

Effect of the addition of commercial apple fibre powder on the baking and sensory properties of cookies

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Abstract

The effects of commercial apple fibre powder (0, 5, 10 and 15 % substitution of fine wheat flour) on dough characteristics, cookies physical and sensory properties were evaluated. Addition of apple fibre powder significantly altered rheological parameters of dough by increasing of water absorption, dough development time and dough stability, however mixing tolerance index was reduced. Apple fibre powder incorporation to cookies negatively affected specific volume and volume index of cookies and reduced thickness and width of products. It was also revealed that apple fibre powder addition resulted in notable decreasing lightness and increasing of redness of cookies. Sensory evaluation showed that cookies with apple fibre powder were characterised by fruity and sweet taste and fruity odour and were firmer than samples without apple fibre. Addition of apple fibre powder up to 10 % is feasible to produce sensorically acceptable cookies. In generally, it can be stated that enrichment of cookies with apple fibre powder is advantageous due to the increased nutritional value, as apple fibre is rich source of dietary fibre.

Keywords: apple, dietary fibre, farinograph, cookies, quality

Introduction

Dietary fibre (DF) as a class of compounds includes a mixture of plant carbohydrate polymers, both oligosaccharides and polysaccharides, e.g., cellulose, hemicelluloses, pectic substances, gums, resistant starch, inulin, that may be associated with lignin and other non-carbohydrate components (e.g., polyphenols, waxes, saponins, cutin, phytates, resistant protein) (Elleuch et al., 2011). Since the middle of the 1970s, the role of dietary fibre in health and nutrition has

stimulated a wide range of research activities and caught public attention (Abdul-Hamid and Luan, 2000). High DF diets are associated with the prevention, reduction and treatment of some diseases, such as diverticular and coronary heart diseases (Figuerola et al., 2005), large intestine cancer and diabetes (Nawirska and Kwaśniewska 2005). Furthermore, increased consumption of DF improves serum lipid concentrations, lowers blood pressure, improves blood glucose control in diabetes, promotes regularity, aids in weight loss, and appears to improve immune function (Anderson et al., 2009).

Baked food products are well liked by consumers all over the world. Because of their high consumption, they can potentially be used as carriers of DF (Lebesi and Tzia, 2011). Different plant fibre products are added to various baked food products in order to increase their fibre content (Masoodi et al., 2001). These products have traditionally come from cereals such as wheat, corn and oats. There is a variety of other products, however, such as fruit, vegetables, legumes, and less commonly used cereals (McKee and Latner, 2000). Apple pomace from the straight pressing, the primary by-product of the apple juice industry, is rich in cell wall material and is an interesting source of pectins (Massiot and Renard, 1997) and DF with well-balanced proportion of soluble and insoluble fibre fractions (Kohajdová et al., 2009). Apples also offer some advantages over cereal brans and legume hulls. It lacks phytic acid which renders minerals like zinc unavailable (Masoodi et al., 2002).

This work examines the proximate composition of commercial apple fibre (AF) powder accessible in Slovak local markets. Moreover, rheological characteristics of fine wheat – AF blends (0, 5, 10 and 15 %, w/w of flour substituted with apple fibre) together with an evaluation of physical properties and sensory parameters of AF enriched cookies were also determined.

Materials and methods

Materials

As a fibre source was used commercial apple fibre powder (Country life, s. r. o., Beroun, Czech Republic). Other raw material included fine wheat flour, sucrose, shortening, sodium bicarbonate and salt. All ingredients were purchased from the Slovak local market.

Chemical analysis

Moisture (oven dry method), ash (gravimetric method) and fat content (Soxhlet extraction) were determined methods described by Sowbhagya et al. (2007), protein content (as Kjeldahl

N x 6.25) was analysed according to İbanoğlu et al. (1999). Total dietary fibre (TDF) content was measured by enzymatic-gravimetric method (Sun-Waterhouse et al., 2010). Pectin compounds content was measured with the method reported by Alcantara et al. (2010).

Preparation of flour-fibre blends

Blends with 0 (control), 5, 10 and 15 % of fine wheat flour substituted with AF powder were prepared.

