Application of citrus dietary fibre preparations in biscuit production

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Summary

Dietary fibre (DF) preparations prepared from citrus (orange and lemon) by-products were analysed for their chemical composition and functional properties. The studies indicated that citrus DF preparations were characterized by high crude DF contents (56.5% lemon, 63.4% orange) and low fat (5.1% lemon, 7.8% orange) and protein (6.4% lemon, 3.3% orange) contents. DF preparations had high water absorption capacity (10.59–12.13 $kg \cdot kg^{-1}$) but low fat absorption capacity (0.07–0.10 $kg \cdot kg^{-1}$). Biscuits prepared from blends with different levels (0, 5, 10, 15%) of citrus DF preparations were also evaluated for rheological properties, physical and sensory parameters. Measurements of farinographic properties showed that water absorption capacity and dough development time increased as the amount of citrus DF increased (from 58.8% to 79.1% and from 3.4 min to 7.5 min), whereas dough stability and mixing tolerance index showed a reverse trend (decrease from 6.4 min to 4.3 min and from 56.0 BU to 36.0 BU). Physical parameters, namely, specific volume, volume index, width, thickeness, spread ratio of DF-enriched biscuits were reduced with increasing level of citrus DF preparations. Sensory evaluation revealed that the most acceptable biscuits were obtained by incorporation of 5% citrus DF preparations.

Keywords

biscuits; citrus by-products; dietary fibre; farinographic properties; physical parameters; sensory evaluation

Consumers' concerns regarding healthy diet and convenience foods have significantly increased in the last decade. Nowadays, consumers are interested in the quality but also in the nutritive value and safety of the products they eat. Dietary fibre (DF) is considered as one of the food ingredients with a significant contribution to health [1]. DF refers to the part of fruit, vegetables, crops, nuts and legumes that cannot be digested by humans [2]. Principal DF sources are cell wall components (cellulose, hemicellulose, lignin and pectic substances) and non-structural components (gums and mucilages) as well as industrial additives (modified cellulose, modified pectin, commercial gums and algal polysaccharides) [3].

DF is considered a physiologically inert material, although the bulking and laxative properties of many fibre sources have long been appreciated [4]. It has been shown to play an important role in the prevention of the risks of carcinogenesis and atherosclerosis, as well as in the control and proper management of diabetes mellitus and obesity [4, 5]. DF is not only desirable for its nutritional properties, but also for its functional and technological properties [6, 7].

Fibre-rich by-products may be incorporated into food products as inexpensive non-caloric bulking agents for partial replacement of flour, fat or sugar, as enhancers of water and oil retention, and as agents improving the emulsion or oxidative stabilities [8]. Fibre in foods can change their consistency, texture, rheological behaviour and sensory characteristics of the end products [9].

In the recent years, an interest in bakery products with increased nutritional value, such as fibre-enriched products, has increased [10]. Addition of DF to bakery products increases DF intake, decreases the caloric density of baked goods [11] and prolongs freshness due to its capacity to retain water and thus reduces economic losses [8].

Nowadays, there is a need to find new sources of DF as ingredients for the food industry [12].

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For some time, the food industry has shown a special interest in finding use for citrus industry by-products. These are mainly used for animal feeding, although, due to their high fibre content, they could represent an interesting source of DF [13]. The main advantage of citrus dietary fibre from citrus fruits, when compared to other sources such as cereals, is its higher proportion of soluble DF [14]. Moreover, citrus fruits have a better quality than other sources of dietary fibres due to the presence of associated bioactive compounds (flavonoids and vitamin C) with antioxidant properties, which may exert stronger health-promoting effects than the dietary fibre itself [6].

The purpose of this study was to determine the chemical composition and functional properties of dietary fibre preparations obtained from citrus fruit residues (orange and lemon). The effects of their incorporation at different levels (0, 5, 10 and 15%) on the farinograph characteristics of fine wheat dough, physical and sensory parameters of biscuits were also determined.

MATERIALS AND METHODS

Materials

Orange, lemon, fine wheat flour and other ingredients used for biscuit preparation were purchased from lokal markets in Slovakia.

