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The impact of sunflower and rapeseed lecithin on the rheological properties of spreadable cocoa cream

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ABSTRACT

The rheological properties of spreadable cocoa cream containing lecithin of different origins (sunflower, rapeseed and soy lecithin) were investigated within this research. A laboratory ball mill was used to produce creams containing varying amounts of lecithin (0.3, 0.5 and 0.7 wt%). The effect of milling time was also studied (between 30, 40 and 50 min).

Comparison between the different origins of lecithin revealed sunflower lecithin to be lower in viscosity than soy or rapeseed lecithin. Sunflower and rapeseed lecithins have a higher phosphatidilcholine content than soy lecithin. Increasing the lecithin concentration decreased the crystallization rate and increased the peak and conclusion temperatures in the cream fat phase. The type of lecithin used had no significant influence on the fat phase viscosity. It is found that the optimal rheological properties of spreadable cocoa cream can be achieved using 0.5 wt% of soy and rapeseed lecithin or 0.7 wt% of sunflower lecithin and 40-min milling time.

1. Introduction

Phospholipids play an important role as biochemical intermediates to aid the growth and functionality of plant cells. The common vegetable lecithin contains primarily phosphatidylcholine (PC), phosphatidylethanolamine (PE) and phosphatidylinositol (PI). It is produced commercially from oil-containing seeds, such as soy, sunflower kernels and rapeseed (Nieuwenhuyzen and Tomas, 2008). During oil processing, phospho- and glycolipids must be removed from oils in order to stabilize them against sedimentation and also to enable further refining steps (Penci et al., 2010). Lecithin is a by-product of the vegetable oil-refining process and can be defined as a mixture of acetone insoluble polar lipids and vegetable oil alongside other minor components. Commercial lecithin is

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mostly obtained from soy oil, typically containing between 0.5 and 3% of phospholipids (Doig and Diks, 2003). The functional properties of lecithin are mainly caused by a surface-active character of its phospholipids. They consist of a glycerol backbone esterified with two fatty acids and a phosphate group which may be esterified with monovalent alcohols (for example choline or ethanolamine), or polyvalent alcohols (such as glycerol or inositol) (Arnold et al., 2013). As an amphipathic molecule, lecithin has found numerous applications in the food industry, mainly as an emulsifier and stabilizer (Fernandes et al., 2012). Lecithin helps to provide a smooth texture to foods and serves as an emulsifying agent in the manufacture of chocolate, bakery products, margarines, and mayonnaise (Cabezas et al., 2009; Ramadan, 2008). One of the most traditional applications of lecithin is its use in chocolate production. Regarding its rheological properties, chocolate represents a complex dispersed matrix of sugar, cocoa particles, milk ingredients and cocoa butter (Bueschelberger, 2004). Unlike chocolate, spreadable cocoa cream does not contain cocoa butter but cheaper vegetable fats and may also contain vegetable oil to improve its spreadability. Cocoa cream ideally features good spreadability across a wide temperature range (ranging between ambient to fridge temperature), a rich creamy taste, smooth homogeneous structure with no fat-phase separation, and good oxidative stability (Pajin, 2014). Cocoa cream, much like chocolate, has a non-uniform particle size distribution and it exhibits thixotropic properties characterized by a plastic flow and yield stress (Pajin et al., 2013). In general, the addition of lecithin to oil-based suspensions causes adsorption of surface-active components on the surface of suspended particles, reducing the surface roughness. This minimizes the friction between the particles, which in turn results in both a decrease in the yield stress and viscosity until a minimum limit is reached. A further increase in the lecithin concentration adds to the yield stress but does not lead to a further reduction in viscosity (Arnold et al., 2013). Lecithin is added in relatively small amounts (0.1–2%) as an emulsifier in food formulations; these concentrations do not generally impact on the colour, odour and flavour of the product (Oke et al., 2010).

To date, no scientific literature sources have so far published any results that involve testing the physical properties of chocolate and cocoa-based confectionery products formulated from lecithin of different origins. Considering that soy lecithin is the most frequently used emulsifier in the food production, and furthermore that the widespread production of sunflower and rapeseed oil presents an opportunity to use lecithin from these sources, the aim of this study was to a) produce a variety of spreadable cocoa cream fat phase containing either sunflower or rapeseed lecithin and to then compare their crystallization kinetics and rheological behaviour with spreadable cocoa cream fat phase containing more commonly used soy lecithin and b) investigate the further impact of each lecithin type on the rheological properties of the spreadable cocoa cream, optimizing to factor both the amount of lecithin and the milling time in the laboratory ball mill simultaneously.

2. Materials and methods

2.1. Materials

The raw materials used in the spreadable cocoa cream production were a cocoa-cream mass, refined by a 3-roll mill in industrial conditions, consisting of powdered sugar (Crvenka JSC, Serbia), cocoa powder (Centroproizvod JSC, Serbia), milk powder (Imlek JSC, Serbia), and the NTFCP (non-trans fat intended for cream production) vegetable fat (Dijamant JSC, Serbia). The NTFCP fat characteristics, i.e. its fatty acid composition, solid fat content at different temperatures and thermal properties are given in our previous research (Lončarević et al., 2013). Sunflower oil (Dijamant JSC, Serbia) was used to improve the cream spreadability, while vanilla powder and hazelnut extract (VK Aromatics, Serbia) were added as flavours. The native soy, sunflower and rapeseed lecithin (Victoriaoil JSC, Serbia) were used as emulsifiers.

The composition of the spreadable cocoa cream included: powdered sugar 50 wt%, vegetable fat 24 wt%, refined sunflower oil 6 wt%, cocoa powder 7 wt%, milk powder 12 wt%, lecithin 0.3–0.7 wt%, vanilla flavour 0.06 wt% and hazelnut flavour 0.04 wt %.

2.2. Process method

Initially, the influence of different amounts of soy, sunflower and rapeseed lecithin on the crystallization and rheological properties of the cream fat phase was investigated according to the following scheme:

Fat phase of spreadable cocoa cream									
Type of lecithin	Soy lecithin - soy			Sunflower lecitin - sun			Rapeseed lecitin – rape		
Concentration (wt%)	0.3	0.5	0.7	0.3	0.5	0.7	0.3	0.5	0.7
Sample	$soy_{0.3}$	$soy_{0.5}$	$soy_{0.7}$	$sun_{0.3}$	$sun_{0.5}$	$sun_{0.7}$	$rape_{0.3}$	$rape_{0.5}$	$rape_{0.7}$

Fat and oil ratios were calculated based on the composition of the spreadable cocoa cream.

A mixture of fat and oil with lecithin was homogenized at 20 °C using a homogenizer Ultraturrax T-25 (Janke Kunkel, Germany) with a rotation speed of 6000 rpm for 5 min.

The spreadable cocoa cream samples were produced in a laboratory ball mill (Mašino Produkt, Serbia), with a capacity of 5 kg. The ball mill contains a double-jacket cylinder, 0.25 m in diameter and 0.31 m in height (0.0152 m^3 in volume), with 30 kg of water-resistant steel balls sized 9.1 mm in diameter and a vertical shaft with horizontal arms. It is equipped with a recirculation pump and a temperature control system made up of a water jacket with a temperature sensor and thermo-regulators controlled by an electric board.

The samples were prepared using different amounts of soy, sunflower and rapeseed lecithin (0.3; 0.5 and 0.7 wt%) and variable milling time (30, 40 and 50 min) for each applied concentration, as shown below: