to predict the chocolate properties from those of the milk powders used.

High free-fat powders (40% fat)

The previous studies were carried out using 56% fat powders, which had high free-fat contents.

Free-fat levels were then raised in powders containing an intermediate fat content of 40%. These powders were prepared:

- from a control milk,

- by ultrafiltration of the skim milk followed by addition of cream to increase the protein:lactose ratio from 0.64 (control) to 0.94 and

- by adding lactose to reduce the protein:lactose ratio to 0.58.

As the protein:lactose ratio increased, the free-fat of the powders increased from 40 (control) to 75%.

Two series of 26 and 40% fat powders were produced by treating milk with plasmin or phospholipase or a combination of both enzymes (40% fat powder only) and compared to control powders.

The free-fat and particle size of these powders were not significantly different from untreated powders. No differences were found in the flow properties of the chocolates made from these powders, but an objectionable rancid off-flavour was found in the combined-enzyme treated chocolates.

Flow properties of high free-fat powders

The flow properties of the high fat powders (40 and 56% fat) produced were poorer than commercial whole milk powders (26% fat). There was no significant effect of fat content (41.5% - 56%) and free-fat content (39% - 100%) on the flow properties of the high fat powders. The flow properties were reduced as the temperature increased from 5 to 25ºC.

Effect of solid fat content of powders on chocolate

The influence of the solid fat content of milk powders on chocolate was then studied. Recombined milk powders (40% fat) were prepared from reconstituted skim milk powder and milk fats with solid fat contents at 10ºC of 41, 51 and 61%.

In contrast to results obtained for high fat powders made in the previous project from creams ranging in solid fat content from 39 to 56%, the free-fat level of the recombined powders was unaffected by *the solid fat content of the fat. There were no differences in the flow properties of the chocolates made with these powders, that is, the expected decrease in yield value did not occur. Thus, changes found in powders made using cream were not reproduced with recombined powders. These changes were already considered to be due to factors associated with the solid fat, rather than to the effect of solid fat per se.*

The toffee process, evaluation methods and trials

The equipment necessary for the toffee confectionery stage of the project was installed and a standard method for the manufacture of toffee confectionery at pilot scale was set up to evaluate the effects of skim milk powder composition. Skim milk powder was first reconstituted in water with sugar to the composition of sweetened condensed skim milk *(Table 1)*.

Ingredient	*%*
Skim milk powder	27.5
Sugar	38.5
Water	34.0

Table 1: Composition of reconstituted skim milk powder as sweetened condensed skim milk for toffee.

The powder and part of the sugar were dry mixed and stirred into water at 60ºC. The mix was stirred for 5 minutes and allowed to stand overnight at 4°C. Hydrogenated palm kernel oil was melted at 60ºC and added to the mixture of glucose syrup and reconstituted sweetened skim milk powder *(Table 2)*.

Ingredient	*%*
Glucose syrup	34.0
Reconstituted sweetened condensed skim milk	32.0
Sugar	22.5
Hydrogenated palm kernel oil	11.5

Table 2: Composition of toffee.

These ingredients were mixed using a Silverson mixer to disperse the melted fat into the aqueous syrup before the addition of the sugar. After the remainder of the sugar was added, the mix was stirred well. The mixture was then placed in the gas cooker (Savage Bros. Co., 1125 Lunt Ave., Elk Grove Village, IL. 60007, USA) and heated with continuous stirring until a temperature of 121ºC was reached. At this temperature, which represents the end of the cooking process, a sample of the molten toffee was taken and cooled to 90ºC for viscosity measurement.

Effect of Gross Composition

The effect of the casein, whey protein and lactose levels of the skim milk powders on the processability, flow properties and microstructure of the toffees was quantified in a statistically-designed series of 23 trials (14 trials and 9 repeated). In 9 of the trials, lactose was added to increase the protein:lactose ratio further.

The firmness G' (Pa) of the cooked toffee after cooling from 121ºC to 90ºC was increased by the casein content and decreased by the lactose content of the skim milk powders. The hardness (kg.m.s^{-2}) of the final toffees was increased both by the casein content and lactose content of the skim milk powders. This means that lactose contributed *to the firmness of the toffee after crystallisation only. Microstructural differences between toffees were observed using laser microscopy. Toffee samples containing powder with a high protein:lactose ratio had more aggregated protein material, some of which was adsorbed at the surface of the fat globules. Samples with a low protein:lactose ratio had a thinner layer of protein surrounding the fat globules. The non-adsorbed protein material was less aggregated.*

Samples with a low protein:lactose ratio also exhibited protein aggregation leading to processing difficulties due to burn-on. An explanation was sought for this instability/burn-on problem. This occurred at a protein:lactose ratio in skim milk powders of 0.68 and below. The effects of the casein and whey proteins was less obvious, and further trials were carried out to clarify their role *(Table 3)*.