Obtaining citrus (orange and lemon) dietary fibre preparations

Orange and lemon fibre preparations were obtained by cutting of whole fruit, pressing of juice and residue chopping. Drying was carried out in a dryer (KCW 100; Premed, Marki, Poland) at 40 °C for 14 h. A grinder mill and sieves (Model 0010; Eta, Hlinsko, Czech Republic) were used to obtain a powder with a particle size of 160–270 μm.

Chemical analysis

Water content, fat and ash content were determined according to Sowbhagya et al. [15]. Nitrogen content was estimated by the Kjeldhal method and was converted to protein using a factor of 6.25 [2]. Crude dietary fibre (CDF) content of fibre preparations was determined by enzymatic-gravimetric method described by Sun-Waterhouse et al. [16]. Pectin content was determined by gravimetric method using calcium pectate [17].

Functional properties

Water holding capacity (*WHC*), water retention capacity (*WRC*) and swelling capacity (*SWC*) were measured by method reported by Raghavendra et al. [4]. The least gelation concentration (*LGC*) of fibres was determined by the method of Kaur and Singh [18]. Bulk density of fibre preparations was measured according to the method of Kaur and Singh [18] and Siddiq et al. [19]. Emulsifying properties (emulsion activity and stability, *EA* and *ES*) were determined according to the method of Siddiq et al. [19]. Fat absorption capacity (*FAC*) was measured according to the method reported by Raghavendra et al. [5].

Dough characteristics

Blends of 0, 5, 10 and 15% were prepared by substituting fine wheat flour with orange and lemon DF preparations. The effect of DF preparations on dough rheology was determined using a farinograph Model SEW (Brabender, Duisburg, Germany) according to the standard ISO 5530-1 methods [20]. Parameters measured were water absorption capacity (*WA*), dough development time (*DDT*), dough stability (*DS*) and mixing tolerance index (*MTI*).

Preparation of biscuits

The fine wheat flour used for biscuit making was characterized by 14.6% moisture, 11.73% proteins, 0.39% ash and 32.9% wet gluten. Biscuits were prepared using a slightly modified basic formula reported by Tyagi et al. [21]. Citrus DF preparations (orange and lemon) were incorporated into biscuits at 4 levels (0%, 5%, 10% and 15%, w/w) by replacing the equivalent amount of fine wheat flour of the biscuit mixture. The biscuits prepared were circular in shape with thickness of 2 mm and diameter of 40 mm. Biscuits were baked in an electrical oven (Model 524; Mora, Hlubočky-Mariánské údolí, Czech Republic) at 180 °C for 8 min, cooled for 30 min and packed in polyethylene bags.

Determination of physical parameters of biscuits

Biscuit specific volume was determined using methods described by Shittu et al. [22]. Volume index of biscuits was measured according to the method reported by Turabi et al. [23]. Width (diameter), thickness and spread ratio of biscuits were determined according to the method of Ajila et al. [24].

Spectrophotometer UV-3600 series (Shimadzu, Kyoto, Japan) was used for colour analysis of grinded and homogenised citrus DF preparations incorporated biscuits and biscuits without citrus DF preparation addition. The parameters: *L* (brightness), *a* (redness), *b* (yellowness) were evaluated. Colour difference, ΔE (taking the control biscuit colour as reference) was calculated according to equation decribed by GOMEZ et al. [11] and KANG et al. [25].

Sensory evaluation of biscuits

Sensory evaluation of biscuits with incorporated DF preparations and without them (marked as control) was carried out regarding the consumer acceptance and preference using 11 trained panelists. Taste, odour and firmness of the products were rated using a 5-point hedonic scale where 5 and 1 represent extremely like and extremely dislike, respectively. For evaluation of overall acceptance, 100 mm graphical non-structured abscissae with the description of extreme points were applied (minimal or maximal intensity, from 0 to 100%).

Statistical analysis

Samples were analysed in triplicate for each property. The results were expressed as mean ± standard deviation.

Statistical analysis, namely, analysis of variance (ANOVA) was applied to the data to determine differences ($p = 0.05$). Multiple range test – Fisher's least significant differences (*LSD*) procedure was used to describe the significance of differences between control and samples enriched with citrus DF preparations. Statgraphic Plus, Version 3.1 (Statsoft; Tulsa, Oklahoma, USA) was used as statistical analysis software.

