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Replacement of fat with functional fibre in imitation cheese

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Abstract

The physical properties of imitation cheeses containing 21.3% dry matter (DM) resistant starch with moisture levels of 52–60%, as well as cheeses (60% moisture) containing 21.3–43.2% DM resistant starch were examined. Flowability of the heated cheese was assessed by an empirical method; the textural properties by texture profile analysis and dynamic rheology. Sensory analysis of cheeses was conducted by panellists using ranking tests. Increasing the moisture decreased cheese hardness did not affect flow but led to an undesirable 'sticky' and 'clingy' mouthfeel. Hardness increased linearly with increasing starch. Flow decreased at starch contents $\geqslant$34.8% DM. Replacement of fat in the higher moisture cheeses resulted in the production of a good, firm cheese as assessed by a sensory panel. It was possible to incorporate up to 43.2% DM resistant starch into cheeses, a level higher than many 'high fibre' products, while maintaining acceptable functional properties.

Keywords: Imitation cheese; Fibre; Resistant starch; Microstructure; Fat replacement

1. Introduction

In recent times, western countries have seen the prevalence of obesity increase and the evidence available strongly points to consumption of a high-fat diet and a lack of physical activity and dietary fibre as the major contributory factors (Jenkins, Kendall, & Ransom, 1998). As a result, in recent years the food industry has responded by introducing reduced fat foods, some of which are fortified with dietary fibres, to help consumers achieve healthier diets. In the 1990s, the cheese industry successfully introduced many new cheese products many of which were low in fat (Anon, 1995; Mistry, 2001).

Mozzarella cheese sales are continually growing due to the widespread popularity of pizzas. Imitation Mozzarella cheese is often used on pizzas as a cheaper alternative to natural Mozzarella. Imitation Mozzarella normally contains about 20–27% fat; thus, there is potential for formulation of low-fat versions of this product. A number of food researchers have examined the effect of reducing the fat content of natural Mozzarella and process cheeses (Fife, McMahon, & Oberg, 1996; McMahon, Oberg, & Mc Manus, 1993; Tunick et al., 1993).

Recently, Montesinos, Cottell, O'Riordan, and O'Sullivan (2006), sought to replace up to half the fat content of imitation cheeses with two types of resistant starch (Novelose 240 or 330). However, it was found that reducing the fat caused the cheeses to become harder, with the lowest fat cheese (12%) having a hardness value considered undesirable from a sensory perspective. Hennelly, Dunne, O'Riordan, and O'Sullivan (2006) showed that increasing the moisture content of imitation cheese reduced the hardness problems associated with replacement of fat by a soluble dietary fibre (Inulin). It is possible that a similar approach might be successful in reducing excessive hardness of reduced fat cheeses containing Novelose 240.

Novelose 240 was preferred over inulin as a fat replacer for two reasons. Firstly, inulin needs to be incorporated into imitation cheese as a pre-formed gel, whereas Novelose 240 can easily be incorporated in powder form. The latter leads to a more efficient processing protocol. Secondly, research from our laboratory has shown that it is possible to incorporate more Novelose 240 than Inulin in

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imitation cheese without adversely affecting the cheese functionality (Hennelly et al., 2006; Montesinos et al., 2006).

Therefore, the first objective of this study was to examine the effects of increasing the moisture content, in the range of 52–60% (w/w), on the physical properties of an imitation cheese in which half the typical fat content was replaced by resistant starch (i.e., starch and starch degradation products not digested and absorbed in the small intestine of humans). The second objective was to examine the effects of progressively replacing the remaining 50% of the fat with resistant starch on the physical properties of imitation cheese containing 60% moisture. It was hypothesised that the first objective would reduce the hardness associated with fat reduced imitation cheese and the second objective would produce a product that is nutritionally superior (increased fibre content, decreased fat content) to commercial imitation cheese.

