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The effects of fibers and proteins addition on biscuits characteristics

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Abstract
Regular biscuits have a high energetic density due high concentration of carbohydrates, sugars and fats. The consumers demand products with lower sugars and fat content, and high content of protein and fibres. We investigated the effect of sugar replacement with inulin and the effect of supplementation with protein. All added ingredients reduced the height of biscuits and decrease the specific volume. Replacement of sugars with inulin increased the resistance and the sweetness and pea protein addition lead to the most fragile biscuits. Protein addition negatively affected the taste and sweetness of biscuits. Inulin had a sweet taste, they increased the sweetness of biscuits when added to recipe but didn't compensate replacement of sugar. By removing the sugars from the formulation the fat content of biscuits increased. The colour of biscuits was affected through addition of inulin and pea proteins but was more dependent to the moisture of dough or final biscuits.
Key words: inulin, pea protein, sensory atributes

1. Introduction

Biscuits are convenient foods consumed mainly highly consumed worldwide [1-3] as small snacks between the main meals. They could be found in different formulation being manufactured in a large array of assortments. They could be sweet or savoury, simple or with cream. Biscuits are characterised by a small content of moisture which allows them to be stored for a long period of time and to be easily transported by consumers [4]. Also, they are characterised as having a very big energy density due the large amount of carbohydrates, sugars and fats. The modern style of life favours food product which come in small portion and could be consumed easily, providing very quick energy and appeasing hunger. Biscuits are very good candidate for that. lately it was observed that the consumption of biscuits increased while the consumption of bread decreased. This shows that biscuits are food products which are current and largely consumed. This could be observed from a market report; the market value of biscuits represented 14.98% of all (bread and bread products) while the total volume, expressed in Mt, represent just 11.57% of total [5]. The biscuits market had the second largest growth rate surpassed only by baking ingredients and mixes.

Many consumers and nutritionist are concerned about the nutritional value of biscuits, usually they have a high energy density, content high amounts of carbohydrates, sugars and fats [3]. They contain small amounts of fibres and proteins, having a high Glycaemic Index (GI). The fats used for their preparation are solid fats, with a high content of saturates fatty acid (SFA) and could contain trans fatty acid [6, 7]. The consumers are more and more concerned about their health and try to make healthier choices about the food consumed [8, 9]. The industry follows this current and improves and updates

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existing products and develops new ones. In 2021 the higher increase of health claims are ”High/Source of fibre” and ”High/source of protein” [5]. Obtaining healthy biscuits, with a reduce content of sugars, is a big challenge due their sensorial and technological importance [10-12]. Several strategies were suggested and investigated, one of them is replacement of sucrose with a combination of high intensity sweeteners combined with poliols or fibres [13]. Another option is the use of inulin as sweetener and a source of valuable fibre [14-17]. Inulin has prebiotic effects but also could act as fat replacer and texture enhancer [14, 18-21].

Another popular option of consumers is foods with high protein content. Protein content of biscuits is low (7-10%) because the wheat flour contain regular use for biscuit manufacturing contains about 7% [2, 3] and other sources of proteins are added in small amounts. Protein sustains the growth of muscular mass, sustain the health of bones, they are a popular choice in diets for reducing the body mass [2, 22, 23]. The effect of protein on the biscuits characteristics is unclear and must be investigated [24]. The quantity and quality of proteins is a major aspect in fortification because of their influence on subject's health [23]. The proteins of cereals have deficiencies in some amino acids like lysine [15]. For a proper fortification should be chosen proteins able to equilibrate the composition of amino acids, proteins for legume are very good candidates having a high amount of lysine and other essential amino acids [25, 26]. Pea is a valuable source of protein [27].

The aim of this work is to investigate the effects of inulin and pea protein on characteristics of biscuits in effort to obtain biscuits with low sugar and high protein and fibre content.

2. Material and methods

Black wheat flour (Moara Cibin) was used in the effort to improve the nutritional value of biscuits. We used for formulation palm oil (Kallas), sugar (Agrana), glucose-fructose syrup (GFS) (Kallas), soy lecithin (Solina), pea protein (EDR Ingredients), inulin (Brentag).

The samples were prepared according to the recipes from the table 1. In sample 1 we added inulin to investigate its effects, in sample 2 we replaced the sucrose with inulin, and we reduced the amount of glucose-fructose syrup and in sample 3 we added pea proteins. All other ingredients were kept constant.