RESULTS AND DISCUSSION

Chemical analysis of citrus DF preparations

The results of chemical composition of citrus DF preparations are presented in Tab. 1. Orange DF preparation had lower ash, water content and protein content, while higher CDF, pectin and fat contents compared to the lemon DF preparation.

Tab. 1. Composition of citrus DF preparations.

Parameters	Lemon DF preparation	Orange DF preparation
	[%]	
Water content	12.3 ± 0.3	6.0 ± 0.1
Ash	5.0 ± 0.0	2.6 ± 0.0
Fat	5.1 ± 0.1	7.8 ± 0.2
Proteins	6.4 ± 0.3	3.3 ± 0.2
Total dietary fibre	56.5 ± 0.1	63.4 ± 0.2
Pectins	21.1 ± 0.3	23.1 ± 0.1

Results are expressed as percentage on a dry matter basis.

It was stated that commercialized DF products are characterized with crude DF content higher than 50% [26]. Lemon DF preparation contained 56.5% and orange DF preparation 63.4% of CDF. These values were higher than values reported by GRIGELMO-MIGUES and MARTIN-BELLOSO [27] and ROMERO-LOPEZ et al. [28] in orange DF preparation (38.7%) and orange baggase (41.5%). Higher CDF content in citrus DF preparations might have been caused by using the whole fruit as a raw material for the preparation of citrus DF preparations. On the other hand, NASSAR et al. [29] reported higher CDF content in orange peel and pulp flours (74.9% and 70.6%) than was determined in our study.

Functional properties of citrus DF preparations

Hydration properties of DF refer to its ability to retain water within its matrix [7]. Fibre with strong hydration properties could increase stool weight and potentially slow-down the rate of nutrient absorption from the intestine [30]. Hydration properties of citrus DF preparations described by *WHC*, *WRC* and *SWC* are presented in Tab. 2. Orange DF preparation was characterized by lower *WHC*, *SWC* and higher *WRC* compared to lemon DF preparation. *WHC* represents the ability of the product to associate with water [2]. *WHC* values of citrus DF preparations determined in this study were similar to data obtained for other fruit sources such as apple-processing waste [26], orange peel and pulp [28]. Lower *WHC* values were presented by CHEN et al. [31] for wheat an oat brans (5.03 $kg \cdot kg^{-1}$ and 2.1 $kg \cdot kg^{-1}$). It was shown that orange DF preparation was characterized by twice as high *WRC* than the lemon DF preparation. The *WRC* values obtained in this study were higher than those reported by FIGUEROLA et al. [32] for orange, lemon, grapefruit and apple DF preparations (1.62–2.26 $kg \cdot kg^{-1}$). It was reported that pectin-rich DF tends to exhibit higer values of hydration properties than other fibres due to the hydrophilicity of pectin substances [33]. This study also showed that citrus DF preparations contained high amounts of pectin substances (21.1% and 23.1%). Swelling is a diffusion process, controlled by the afinity of the molecules of the swelling substance for the component molecules of the fluid [34]. Orange and lemon DF preparations exhibited higher *SWC* values (7.85 $dm^3 \cdot kg^{-1}$ and 9.25 $dm^3 \cdot kg^{-1}$, respectively) than those obtained by ROSSELL et al. [1] for fibres from chicory root, sugar beet and pea (2.32–6.6 $dm^3 \cdot kg^{-1}$).

Tab. 2. Functional properties of citrus DF preparations.

Functional parameters	Lemon DF preparation	Orange DF preparation
Water absorption capacity [kg·kg^{-1}]	12.13 ± 1.12	10.59 ± 0.22
Water retention capacity [kg·kg^{-1}]	3.23 ± 0.08	6.40 ± 1.19
Swelling capacity [dm^3·kg^{-1}]	9.25 ± 0.25	7.85 ± 0.35
Bulk density [kg·dm^{-3}]	0.48 ± 0.01	0.62 ± 0.01
Fat absorption capacity [kg·kg^{-1}]	0.07 ± 0.01	0.10 ± 0.01
Emulsifying activity [cm^3·dm^{-3}]	221.70 ± 6.10	81.80 ± 2.90
Emulsion stability [cm^3·dm^{-3}]	47.80 ± 2.40	40.90 ± 1.40

FAC is the measure of retention of fat in the food [5], hydrophobic constituents being mainly responsible for this parameter [2]. It was concluded that citrus DF preparations were characterized by low *FAC* (0.07 kg and 0.10 kg oil per kilogram fibre). Higher *FAC* values were reported by FIGUEROLA et al. [32] for various fruit DF preparations (0.60–1.52 kg oil per kilogram) and by RAGHAVENDRA et al. [5] for coconut residues (4.80 kg·kg^{-1}).