2. Materials and methods

2.1. Materials

Kerry Ingredients Ltd. (Listowel, Co. Kerry, Ireland) provided the rennet casein (80% protein). Rapeseed oil and hydrogenated palm oil were obtained from Trilby Trading (Ireland) Ltd. (Drogheda, Co. Louth, Ireland). The resistant starch Novelose 240 (40% granular RS2 starch, derived from high amylose corn starch) was obtained from National Starch (National Starch and Chemicals, Manchester, England). All chemicals, including anhydrous disodium phosphate (Albright and Wilson Ltd., Cheshire, England), trisodium citrate, anhydrous citric acid (Jungbunzlauer GmbH., Pernhofen, Austria), sodium chloride (Salt Union, Cheshire, England) and sorbic acid (Hoechst Ireland Ltd., Dublin, Ireland) were of food grade.

2.2. Manufacture of imitation cheese

Batches (4 kg) of imitation cheese with moisture contents of 52%, 55%, 58% or 60% w/w were manufactured in a Blentech twin-screw cooker (model CC-0010, Blentech Corporation, Rhonert Park, CA, USA). As the percentage moisture was increased, the relative proportions [% (w/w) dry matter (DM)] of all the other dry ingredients were maintained constant. The formulation, expressed on a DM basis (%, w/w), was as follows: 48.3% rennet casein, 21.3% Novelose 240, 15.5% rapeseed oil, 7.8% hydrogenated palm oil, 1.9% trisodium citrate, 0.9% disodium phosphate, 3% salt, 1.1% citric acid and 0.2% sorbic acid. The final moisture content of the cheeses was controlled by varying the amount of water added during manufacture. Other sources of moisture, i.e., that which is present in the dry ingredients and water arising from the steam condensing during the manufacturing stage, were consistent for all cheese batches. All imitation cheese batches were manufactured according to Montesinos et al. (2006).

A second series of cheeses with 60% (w/w) moisture was prepared using a similar manufacturing procedure, by substituting up to 100% of the hydrogenated palm oil and rapeseed oil in the above formulation with starch. This resulted in products containing 8.5%, 11.4%, 13.9%, 15.6% or 17.3% and 21.3%, 28.5%, 34.8%, 39.0% or 43.2% starch on a w/w DM basis respectively.

An ideal control sample for this latter study would be a 60% moisture cheese with 18% fat and no added starch. However, it proved impossible to manufacture cheese to this formulation using our manufacturing protocol since the matrix was unable to bind such high levels of water in the absence of starch.

2.3. Compositional analysis of imitation cheese

The fat content of imitation cheese was determined by the Gerber method (National Standards Authority of Ireland, 1955), the moisture by the oven drying method (IDF, 1958) and the protein content was determined by macro-Kjeldhal (IDF, 1993). The pH was measured by inserting a calibrated Unicam glass/Ag/AgCl combination pH electrode attached to a pH metre (model 9450, Unicam, Cambridge, UK) directly into the cheese at three randomly chosen locations after equilibration of imitation cheese to room temperature for at least 1 h.

2.4. Flow test

The method of Mounsey & O'Riordan (1999) was used to assess meltability. Cylinders (25 mm diameter, 20 mm height, 10 g ± 0.05 g weight) were cut from blocks of imitation cheese, wrapped in aluminium foil and tempered to 10 °C. The foil was then removed and the cylinders were individually placed into one end of a Pyrex glass tube (250 mm length, 30 mm diameter). The end containing the cheese was closed with a solid rubber stopper and the opposite end was plugged with a stopper pierced with a hole to allow gas to escape. The tubes were placed horizontally in a conventional oven at 180 °C for 10 min. The tubes were removed from the oven and, after 1 min at room temperature, the horizontal distance flowed (length) from a reference line was measured in millimetres using a purpose built ruler.

2.5. Texture profile analysis

Textural properties were measured with an Instron Universal Testing Machine (Instron Model 5540, Instron Corp., Canton, MA, USA) fitted with a 1 kN load cell and 35 mm diameter plates. Cylinders of cheese 20 mm high and 25 mm diameter were cut with a cheese borer, wrapped in cellophane to prevent dehydration, and allowed to equilibrate to 22 °C by placing the samples in a temperature control room (22 °C) until the desired temperature was obtained. Samples were compressed by 80% of their initial height using a 35 mm diameter plate at a crosshead speed