Rheological characteristics

Farinographic tests for fine wheat flour and various flour blends with AF powder were conducted using a Brabender farinograph (Duisburg, Germany). The following parameters were determined: water absorption capacity (WA), dough development time (DDT), dough stability (DS), mixing tolerance index (MTI) and degree of softening (DOS) after mixing dough for 12 min after reaching the optimum.

Cookies formulation

The cookies were prepared according to formula described by Tyagi et al. (2007). The control cookies formula based on flour weight was: 100 g fine wheat flour, 53 g sugar, 26.5 g shortening, 1.1 g glucose, 1.1 g sodium bicarbonate, 0.89 g sodium chloride and 12 cm³ water. The cookies were round in shape with diameter of 40 mm and thickness of 2 mm and were baked in an electric oven (Mora, Slovak Republic) at 180 °C for 8 – 9 min.

Cookies physical properties

Specific volume of cookies was determined with method reported by Shittu et al. (2007), volume index measurements were carried out according to Turabi et al. (2008). Width and thickness and spread ratio of cookies were determined according to the method described by Jia et al., (2011). Spread ratio of cookies was calculated from the formula (spread ratio = diameter/ thickness).

Colour of cookies

The colour of prepared cookies was assessed using a spectrophotometer UV-3600 series (Shimadzu, Japan). The parameters L*, a*, b* and total colour difference (ΔE^*) were determined. The L* value gives a measure of the lightness of the product colour from 100 for perfect white to 0 black, as the eye would evaluate it. The redness/greenness and yellowness/blueness were denoted by the a* and b* values respectively (Stojceska et al., 2008).

Total colour difference (ΔE^*) was determined using the equation described by Garau et al. (2007).

Sensory evaluation

Sensory attributes such as taste, odour and texture of cookies were evaluated by 11 assessors using five point hedonic scale in which a score of 1 represents the attributes most disliked and a score of 5 represents the attributes most liked. Overall acceptability of cookies was assessed using a 100 mm graphical non-structured abscissas with the description of extreme points (minimal or maximal intensity, from 0 to 100%).

Statistical analysis

All analyses were performed in triplicate and data were reported as mean \pm standard deviation. Data were assessed by analysis of variance. Duncan's multiple range test was used to separate the mean. Statistical significance was determined at $p = 0.05$. Data were analysed by the statistical software Statgraphics Plus for Windows, Version 3.1 (Statsoft –Inc., USA)

Results and Discussion

Table 1 summarises the proximate composition of fine wheat flour and AF powder applied in this study. The AF powder was characterised by a TDF content of 46.10 %. Higher TDF contents were described by Ognean et al. (2010) in the commercial AF (55 %) and Clay et al. (1996) in the apple fibre (62.20 %). Lower TDF values were reported by Romero-Lopez et al. (2011) in orange bagasse and by Grigelmo-Miguel et al. (1999) in the peach DF concentrates (30.7 – 36.1 %). Moreover AF powder was also characterised by high content of pectins (20.42 %). These results were higher in comparison to those determined by Nawirska et al. (2005) in the apple pomace (11.70 %).

Table 1. Proximate composition of apple fibre powder and wheat flour.

Sample	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	TDF (%)	Pectins (%)
Apple fibre	6.63 \pm 0.32	5.75 \pm 0.07	8.03 \pm 0.37	2.07 \pm 0.06	46.12 \pm 0.21	20.42 \pm 0.31
Fine Wheat flour	13.90 \pm 0.02	1.48 \pm 0.04	11.32 \pm 0.47	0.46 \pm 0.05	2.04 \pm 0.02	nd

nd – non detectable

Rheological characteristics reflect the dough properties during processing and the quality of the final product (Shahzadi et al., 2005; Kohajdová and Karovičová 2008). From

the farinographic measurements we concluded that addition of AF powder influenced dough properties by different ways (Table 2).

Table 2. Farinographic parameters of blend flours.

