LWT - Food Science and Technology 44 (2011) 729–736

Contents lists available at ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

Cocoa fibre and its application as a fat replacer in chocolate muffins

S. Martínez-Cervera [a], A. Salvador [a], B. Muguerza [b], L. Moulay [b], S.M. Fiszman [a,*]

[a] Instituto de Agroquímica y Tecnología de Alimentos (CSIC), Apartado de Correos 73, 46100 Burjassot (Valencia), Spain
[b] Research and Development Department, Natraceutical, Autovia A-3, Salida 343, Camí de Torrent s/n, 46930 Quart de Poblet (Valencia), Spain

ARTICLE INFO

Article history:
Received 20 November 2009
Received in revised form
30 June 2010
Accepted 30 June 2010

Keywords:
Muffins
Soluble cocoa fibre
Rheology
Texture
Descriptive sensory analysis

ABSTRACT

A study was made of the texture, composition, appearance, colour and descriptive sensory analysis of low-fat chocolate muffins in which part of the oil ingredient (25%, 50% and 75%) had been replaced by soluble cocoa fibre and full-fat (no fat replacement) control sample to which cocoa powder had been added for comparison purposes.

The rheology of the batter was studied with a rheometer. The height of the baked product fell as the fat replacement percentage rose, but no weight loss differences were observed after 1-h cooling. The texture of the fat replacement muffins showed lower values for hardness, chewiness and resilience than those of the control sample and retained greater moisture.

The chocolate colour of samples with the highest level of fat replacement was scored similar to the full-fat control formulation indicating a good colour development without adding cocoa powder. The sponginess and springiness of the samples with the lowest fat replacement were scored similar to the full-fat control formulation. In general, muffins containing cocoa fibre were increasingly more cohesive and more difficult to chew and swallow when higher level of cocoa fibre was added. A certain degree of stickiness and a bitter taste different from that of cocoa were found.

1. Introduction

In recent decades, the supply and consumption of sweet bakery products with a reduced energy content has been increasing in response to the demand for products with a lower calorie count (Sandrou & Arvanitoyannis, 2000). The rise in cardiovascular disease and obesity and in other diet-related illnesses (Cheng et al., 2009) has led to consumers taking a greater interest in the ingredients of food products and valuing those with a reduced caloric value more positively. Moreover, because of the lifestyle and habits of the population, fibre consumption continues to be below the recommended rates. An effect of the lower consumption of fruit and vegetables, pulses and other plant products in recent decades is insufficient fibre intake (Miller-Jones, 2004). Dietary reference intakes recommend the consumption of 14 g of dietary fibre per 1000 kcal, or 25 g for adult women and 38 g for adult men, based on epidemiologic studies showing protection against cardiovascular disease (Slavin, 2008).

In the field of sweet bakery products, studies have been carried out to replace part of the fat with fibres, for example: peach fibre (Grigelmo-Miguel, Carreras-Boladeras, & Martín-Belloso, 2001), inulin (Devereux, Jones, McCormack, & Hunter, 2003), corn bran fibre (Jung, Kim, & Chung, 2005), corn dextrins (Kim, Yeom, Lim, & Lim, 2001), guar gum or carboxymethyl cellulose (Kaur, Singh, & Kaur, 2000), potato pulp and pea flour (Kaack & Pedersen, 2005) or β-glucan concentrates prepared from barley and oats (Kalinga & Mishra, 2009) or soluble fibre from corn and oats (Warner & Inglett, 1997).

In other studies, part of the flour has been replaced with different types of fibre, such as potato skin (Arora & Camire, 1994), resistant starch (Baixauli, Salvador, & Fiszman, 2008), oat bran, rice bran or barley fibre fractions (Hudson, Chiu, & Knuckles, 1992; Willis, Eldridge, Beiseigel, Thomas, & Slavin, 2009) or peach fibre (Grigelmo-Miguel, Carreras-Boladeras, & Martín-Belloso,1999), among others.

Dietary fibres, produced and launched as innovative, healthy and multifunctional, are widely available; many of them are stated to have a white colour and a bland flavour. However, in a sustainable world, the interest in recovering byproducts which may be used as an alternative source of fibre should not be ignored (Moulay, Vilanova, Ibarra, & Muguerza, 2006). Cocoa husks, a waste product from the chocolate industry, are an underutilized source of dietary fibre (McKee & Latner, 2000). Cocoa husks are rich in insoluble dietary fibre as well as containing attractive quantities of antioxidant compounds (Lecumberri et al., 2007). When submitted to an enzymatic treatment, they yield a product that contains over

* Corresponding author. Tel.: +34 963900022; fax: +34 963636301.
E-mail address: sfiszman@iata.csic.es (S.M. Fiszman).

0023-6438/$ – see front matter
doi:10.1016/j.lwt.2010.06.035

40% of soluble cocoa fibre. In particular, this fibre could add a cocoa colour and flavour to bakery products, making them more attractive than the conventional product while at the same time helping to reduce the fibre intake deficit. The fibre contains high quantities of branched pectic polysaccharides, which can be used to avoid the hypercholesterolemia associated with a high atherogenic index. As part of the diet, this fibre has led to a reduction in food intake and body weight, ascribed to a satiating effect (Moulay, Ramos, et al., 2006). For this reason, it is considered of interest both for fat replacement (reducing the calorie content) and fibre enrichment in sweet bakery products and for the cocoa taste and colour it adds.

The aim of the present study is to assess the effects of a soluble cocoa fibre used as a fat replacer in chocolate muffins on (a) the properties of the batter and (b) the physical and sensory properties of the muffins.