Table 1. Recipes of samples

INGREDIENTS	Control	Sample 2	Sample 3	Sample 4
Wheat flour type 1200	100	100	100	100
Palm oil	15.6	15.6	15.6	15.6
Sugar	15.2	15.2	-	-
Inulin	-	6.7	13.5	13.5
Pea Proteins	-	-	-	13.5
Glucose-Fructose Syrup	10	10	3	3
Lecithin	2	2	2	2
$NaHCO_3$	1	1	1	1
$(NH_4)HCO3$	1	1	1	1
NaCl	0.5	0.5	0.5	0.5
Water	17	17	17	17

The dough was prepared in the lab using a lab scale planetary mixer, in a manner similar with industrial one and the dough was mechanically processed and baked on industrial machines.

The sensory evaluation was done by a trained team consisting in 10 persons (2 male, 8 female) using a hedonic scale with 9 points (1 extremely unpleasant, 5 neither unpleasant, neither pleasant and 9 extremely pleasant). Overall aspects, smell, texture, taste and flavour, sweetness and after taste were evaluated.

Colour was evaluated using the L*a*b scale using a Colorimeter Agera as described by Mieszkowska [15]. The dimensions were measured a calliper and expressed as average of ten measurement. Moisture of doughs and biscuits was determined by drying for 40 min ant 130°C. pH of samples was measured on a 10% w/v suspension of biscuits in water, at 20°C (Thermo Orion 2 Star pH meter). The glucose content and total sugars were determined using the Luff-Schorl method (STAS 1227/3-90). The fat content was

measured by extraction with petroleum ether with a semiautomatic installation (Velp Scientifica SER 148/3).

3. Results and Discussion

3.1. Sensory attributes

In Figure 1 are presented the obtained biscuits for comparison. All stacks contained 10 biscuits. Could be observed that the control biscuits had the bigger height while other samples had similar height. The colour of sample 2 was the darkest while the sample 3 (with almost no sugar added) was the lightest. The sample 4 had a greyish tone.

Figure 1. Biscuit sample

In figure 2 is presented the scores obtained by biscuits sampling during the sensory evaluation. On the left are presented the scores obtained by samples for each sensory aspect evaluated, in the right are presented the total number of points accumulated by each sample. Could be observed, from both graphics, that the control sample and sample 1 are very similar evaluated. By adding inulin all aspects of biscuits were improved. The colour was not for evaluated. The highest difference was observed the sweetness, inulin fibre increased the sweet taste of samples. By replacing sugars with inulin the overall aspects was improved but all other aspects were negatively affected. The sweetness was the most affected, inulin was not able to recreate the sweet taste of sugar and GFS. When pea proteins are added at low sugar formula the sensory attributes decreased even more. The taste, sweetness and after taste were the mst affected by protein addition.

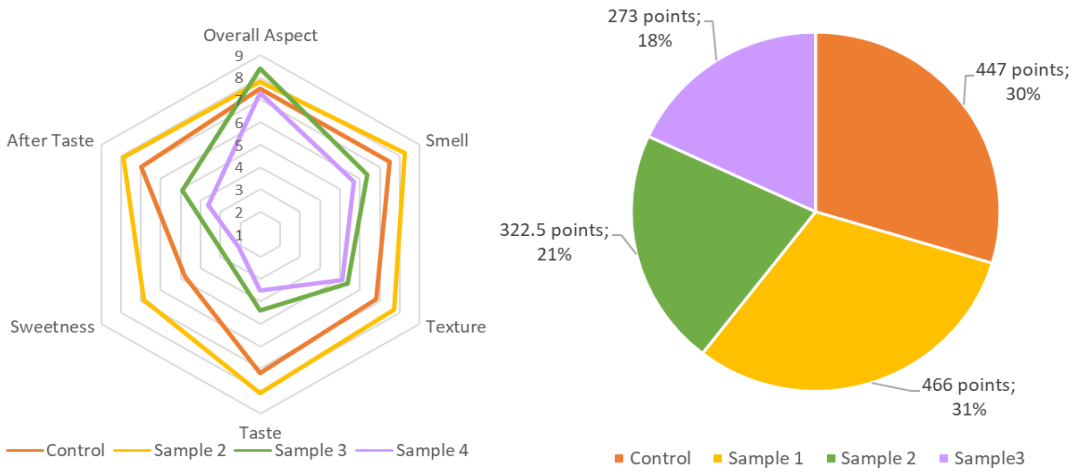

Figure 2. Sensory attributes of biscuits prepared with inulin fibre and pea protein