	Water absorption (%)	Dough development time (min)	Degree of softening (BU)	Dough stability (min)	Mixing tolerance index (BU)
Fine Wheat flour	58.90 ± 0.51	3.47 ± 0.13	60.16 ± 0.28	6.40 ± 0.15	35.66 ± 1.15
AF 5%	65.81 ± 0.33	4.52 ± 0.09	82.00 ± 1.74*	8.00 ± 0.82*	24.00 ± 0.30*
AF 10%	69.31 ± 0.41*	5.41 ± 0.11*	92.21 ± 0.71*	9.21 ± 0.96*	14.32 ± 1.10*
F 15%	74.54 ± 0.16*	6.40 ± 0.04*	112.00 ± 0.97*	9.30 ± 0.64*	10.12 ± 0.92*

* indicates a statistically significant differences (p = 0.05)

WA is the amount of water that the flour can absorb until the dough consistency reaches 500 BU (Brabender Units) (Hallén et al., 2004). The enhancement in AF content from 0% to 15% significantly increased the WA from 58.80 % to 74.54 %. The increasing WA may be caused by the greater number of hydroxyl group which exist in the fibre structure and allow more water interaction through hydrogen bonding (Sudha et al., 2007). DDT which represents the time required for the curve to reach its maximum height (i.e. 500 BU) (Hallén et al., 2004) significantly increased when the higher proportion (10 and 15 %) of AF were incorporated to dough. The increase in DDT indicated that higher fibre content in blends has slowed down the rate of hydration and development of gluten (Sudha et al., 2007). The DS of dough is an indicator of the strength, which higher values suggesting stronger doughs (Rossel et al., 2001). It was found that DS prolonged remarkably when 10 and 15 % of AF powder were added to dough. The same effect on the DS was observed by Nassar et al. (2008) in the citrus by-products supplemented doughs but the opposite effect was reported by Sudha et al. (2007) after addition different levels of apple pomace. As the level of AF powder increased, MTI declined significantly. Similar decrease in MTI was recorded when the citrus-by products (Nassar et al., 2008) and mango peel (Ajila et al., 2008) were incorporated in wheat flour. It was also found that increasing level of AF powder concluded in notable increasing of DOS. Similar effect was observed by Ognean et al. (2010) after adding 0-15 % of commercial AF product.

Table 3 summarises physical properties of AF supplemented cookies. It was observed that addition of AF caused significant decreasing of specific volume of samples (from 218.16 to 193.43 cm³.100g⁻¹). This effect is due to the dilution of gluten, and also could result from the interaction between gluten and fibre material (Chen et al., 1988). Replacing fine wheat flour by 15 % proportion of AF in cookies revealed a significant reduction of volume index from 1.66 to 1.44. Addition higher levels of AF (10 and 15 %) resulted in relevant decreasing thickness and width of cookies. The similar reduction in cookies thickness was also observed after addition of mango peel powder (Ajila et al., 2008) and decreasing width of cookies was described by Chen et al. (1988) and Nassar et al. (2008) in the AF and citrus by-products incorporated wheat biscuits.

Table 3. Physical parameters of AF supplemented cookies.

	Specific volume (cm ³ .100g ⁻¹)	Volume index (cm)	Thickness (T, mm)	Width (W, mm)	Spread ratio (W/T)
Control	218.16 ± 11.09	1.66 ± 0.03	5.78 ± 0.05	47.00 ± 0.08	8.13 ± 0.08
AF 5 %	210.39 ± 8.04*	1.58 ± 0.06	5.70 ± 0.04	46.60 ± 0.12	8.18 ± 0.14
AF 10 %	204.62 ± 10.63*	1.47 ± 0.07	5.51 ± 0.07*	45.20 ± 0.09*	8.20 ± 0.10
AF 15 %	193.43 ± 4.21*	1.44 ± 0.05*	5.33 ± 0.02*	44.00 ± 0.05*	8.26 ± 0.05

* indicates a statistically significant differences (p = 0.05)

Effect AF powder to cookies colour is showed in Table 4. It was concluded that AF powder supplemented cookies were notably darker (lower L* - values) and more reddish (higher a* -values) colour than the control.

Table 4. Physical parameters of AF supplemented cookies.

	L*	a*	b*	ΔE*
Control	84.67 ± 2.01	11.40 ± 0.51	28.90 ± 0.78	0
AF 5 %	73.71 ± 1.02*	14.23 ± 0.21*	28.10 ± 0.56	11.35 ± 0.53*
AF 10 %	70.23 ± 0.89*	14.29 ± 0.18*	25.39 ± 0.78*	15.13 ± 0.72*
AF 15 %	67.26 ± 0.49*	15.25 ± 0.29*	24.89 ± 0.92*	18.28 ± 0.38*

* indicates a statistically significant differences (p = 0.05)

No significant differences in yellowness were detected between control sample and cookies enriched with 5 % level of AF. On the other hand, higher levels of AF significantly

increased yellowness of cookies (lower b^* -values). The significant enhancing of total colour difference ΔE^* values of AF enriched cookies in comparison to control cookies (without AF addition) were also observed.