The emulsifying capacity is the abilty of the molecules to facilitate solubilization or dispersion of two immiscible liquids. Emulsifying stability is the ability to maintain the integrity of an emulsion [35]. DF preparation from lemon exhibited a significantly greater *EA* (221.70 cm^3·dm^{-3}) than the orange DF preparation (81.80 cm^3·dm^{-3}). *ES* values of both preparations were similar. The low protein contents of DF preparations would explain low *EA* and *ES* values, since most proteins are strong emulsifying agents. These observations are similar to the data reported by ABDUL-HAMIT and LUAN [36] and VIUDA-MARTOS et al. [35] for DF preparations prepared from defatted rice bran and pomegranate.

The least gelation concentration is used as the index of gelation capacity, which is a property essential for the preparation and acceptability of many foods [37]. Gelation properties observed at citrus DF preparations at different concentrations (20–200 g·dm^{-3}) in dispersions are shown in Tab. 3. It was observed that gelation generally started at 80 g·dm^{-3} concentration (orange DF preparation) and 100 g·dm^{-3} concentration (lemon DF preparation), with complete gelation observed at ≥180 g.dm^{-3}.

Farinograph characteristics of dough with DF preparations

It was reported that DF from different sources alters the rheological properties of the dough [34, 38]. Data presented in Tab. 4 show the effect of adding citrus DF preparations on the rheological properties of the dough as evaluated by a farinograph.

WA capacity of flours defines its quality and its ability to form viscoelastic dough [39]. Addition of citrus DF preparations at 10% and 15% levels significantly ($p = 0.05$) increased the *WA* from 58.8% (control) to 79.1% (15% of lemon DF preparation). Similar increase in *WA* was also observed when mango peel powder [24], orange peel and pulp [29] and extruded orange pulp [34] were incorporated into wheat flours. The increasing trend in *WA* is likely caused by the great number of hydroyl groups existing in the fibre structure, which allow more water interactions through hydrogen bonding [40].

DDT is the time from the first addition of water to the time when the dough reaches the point of greatest torque. During this phase of mixing, water hydrates the flour components and the dough is developed [41]. *DDT* increased from 3.37 min for control to 6.7 min and 7.50 min for lemon DF

Tab. 3. Least gelation concentration of citrus DF preparations.

Citrus DF preparation	Concentration of DF preparations [g·dm^{-3}]									
	20	40	60	80	100	120	140	160	180	200
Lemon	–	–	–	–	±	±	±	±	+	+
Orange	–	–	–	±	±	±	±	±	+	+

No gelling (–), complete gelling (+), or partial gelling (±).

Tab. 4. Effect of citrus DF preparations on farinographic characteristics of their blends with fine wheat.

Preparation level [%]	Water absorption capacity [%]	Dough development time [min]	Dough stability [min]	Mixing tolerance index [BU]
0	58.80 ± 2.21	3.37 ± 0.21	6.40 ± 0.04	56.00 ± 1.14
Lemon DF preparation				
5	67.61 ± 3.02	4.81 ± 0.18	6.50 ± 0.26	55.00 ± 2.51
10	73.82 ± 2.95*	5.80 ± 0.23*	6.35 ± 0.32	48.00 ± 1.67*
15	79.10 ± 1.86*	6.70 ± 0.11*	5.30 ± 0.14*	40.00 ± 1.09*
Orange DF preparation				
5	64.11 ± 2.08	3.80 ± 0.08	6.60 ± 0.27	51.00 ± 1.25
10	76.83 ± 2.45*	4.51 ± 0.22	5.51 ± 0.19*	44.00 ± 0.95*
15	76.51 ± 1.55*	7.50 ± 0.32*	4.32 ± 0.26*	36.00 ± 1.06*

* – denotes a statisticall significant difference at $p = 0.05$ level.

