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Evaluation of the effect of replacing shortening for sesame paste (*Sesamum indicum*) in nixtamalized maize cookies

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Abstract

Cookies are products highly consumed around the world, with time, consumers are demanding products with higher nutritional value and that are focused on current market trends. The objective of this work was to evaluate the effect of substituting vegetable shortening for sesame paste (*Sesamum indicum*) in nixtamalized maize flour cookies to obtain a product with high nutritional quality and gluten-free to be suitable for the consumption of people with celiac disease. A total of five treatments were evaluated, alternating the sesame seed paste and vegetable shortening ratio 100:0 (T1), 75:25 (T2), 50:50 (T3), 25:75 (T4) and 0:100 (T5), respectively. Spread factor, protein content, fat content, ash content, colour and texture (fracturability and hardness) on days 0, 2 and 7 were analyzed. Significant differences were found between T3, T4 and T5 in spread factor value, T5 with the highest value. T5 cookies had 56% protein content. There was no significant difference between ash and raw fat. In colour, T2 presented the biggest L* value, in difference against T1, T3 and T5. In a* value, T1 and T5 are the ones with the biggest value (12.58), T1 and T3 have no difference and the lowest value is reported in T2 and T4 (8.96). In b* value, T2, T4 and T5 treatments had the highest value (31.70) while T2, T4 and T1 did not present any difference with T3. On day 0, fracturability and hardness only T3 is higher compared to other treatments. On days 2 and 7, the difference is increasing, with being T3 the one with the highest value and T5 with the lowest value. By substituting vegetable shortening for sesame seed paste in cornmeal cookies in 100% (T5), protein percentage was higher and a lower value in fat percentage. Likewise, it was concluded that substitution of vegetable shortening for sesame seed paste can produce a cookie with better nutritional value (higher protein and lower fat content) and with favourable physical characteristics such as less hardness, less fracturability and less spread factor.

1. Introduction

Cookies are consumed throughout the world for their nutritional value and also can be stored for longer durations. Cookies are a very significant part of the food industry in most countries of the world. Their success can be attributed to at least three key factors: relatively long shelf life, great convenience as a food product, and relatively good value for money. Cookies are defined as baked products based on flour, vegetable shortening, sugar and eggs. Besides these basic ingredients, cookies can have other ingredients making them very variable (Manley, 2011; Chavan *et al.,* 2016). Cookie formulations have evolved due to a gluten-free market trend causing several new developments using different flours such as nixtamalized maize flour. (Pérez-Carrillo *et al.,* 2017; De la Rosa-Milan *et al.,* 2017) On the other hand, fat is one of the most important ingredients in biscuits. It adds structure, eating quality and flavour to the product (Atkinson, 2011). Several studies have been conducted on different cookie formulations to reduce fat content, like toasted watermelon seed meal, polydextrose, and resistant starch (Peter-Ikechukwu *et al.,* 2018; Moriano *et al.,* 2018; Longoria-García *et al.* 2020).

The functional and health benefits of sesame seeds (*Sesamum indicum*) have been well studied. The sesame seed contains high nutritional qualities that allow the study of the grain and new derived products since it is a great source of energy and protein because it contains 17 -23% of crude protein with a large amount of

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methionine, classified as an essential amino acid. In addition, it contains 42-50% lipids, which are 80% polyunsaturated, where linoleic acid stands out and in a lesser amount alpha-linolenic acid (omega 6 and 3) respectively, which have been highly valued for their benefits that prevent the accumulation of blood clots responsible for many cardiovascular accidents. Likewise, it has values of 4 - 7% of ash, mainly calcium with 98%, however, it has the presence of iron, magnesium and zinc, which makes it a functional food (Hernández-Monzón *et al.,* 2015). Sesame seeds could be processed by roasting, dehulling and grinding. Generally, roasted seeds are used for oil production, whereas the grinding process generates sesame seeds for sprinkling (Hanm and Kuei, 2015). Sesame paste made of roasted sesame seeds is widely popular in East Asian and Middle Eastern countries, used as the spread on steamed bread, the dressing, as an ingredient in food or as a base for developing a new creamy product. Sesame paste is a kind of colloidal suspension with hydrophilic solids suspended in sesame oil, behaving as non-Newtonian pseudo-plastic foodstuff (Hou *et al.,* 2018). The objective of this work was to evaluate the effect of substituting vegetable shortening for sesame paste (*Sesamum indicum*) in nixtamalized maize flour cookies to obtain a product with high nutritional quality and gluten-free to be suitable for the consumption of people with celiac disease.