Sensory evaluation data of the AF powder enriched cookies are presented in Table 5. Addition of AF powder significantly decreased grain taste and odour and increased fruity and sweet taste and fruity odour of cookies.

Table 5. Sensory evaluation of AF powder enriched cookies.

	Control	AF 5%	AF 10%	AF 15%
Odour				
grain	5.00 ± 0.10	3.50 ± 0.05*	3.25 ± 0.07*	2.34 ± 0.02*
fruity	0.00 ± 0.00	1.20 ± 0.04*	1.54 ± 0.15*	1.46 ± 0.08*
Taste				
grain	5.00 ± 0.10	3.20 ± 0.01*	3.02 ± 0.11*	2.10 ± 0.03*
sweet	1.50 ± 0.14*	2.51 ± 0.02*	1.71 ± 0.06*	3.61 ± 0.02*
bitter	0.00 ± 0.00	0.20 ± 0.01	0.62 ± 0.02	1.01 ± 0.02*
fruity	0.00 ± 0.00	2.06 ± 0.04*	2.70 ± 0.01*	3.60 ± 0.22*
Structure				
firmness	1.00 ± 0.01	1.50 ± 0.01*	1.65 ± 0.03*	2.60 ± 0.11*
density	1.07 ± 0.04	1.02 ± 0.13	1.02 ± 0.01	2.30 ± 0.47*
stickiness	1.45 ± 0.01	1.55 ± 0.01	1.63 ± 0.21	1.78 ± 0.02
Overall acceptability				
	100.00 ± 0.00	98.00 ± 1.01	93.00 ± 1.07	85.00 ± 4.25*

* indicates a statistically significant differences (p = 0.05)

Similar increasing in sweet taste was observed by Wang and Thomas (1989) in the muffins enriched with apple pomace. The increasing in fruity taste was also described by Sudha et al. (2007) in the apple pomace incorporated cakes. Moreover it was reported that addition of apple pomace avoids the use of any other flavouring ingredients because has a pleasant fruity flavour (Sudha et al., 2007; Dhingra et al., 2011). No significant differences were observed between control samples and AF enriched cookies in bitter taste and texture parameters: density and stickiness of cookies. Table 5 also shows that AF powder addition exhibited significantly higher firmness values as was observed in samples without fibre addition. The same effect was also observed by several authors (Abdul-Hamid and Luan, 2000; Ajila et al., 2010; Gomez et al., 2010) after incorporation of DF rich by-products from

different sources into the bakery products. It was found that increasing the amount of AF powder reduced the overall acceptability of the cookies and the significant differences were observed between control sample and cookies containing 15 % of AF powder.

Conclusion

Bakery products are sometimes used as a vehicle for incorporation of different nutritionally rich ingredients (Hussein et al., 2011). Addition of DF to bakery products increases DF intake and decreases of the caloric density of baked goods (Gomez et al., 2003). This study confirms that the commercial AF available in Slovak markets contains more than 46 % TDF. In addition, AF powder is also good source of pectin compounds.

Dough is the intermediate products between flour and cookies and its rheological behaviour is of considerable importance in cookies manufacture as it influences the processibility and the quality of cookies (Piteira et al., 2006). Measurements rheological properties of AF substituted dough showed that AF powder addition concluded in significant increasing of WA, DDT, DOS and DS and decrease of MTL. It was also found that incorporation of AF powder modified physical properties of final products (reduction of specific volume and volume index, thickness and width). Further it was observed that addition of AF powder resulted in markedly darker colour of cookies. Garau et al. (2007) refer to limitations with respect to the use of apple pomace concentrates in very light-coloured foods due to the slightly brown hue of apple pectins caused by enzyme browning. With increasing levels of AF powder, cookies had pleasant fruity taste and odour. It may be also concluded that AF powder could be incorporated up to a 10% level in the formulation of cookies without affecting their overall acceptability.

The results indicate that AF powder a by-product from apple processing, could be considered as an alternative dietary fibre for cookies and other bakery products.

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