Tab. 5. Influence of citrus DF preparations on physical characteristics of biscuits.

Preparation level [%]	Specific volume [$cm^3 \cdot kg^{-1}$]	Volume index [cm]	Width *W* [mm]	Thickness *T* [mm]	Spread ratio *W*/*T*
0 (control)	1 998.30 ± 33.30	1.72 ± 0.05	48.00 ± 0.51	5.80 ± 0.35	8.28 ± 0.11
Lemon DF preparation					
5	1 857.50 ± 50.40	1.67 ± 0.03	45.20 ± 0.23*	5.60 ± 0.41*	8.07 ± 0.12*
10	1 802.10 ± 20.30	1.62 ± 0.08*	44.50 ± 0.12*	5.53 ± 0.14*	8.04 ± 0.21*
15	1 612.20 ± 35.30*	1.40 ± 0.04*	43.30 ± 0.18*	5.44 ± 0.28*	7.95 ± 0.23*
Orange DF preparation					
5	1 717.80 ± 21.00	1.64 ± 0.08	44.80 ± 0.17*	5.51 ± 0.25*	8.13 ± 0.32*
10	1 691.80 ± 10.50	1.58 ± 0.05*	43.70 ± 0.24*	5.42 ± 0.18*	8.05 ± 0.10*
15	1 598.60 ± 21.40*	1.39 ± 0.07*	43.10 ± 0.22*	5.40 ± 0,26*	7.98 ± 0.14*

* – denotes a statisticall significant difference at $p = 0.05$ level

preparation and orange DF preparation at level 15%, respectively. A significant increase ($p = 0.05$) in *DDT* was observed when 10% and 15% lemon and 15% orange DF preparations were added.

DS that indicates the dough strength [29] significantly decreased ($p = 0.05$) from 6.40 min to 5.51 min and from 5.32 min to 4.32 min with incorporation of 10% orange and 15% of citrus DF preparations, respectively. The increase in *DDT* and the decrease in *DS* indicated that the decrease in dough strength might have been due to the dilution of gluten proteins [24]. Recently, Ajila et al. [24] and Sudha et al. [42] also described an increase in *DDT* and decrease in *DS* in wheat flour to which mango peel powder and cereal brans were added.

MTI values increased from 35 BU to 40 BU and 36 BU (Brabender Units) for lemon and orange DF preparations at the level of 15%, respectively. Statistically significant differences ($p = 0.05$) between control sample and DF-enriched samples were recorded when 10% and 15% of DF preparations were incorporated. Nassar et al. [29] made similar observations at incorporation of different levels of citrus by-products to wheat flour. Reduction in *MTI* could be explained by the interactions between fibres and gluten [40].

Physical characteristics of biscuits

Data on the effect of citrus DF preparations on physical properties of biscuit samples are presented in Tab. 5. As the concentration of citrus DF increased from 0% to 15%, the specific volume of biscuits decreased from 1998.40 $cm^3 \cdot kg^{-1}$ to 1612.20 $cm^3 \cdot kg^{-1}$ and 1598.60 $cm^3 \cdot kg^{-1}$ for lemon and orange DF-enriched products, respectively. Significant differences ($p = 0.05$) between the control sample and DF-enriched samples were found when 15% of DF preparations were added. Similar results were obtained for biscuits supple-

Tab. 6. Influence of citrus DF preparations on the colour of biscuits.