2. Materials and methods

2.1 Cookies preparation

Nixtamalized maize flour (100 g), baking soda (1.5 g), salt (1.0 g), and SSL (0.2 g) and were placed in a bowl for 3 mins at low speed. In another bowl, whole egg (50 g), lecithin (0.3 g) and vanilla (0.5 g) and water (30 g) were incorporated and mixed for 5 mins. Subsequently, brown sugar (40 g), and 20 g of shortening and sesame paste mix 100: 0 (T1), 75:25 (T2), 50:50 (T3), 25:75 (T4) and 0: 100 (T5) were creaming and dry and liquids mixtures were added in order to achieve a homogeneous dough. The dough obtained was left to stand and cool for 30 mins. Subsequently, the dough was sheeted into 3.0 cm and cut with circular moulds of 6.5 cm in diameter, after cutting they were left to rest on a baking tray for 10 mins and then placed in the oven at a temperature of 190°C for 14 mins or until the edges brown. They were allowed to cool for 10 mins and packed.

2.2 Physical characterization

The L*, a* and b* colour parameters for the different cookie treatments were obtained with a colourimeter (CR -300 Series, Minolta, Japan). This test was performed in triplicate for each of the five treatments studied. The value of the spread factor is the parameter that indicates how much the cookie expands when baked and was calculated through the relationship of the diameter divided by the thickness of the cookies individually, according to the method 10-50.05 (AACC, 2000b).

2.3 Chemical composition

Crude protein is done by micro-Kjeldahl according to Method 46-13.01 (AACC, 2000d). Briefly, 0.1 g of dried sample milled were mixed with digestion salt and Sulphuric Acid, after digestion steam was distilled using a Hydroxide Sodium solution. The steam obtained from distillation was then titrated with 0.02 N hydrochloric acid. Crude fat was done using a Goldfish system with petroleum ether for 4 hours of reflux, and ashes were determined according to 30-20.01, 08-01.01, respectively Methods AACC (2000a, 2000c).

2.4 Textural shelf life

The texture of the cookies was done according to de la Rosa-Milan *et al*. (2017) with slight modification using a TA.XT2 texture analyzer (Stable Micro Systems Ltd, Surrey, UK), with a 3 mm diameter cylinder accessory. The test speed was 1 mm/s and during the test the cylinder was lowered 5 mm to make contact with the biscuit, obtaining the hardness (positive area) and fracturing (peak positive force). Five tests were carried out for each of the 5 treatments studied. Likewise, the same test was carried out for days 0, 2 and 7, to know the changes in texture during the storage times in each treatment.

2.5 Statistical analysis

Statistical analysis was performed using the MINITAB 16 software platform, generating the ANOVA to determine if there were significant differences between the five treatments studied. Subsequently, the Tukey test was used to classify into groups if they are significantly different ($p<0.05$).

3. Results and discussion

Table 1 shows the physical and chemical characterization of nixtamalized maize cookies. Sesame paste substitution did not have an effect on the spread factor in cookies without sesame paste (T1). This could be explained due to sesame paste behaved in the same way as gel-like structured material in which the storage modulus was greater than the loss modulus (Hou *et al.,* 2018). However, T5 had a lower spread factor than T3 and T4. The cookie spread factor is related to the viscosity of dough that is affected by protein content in the dough. In Table 1 is observed that T5 had the highest

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Table 1. Effect of shortening: sesame paste substitution 100:0 (T1), 75:25 (T2), 50:50 (T3), 25:75 (T4) and 0:100 (T5) on spread factor, colour, and content of protein, fat and ash in nixtamalized maize cookies.