The sensory panel observed that the control sample had a pleasant aspect and colour, little floury with a moderate resistance at bite. When inulin was added the colour become darker, uneven and the biscuit become fatty and tender, with a very good imprinted pattern which confirmed that inulin could mimic the fats in food products [11, 15]. When sugar was removed totally and replaced with inulin the colour was lighter due the reduction of

reducing sugars able to produce melanoidins but remains pleasant. The biscuit became stronger (the hardest sample) and at mastication formed a gluey and viscous mass and developed a slightly unidentifiable taste. Visible cracks appear when pea proteins were added, it broke easily, became fragile. The biscuits did not opposite resistance at bite, it was gluey and tender at mastication and a strange unidentified taste appeared.

3.2. Colour of biscuits

In Figure 3 are presented the colours of biscuits, expressed in CIELAB system. The figures confirmed that the lighter sample was Sample 3 (with pea protein, inulin and no sugar). This sample shown smallest numbers in terms of redness and yellowness. The darker sample was the sample with sugar and inulin added and had the highest a number and lowest b number. The sample 2 was more yellow than other samples. The biggest difference of colour (ΔL) was observed at sample 3 and smallest at sample. This numbers showed that the inulin addition enhanced the colour biscuits, biscuits became darker, and inulin could replace in some formulation sugars for keeping the characteristic colour. Pea protein did not darken the biscuit colour, probably it did not contain free amino acids and peptides able to form melanoidins.

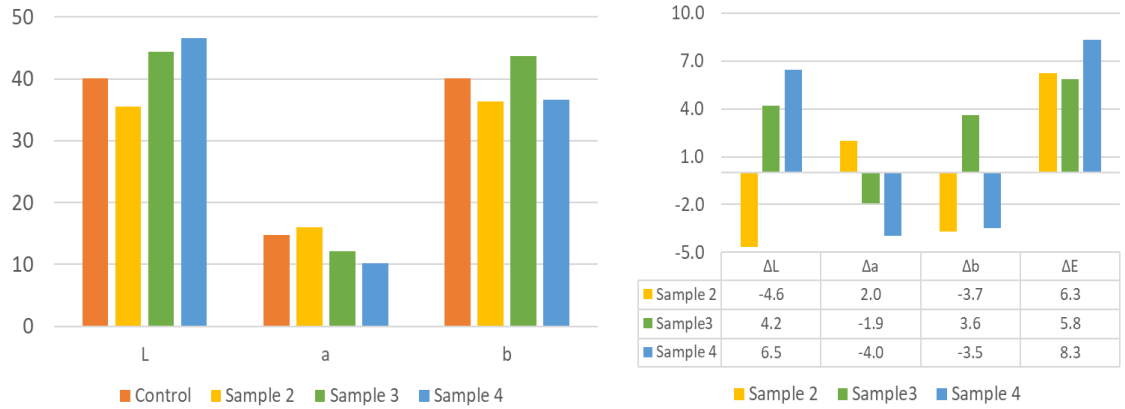

Figure 3. Colour of biscuits (colour in L*a*b system on left; colour differences on right)

3.3. Physical characteristics of biscuits

In table 2 are presented the geometrical dimension of biscuit, average mass and specific volume. The physical characteristics of biscuits are very important because there are sold in specific package, with exact dimensions. If the biscuits are to big they will not fit in the package or if they are to small empty space will remain in package. Their weight is also very important. All biscuits were mechanical processed in the same machine. The biscuits are hard biscuits, laminated and stamped. The geometrical differences will reflect how the dough respond to shaping and how behave during baking [28]. They have the tendency to reduce this ileir length due the dough elasticity and to increase their length and width due gas formation during baking. The biscuits had rectangular shape. The sample 2 showed a small increase of length while the width was smaller than control sample. In dough accumulate tension because the unidirectional lamination. In sample 2 inulin acts as fats and the dough was more plastic and less elastic, the shrinkage was smaller. In samples 3 and 4 sugars was removed, the moisture of dough was higher (Table 3), gluten developed better and dough became more elastic and shrunk more after cutting.