Effect of casein:whey protein ratio

Artificial skim milk powders with specific casein:whey protein ratios were prepared. Various ratios of phosphocasein and whey protein isolate *(Table 3)* were reconstituted (total protein 3.2%) in a simulated milk salt solution with 4.5% lactose. These artificial milks were pre-heated at 97.5ºC x 2 min, concentrated by evaporation to 45% solids and spray-dried. The powders were then evaluated in toffee.

Artificial milk powder	Firmness G (Pa)	Hardness (kg.m.s^2)	Comments
Casein:whey protein 100:0	518	1.3	Homogenous mix, dark colour
Casein:whey protein 90:10	300	4.2	Smooth, pale colour, filled moulds well
Casein:whey protein 80:20	795	7.6	Smooth, good intermediate colour
Casein:whey protein 70:30	612	4.6	Dark colour
Casein:whey protein 0:100	-	-	No shape, dark areas, protein aggregation.
80:20; no pre-heat treatment	423	8.0	Lumpy with dark patches, like caramel

Table 3: Flow properties of toffees made with artificial milk powders with various casein:whey protein ratios.

Maximum toffee firmness, hardness and good colour were found at the intermediate casein:whey protein ratio of 80:20. Milk powders with casein:whey protein ratios between 100:0 and 70:30 produced toffees which were stable to heat, but toffees containing a 0:100 ratio (whey protein alone) or an 80:20 ratio without pre-heat treatment exhibited instability and burn-on to the sides of the cooker. In both cases of instability/burn-on, the whey proteins were not bound to the heat-stable casein and were free to exhibit instability and burn-on. This demonstrates that the binding of the heat-sensitive whey proteins to casein at low milk solids concentration is a necessary requirement for the production of stable toffees.

Table 4 summarises the microstructure of six toffee formulations as observed by confocal scanning laser microscopy (CSLM). Each toffee sample was stained with a fluorescent dye for the fat and protein, which highlighted their distribution in the toffees (see *Fig.1*).

Table 4: CSLM observations of toffees made with sweetened condensed milk and artificial milk powders with various casein:whey protein ratios.

Milk Ingredient	Microstructure Observations
Sweetened condensed milk (control)	Small fat globules adsorbing small protein aggregates. Some pools of free-fat up to 20 µm.
Casein:whey protein 100:0	Large pools of free-fat up to 30 µm. Protein highly aggregated and adsorbed to fat interface.
Casein:whey protein 90:10	Some free-fat. Small fat globules with high level of adsorbed protein. Similar to control but with smaller fat pools.
Casein:whey protein 80:20	Small fat globules with protein adsorbed. Similar to control.
Casein:whey protein 70:30	Similar to control but with more free-fat.
Casein:whey protein 0:100	Extensive free-fat with very large network of protein aggregates. Very little adsorbed protein.

The microscope observations suggest that casein-whey protein interactions play an important role in the physical structure of toffee. Small fat globules with adsorbed small protein aggregates were present in the acceptable toffees made with sweetened condensed milk and the powder with casein:whey protein ratio of

80:20. The toffees made with powders with casein:whey protein ratios of 100:0 and 0:100 contained highly aggregated protein material. However, their flow properties were quite different from the whey protein-only toffee being much more viscous that the phosphocasein-only toffee.

This suggests that denatured whey is largely responsible for the structure-forming properties of toffee. The milk protein composition also influenced the size of the fat pools, which in turn would be expected to influence sensory properties such as greasiness and flavour release.

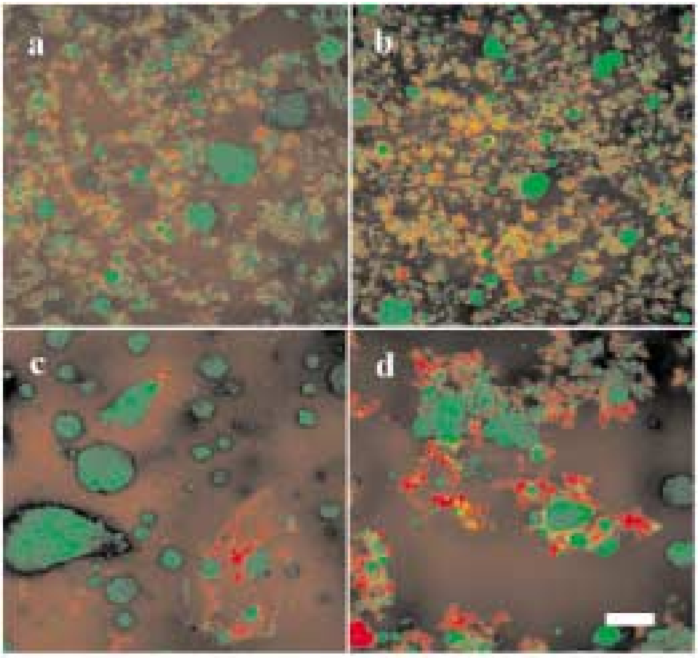

Fig. 1. Confocal scanning laser micrographs of toffees made with, a) sweetened condensed milk, b) 80:20 phosphocasein:whey, c) whey only, and d) phosphocasein only. Dual labelled indicating the distribution of fat (green) and protein (red). Bar = 25 μm.

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