Treatment	Spread Factor	Crude Protein (% dw)	Crude Fat (% dw)	Ashes (% dw)	Colour		
					L*	a*	b*
T1	5.98^{AB}	1.13^{C}	7.82^{AB}	2.12	60.08^{BC}	11.33^{AB}	30.24^{BC}
T2	5.59^{AB}	1.32^{BC}	11.80^{AB}	1.99	62.46^{A}	8.96^{C}	30.89^{AB}
T3	6.36^{A}	1.44^{B}	15.09^{A}	2.16	60.35^{BC}	10.69^{B}	29.00^{C}
T4	6.23^{A}	1.52^{B}	5.53^{AB}	2.37	61.54^{AB}	9.211^{C}	30.69^{AB}
T5	5.14^{B}	1.77^{A}	2.89^{B}	2.42	59.16^{C}	12.58^{A}	31.70^{A}

Mean values with the different superscript within the same column are significantly different (P<0.05). dw, dry weight.

crude protein content. According to Pareyt *et al.* (2008), the spread factor has a negative correlation with the rate of gluten and the diameter of the cookies decreases with the increase in the rate of gluten or protein. In the case of colour parameters, T1 values are similar to those reported by Perez-Carrillo *et al.* (2017) for nixtamalized maize cookies. In the L* parameter, significant differences were found between T2 and T4 with respect to T5. Only T2 is different to T1. For a* parameter in colour, T1 did not show a difference with respect to T3 and T5. The lowest a* was reported for T2 and T4. In a study carried out by Goldstein and Seetharaman (2011), when comparing different cookies with different types of fat, it was also found that the value of a* was for the cookie with shortening. It can be concluded that the higher the proportion of shortening, the greater the value of a*. In the parameter of b* in colour, statistically significant differences were found between T5 against T3 and T1, as well as a difference between T3 against T2, T4 and T5. T5 is the highest value and T3 is the lowest value. As can be seen in Table 2 of the results, the values of b* were not so variable among themselves. The substitution of vegetable shortening for sesame paste does not have a great impact on the value of b*. In the case of T5, without shortening this could be explained by the presence of phenolics compounds in sesame paste that are associated with an increase in colour (Alves de Magalhães *et al.,* 2020)

The content of protein increases according to the sesame paste substitution level increase (Table 1). The highest protein content is observed in cookies T5, 56.64% higher than T1. This is due to the difference in protein that can be found in sesame paste compared to vegetable shortening. According to information from Atkinson (2011), vegetable shortening has a protein value of 0%, while sesame paste has a value of 17-23% (Akbulut and Çoklar, 2008; Hou *et al.*, 2018). The proteins contained in sesame seeds are primarily storage proteins. Based on their solubility, they are classified mainly as globulins with the amount of 67.3% (Kotecka-Majchrzak *et al.* 2020). In the crude fat percentage results, a noticeable decrease in the value the less shortening the cookie contains. However, only samples T3 and T5 showed a statistically significant difference between them. This difference in the fat percentage values may be due to the composition of the vegetable shortening and that of the sesame paste. According to Atkinson (2011), vegetable shortening contains 99.9% crude fat with 24% of this fat being saturated and 41% monounsaturated while sesame paste contains 53-55% crude fat (Akbulut and Çoklar, 2008; Hou *et al.,* 2018) being 7% saturated and 28% monounsaturated, in addition to 28% polyunsaturated. Sesame crude fat contains lignans (sesamin, sesaminol, sesamol and sesamolin) that have antioxidative properties and phytosterols, which are associated with reducing cholesterol levels in the blood and enhancing immune response (Hamn and Kuei, 2015). The ash values were not influenced by the substitution of shortening for sesame paste. Although they are not statistically different, it can be found that T5 presents a slight increase in the percentage of ash, this is mainly due to the high amount of calcium present in sesame, although there is also high availability of iron and magnesium. The study by Bamigboye *et al.* (2010), found that sesame is an important source of iron, zinc, calcium and other minerals.