2. Materials and methods

2.1. Chocolate muffin ingredients

The chocolate muffin ingredients were wheat flour with a 10.47 g/100 g moisture content measured by Method 44-40 (AACC International. 2000) (10.0 g/100 g protein content according to the supplier, Belenguer S.A., Valencia, Spain), sucrose (Azucarera Ebro, Madrid, Spain), pasteurized liquid egg white (Ovocity, Valencia, Spain), whole milk (Puleva, Granada, Spain), refined sunflower oil (Coosur S.A., Jaén, Spain), pasteurized liquid egg yolk (Ovocity, Valencia, Spain), sodium bicarbonate, citric acid (Martínez, Valencia, Spain), salt and soluble cocoa fibre (Natraceutical S.L, Valencia, Spain). The chemical composition of the cocoa fibre (in g/100 g on an "as is" basis) is 41.2 of the soluble dietary fibre, a negligible fraction of insoluble dietary fibre (<0.01) determined by the AOAC method 991.43 (AOAC, 1995), 17.92 g/100 g of proteins and 5.26 g/100 g of fat (data provided by the supplier). The water retention capacity (WRC) and swelling power values were 5.15 g/g and 5 ml/g, respectively.

The cocoa fibre gives the batter a cocoa colour, so powdered cocoa (cacao Toledo, Natra, Valencia, Spain, moisture 4.5 g/100 g) was added to the control sample alone for comparison purposes.

2.2. Muffin preparation

Four muffin formulations were prepared. One was used as the control (the only one with cocoa powder added) and the other three were prepared by replacing part of the oil with soluble cocoa fibre. The quantities of the ingredients that were present in all the formulations are shown in Table 1. The samples were identified as control, LFR (low-fat replacement) (11.5 soluble cocoa fibre and 34.5 oil, g/100 g flour), MFR (medium-fat replacement) (23.0 soluble cocoa fibre and 23.0 oil, g/100 g flour) and HFR (high-fat replacement) (34.5 soluble cocoa fibre and 11.5 oil, g/100 g flour). The batter was prepared in a mixer (Kenwood Major Classic, UK), in which the egg whites were whisked for 2 min at top speed. The sugar was added and mixed in for 30 s more at top speed. The egg yolk, half the milk and the citric acid were then added and the mixer was set to speed 3 for 1 min. The flour, sodium bicarbonate and cocoa fibre (or cocoa powder, depending on the formulation) was added and the batter was beaten for an additional minute at speed 3. Lastly, the mixer speed was increased to setting 4, the rest of the milk was added and the oil was gradually dripped in. The batter was beaten for 3 min at speed 4 until smooth.

Table 1
Formulation for control and low-fat replacement (LFR), medium-fat replacement (MFR), and high-fat replacement (HFR) muffins.

Ingredients (g)	Control	LFR	MFR	HFR
Flour	100	100	100	100
Egg yolk	27	27	27	27
Egg white	54	54	54	54
Milk	50	50	50	50
Sugar	100	100	100	100
Cocoa	10	0	0	0
Oil	46	34.5	23	11.5
Cocoa fibre	0	11.5	23	34.5
Bicarbonate of soda	4	4	4	4
Citric acid	3	3	3	3
Salt	1.5	1.5	1.5	1.5

The batter was poured into a dosing machine (Edhard Corp., Hackettstown, USA). With the aid of a weighing scale, the quantity of batter dispensed was adjusted to exactly 45 g in each 60 mm diameter and 36 mm high paper mould. Twelve moulds were arranged in three rows of four on a baking tray and baked for 17 min at 175 °C in a conventional electric oven (Fagor Elegance 2H-114B, Guipúzcua, Spain) that had been preheated to this temperature for 10 min. The oven, the tray and the tray position in the oven were identical in each case.

The muffins were left to cool at room temperature for 1 h on a rack in order to avoid moisture condensing on their undersurface. The 12 muffins baked on the same baking tray were packed in sets of six in two polypropylene bags (O_2 permeability at 23 °C = 1650 cm^3/m^2.day; water vapour permeability at 38 °C and 90% humidity = 9 g/m^2.day; thickness = 65 μm) and stored at 20 °C for 28 days. The measurements to study the effect of storage time were made at 0, 7, 14, 21 and 28 days from the baking date.

2.3. Properties of the batter

The specific gravity (SG) of the batter was measured as the ratio of the weight of a standard container filled with batter ($W2$) to that of the same container filled with water ($W1$) (specific gravity = 1 g/ml) as follows:

$$SG = \frac{W2}{W1}$$

For the rheological determinations, special attention was paid to maintaining samples with the same thermomechanical history before testing. Accordingly, the batters were all kept at 25 °C for 60 min after batter preparation before the rheological test. The flow properties of the muffin batters were studied using an AR G2 controlled-stress rheometer (TA Instruments, Crawley, UK) equipped with a Julaba F30-C thermostatic bath. The samples were allowed to rest in the measurement cell for a 25 min equilibration time. A 40-mm diameter plate–plate sensor geometry with a serrated surface and a 1-mm gap between the plates was employed, which was considered large enough with regard to the starch granule size (maximum size around 35 mm). A continuous ramp was applied and apparent viscosity was measured as a function of shear rate over the 0.01–100 s^{-1} range for 5 min; 100 points with a logarithmic distribution at 25 °C were recorded. Two replicates of each flow curve were run with samples prepared on different days, with good reproducibility since the differences between duplicates were less than 10%. To protect against dehydration during long measurement times, vaseline oil (Panreac, Spain) was applied to the exposed surfaces of the all samples.

All curves were adjusted to the Ostwald model following the power-law equation (Ferguson & Kembloski, 1991):

$$\eta = K\dot{\gamma}^{n-1}$$

where η is the apparent viscosity, K is the consistency index, $\dot{\gamma}$ is the shear rate and n is the flow index.