Preparation level [%]	*L*	*a*	*b*	Δ*E*
0 (control)	84.67 ± 1.01	11.41 ± 0.08	28.89 ± 0.11	–
Lemon DF preparation				
5	84.93 ± 0.89	11.68 ± 0.12	25.35 ± 0.07	3.56 ± 0.02
10	85.02 ± 0.52	11.95 ± 0.04	32.84 ± 0.06	4.00 ± 0.03
15	85.68 ± 0.63	12.15 ± 0.09	37.26 ± 0.10	8.45 ± 0.04*
Orange DF preparation				
5	81.72 ± 1.12	13.62 ± 0.10	33.89 ± 0.15	6.21 ± 0.04*
10	79.88 ± 0.21	14.7 3± 0.05	34.82 ± 0.12	8.64 ± 0.03*
15	78.98 ± 0.34	15.03 ± 0.08	35.27 ± 0.20	8.98 ± 0.05*

* – denotes a statistically significant difference at $p = 0.05$ level.

mented with different percentages of the extruded orange pulp [34] and cakes to which apple pomace was incorporated [43]. This effect may be attributed to the interaction between fibre and gluten, which leads to a decrease in the gas retention capacity [11]. Deleterious effect of orange DF preparation on specific volume of biscuits was greater than that of the lemon DF preparation. This effect may be related to a higher content of CDF in this preparation. It was also determined that volume index of biscuits decreased significantly ($p = 0.05$) with the addition of higher amounts of citrus DF preparations (10% and 15%).

Incorporation of citrus DF preparations at different levels significantly decreased ($p = 0.05$) the width and thickness of biscuits (Tab. 5). Recently, AJILA et al. [24] also reported a decrease in the diameter and thickness of biscuits upon the addition of mango peel powder. These authors stated that the decrease in these physical parameters may be due to the dilution of gluten. The changes in width and thickness are significantly ($p = 0.05$) reflected in the spread ratio, which was 8.28 for control biscuits and these values was decreased from 8.13 to 7.98 in orange DF preparation and from 8.07 to 7.95 in lemon DF preparation. Earlier study of NASSAR et al. [29] also showed that the increasing proportion of orange peel and pulp caused a decreasing spread ratio of biscuits.

Tab. 6 presents colour parameters for biscuits enriched with citrus DF preparations. Colour of these biscuits became slightly darker (reflected by lower *L* values), barely reddish (higher *a* values) and slightly yellowish (higher *b* values). On the other hand, no significant differences ($p = 0.05$) in *L*, *a* and *b* values were found between control samples and samples enriched with citrus DF preparations. The colour difference Δ*E* shows the

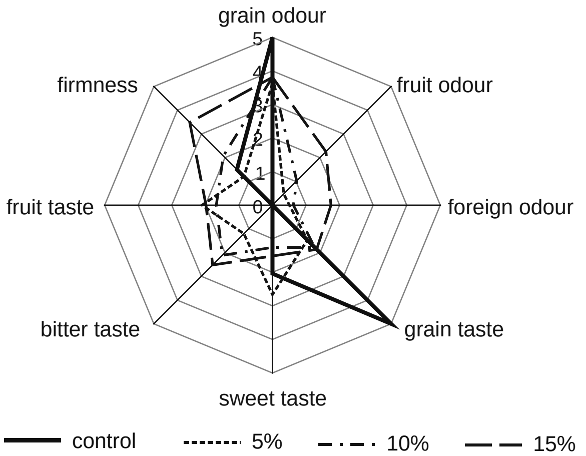

Fig. 1. Sensory parameters of biscuits enriched with orange DF preparation.

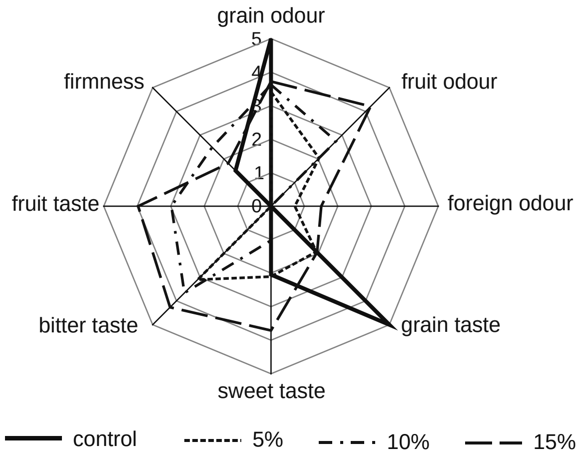

Fig. 2. Sensory parameters of biscuits enriched with lemon DF preparation.

influence of citrus DF preparations on the biscuits colour. Remarkable differences ($p = 0.05$) between control biscuits and DF-enriched biscuits were noticed when 15% of orange and various levels of lemon DF preparations were added.