Table 2. Physical characteristics of biscuits

	Length, mm	Width, mm	Height	L/W	Weight, g/pcs.	Specific volume, mL/g
Control	56.1	52.0	6.9	1.08	7.76	2.59
Sample 2	57.0	50.7	5.7	1.13	7.17	2.28
Sample 3	52.7	49.0	5.5	1.08	7.24	1.96
Sample 4	54.8	49.0	5.6	1.12	6.83	2.20

Tabel 3. Chemical composition of biscuits

	Dough moisture %	Biscuit moisture %	pH	Total sugars %	Fat %
Control	22.6	6.3	7.5	11.6	12.91
Sample 2	21.7	4.0	6.9	15	12.72
Sample 3	25.3	6.0	7.75	16.4	13.59
Sample 4	28.5	7.6	7.45	8.6	14.23

Pea protein did not strengthen the gluten and even made the dough more plastic because the shrinkage was smallest despite higher moisture of dough. During the baking process biscuits increases their dimensions due gas formation but the final dimensions depend on the dough characteristics. The control sample and sample 2 spread more than other samples. This was observed by looking at the width of biscuits. The widest sample was control and narrowest were samples 3 and 4. The squareness of biscuits is evaluated by the ratio between length and width. The control sample and sample 3 were similar because they spread similarly at baking but the spreading of sample 3 was smaller, the length and width were smaller than control. The bigger height oh biscuit was observed for control, the others shown similar height. Probably the gluten was weakened through addition of inulin and pea protein and retained les gases during baking. The final weight of biscuits depends on the density of dough. The lamination and cutting were similar for all samples, the dough pieces cut had the same volume. The biggest weight was observed for control. That shown that the dough had higher density and that explain to the largest height after baking and a good correlation was observed between the height and weight of biscuits (R^2=0.7495). The control shown the biggest specific volume (lighter biscuits), explained by biggest height. This shown that the density of dough at lamination and cutting will affect dimension and density of final product.

3.3.Chemical composition

After baking the highest moisture was observed at sample 4, which had the highest dough moisture too. The sample 2 had the lowest final moisture and that could explain the darker colour of biscuits while the lightest sample had the highest moisture. The moisture is lost during baking. The sample 2 had the dough with the lowest moisture and water was lost fast during the baking and after that the received heat increased the biscuit temperature and more colour was formed. A good corelation (R^2=0.8181) was observed between the lightness of samples and their moisture. Even a better corelation (R^2=0.8759) was observed between the dough moisture and biscuits lightness.

Sample 1 contained inulin added to regular amount of sugars and the content of total sugars increased. This shows that the inulin had a high concentration of oligosaccharides with low degree of polymerisation or the inulin are sensitive to baking conditions and chemical method for determination and in some steps inulin were hydrolysed. In sample 2 the content of total sugars was higher than in sample 1, due the more concentrated dough through removing the sugars. In sample 3 the total sugar decreased by adding proteins which diluted the sugars in dough and final biscuits. These results showed that chemical methods for sugar determination are not very well fitted for determination of sugar content in food with added inulin. The fat content of biscuits is affected by formulation, when fibres and proteins were added the fat content decreased and when sugars were removed the fat content increased.

4. Conclusions

The process of food reformulation brings many challenges. Improving nutritive value of biscuits is done by addition or replacement of regular ingredients with others, healthier. These additions/replacements will modify the characteristics of final products and research are done to understand how they will work. Addition of inulin will increase the sweetness of biscuits but replacement of sugars with inulin will not provide enough sweetness. The addition of proteins will increase the protein content required by some consumers and will equilibrate de amino acid composition but will affect the aspects and taste of biscuits. The inulin and protein addition developed an after taste and made biscuits more tender. The colour of biscuits could be influenced through

inulin and fibre addition, but biscuit colour seemed to be more dependent to dough moisture. The dimensions and geometry of biscuits is affected by inulin and protein addition. The doughs with inulin and pea proteins seems to be less elastic and remained more rectangular but this property of dough could be also influenced by dough moisture. Inulin addition will influence the content of total sugars, but more research should be done to develop a more suitable chemical method for sugar determination in samples with added inulin.

Compliance with ethics requirements

Authors declare that we respected the journal's ethics requirements. Authors declare that we have no conflict of interest and no procedure involving human and/or animal subjects was used in research. Authors declare that we present our own literature survey and results/ discussion/conclusion in the article.

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