Sensory evaluation of biscuits

Enrichment with DF not only influences the overall properties, but also significantly affects the sensory properties of the product [7]. Fig. 1 (orange) and Fig. 2 (lemon) show sensory parameters of biscuits supplemented with citrus DF preparations. Addition of citrus DF preparations significantly influenced ($p = 0.05$) grain odour and taste of biscuits, while no remarkable differences ($p = 0.05$) were found between control sample and DF-enriched biscuits in sweet taste. Incorporation of citrus DF preparations at 15% levels significantly ($p = 0.05$) increased bitter taste, as well as fruit odour and taste of biscuits. Higher proportions of citrus DF preparations (10% and 15%) in biscuits also markedly increased ($p = 0.05$) foreign odour of biscuits. Additionally it was found that high levels of astringent compounds present in citrus peel make it unsuitable for human consumption [28]. From sensory evaluation it can be also concluded that biscuits enriched with lemon DF preparation were characterized by higher intensity of fruit taste and odour, and bitter taste than was observed at biscuits with orange DF preparation. Moreover it was found that the biscuits with 15% level of citrus DF preparations became significantly ($p = 0.05$) harder compared to control biscuits. This may be due to a relatively higher water content in DF-enriched doughs. Doughs with a higher water content produce an extensive gluten structure that results in harder biscuits [24].

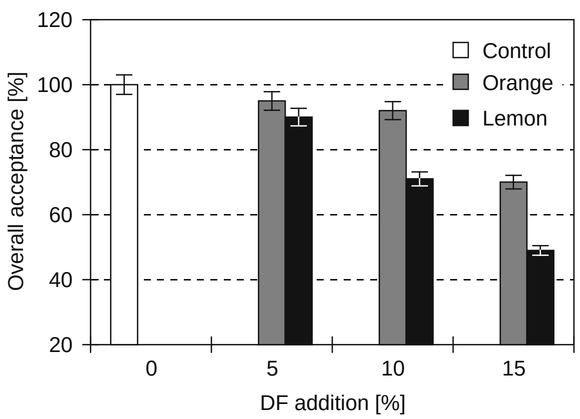

Fig. 3. Overall acceptance of biscuits enriched with citrus DF preparations.

With the increase in the citrus DF level in the formulation, the overall acceptance of biscuits decreased (Fig. 3). The same effect was also observed by SUDHA et al. [43] and NASSAR et al. [29] in the apple pomace-enriched cakes and in biscuits supplemented with citrus by-products. Significant ($p = 0.05$) reduction in the overall acceptance of biscuits was observed when 10% lemon, and 15% lemon or orange DF preparations were added.

CONCLUSION

DF from several sources increases the nutritional value of food but usually also alters the rheological properties of the dough, which affects the quality and sensory properties of end products [34]. The suitability of citrus by-products (orange and lemon) as a source of DF for biscuits making was investigated in this study.

Chemical analysis of citrus DF preparations showed that they are a good source of CDF and pectins. Additionaly, citrus DF preparations were characterized by higher water absorption and swelling capacities. On the other hand, their fat absorption capacities were low. Moreover, the emulsifying activity of the lemon DF preparation was high. The addition of citrus DF preparations to fine wheat flour modified the farinographic properties of the dough in different ways mainly when higher proportions of DF preparations were incorporated in the dough (increase in *WA* and *DDT*, reduction of *DS* and *MTI*). It was also stated that incorporation of citrus DF preparations to fine wheat flour negatively influenced physical properties, namely, specific volume, volume index, width, thickness and spread ratio. Nevertheless, some additives, such as vital gluten or oxidizing and emulsifying agents, would be added to counteract the unwanted effect of fibre addition on the dough handling characteristics and volume reduction [11]. Results of sensory evaluation suggested that citrus DF preparations can be added into biscuits at a replacement level of 5% without large adverse effects on biscuit quality. Biscuits with greater addition of citrus DF preparations (10% and 15%) are otherwise richer in biologically active components such as DF, but their physical and sensory properties may become worse. Finally, it could be concluded that citrus DF preparations may be considered a potential functional ingredient in biscuits and other sweet bakery products such as cakes and muffins.

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