Table 2. Effect of shortening: sesame paste substitution 100:0 (T1), 75:25 (T2), 50:50 (T3), 25:75 (T4) and 0:100 (T5) on nixtamalized maize cookies textural shelf, fracturability and hardness, during 0, 2 and 7 days.

Treatment	Peak Positive Force (Newtons)			Positive Area (N.s)		
	Day 0	Day 2	Day 7	Day 0	Day 2	Day 7
T1	0.753^{B}	3.050^{B}	3.202^{B}	19.49^{B}	78.23^{B}	83.02^{B}
T2	0.355^{B}	0.455^{C}	0.961^{D}	8.62^{C}	11.21^{C}	21.71^{D}
T3	1.640^{A}	5.242^{A}	6.007^{A}	37.79^{A}	141.11^{A}	164.68^{A}
T4	0.630^{B}	0.789^{C}	2.047^{C}	18.79^{B}	18.79^{C}	49.58^{C}
T5	0.586^{B}	0.629^{C}	1.595^{CD}	17.15^{BC}	15.75^{C}	39.40^{CD}

Mean values with the different superscript within the same column are significantly different (P<0.05).

According to Table 2, T3 had the highest fracturability (peak positive force) and hardness (positive area) in fresh and during storage. Results showed for T1 are similar to those reported by Perez-Carrillo *et al.* (2017) for the same kind of cookies. Data showed that T5 cookies had fewer changes in terms of texture during storage. On day 2, there were differences between samples T2, T4 and T5 versus having the lowest values of fracturability and hardness. Furthermore, it could be observed that during this shelf-life study, cookies T1 has higher fracturability values than cookies T5. This may be because fat also contributes to an increase in the length and a reduction in the thickness and weight of the cookies, which are characterized by a fragmentable structure that is easy to break. This means that the lower the fat content, the lower the fracture ability. The fat difference was discussed earlier in the document. Another factor that can influence fracture is the percentage of protein, as discussed above, T5 contains a higher percentage of protein due to the composition of the sesame paste. According to Secchi *et al.* (2011) found that the fracture values are lower when there is a higher percentage of protein. In the case of hardness on day 2, there were differences between samples T2, T4 and T5 versus samples T3 and T1. On day 7 all samples were statistically different. In the three days evaluated, the T3 sample was the one with the highest hardness value. The hardness in T5 was lower than the hardness in T1 during the three days, in addition, T5 contains the highest percentage of protein, which indicates that the hardness seems to decrease with the increase in the percentage of protein. Hadnađev *et al.* (2013) the same effect on gluten-free cookies due to the addition of buckwheat flour. The first studied gluten-free biscuits with rice flour-starch-protein mixtures. Hadvadev *et al.* (2013) measured the effect of the partial substitution of rice flour for buckwheat on the quality and texture of the cookies, and observed a decrease in the hardness of the cookies.

4. Conclusion

It can be concluded that the development of a gluten-free cookie by replacing vegetable shortening with sesame paste generated a product in which an increase in protein percentage and a decrease in fat were obtained, this is due to the composition of the sesame paste and vegetable shortening. It was concluded that the higher the proportion of sesame paste, the spread factor of the final product will be reduced. Furthermore, the amount of ash was not statistically affected by the substitution. Regarding the colour parameter, the values of L* and a* were directly proportional to the content of vegetable butter, but in the value b* there was no difference between the treatments. Based on this, it was concluded that the lower the fat content, the lower the fracture and hardness. The substitution of shortening for sesame paste in 100% (T5) can achieve a cookie with better nutritional value (more protein and less fat) and with physical characteristics favourable such as lower hardness, lower fracture and lower spread factor.

Conflict of interest

The authors declare no conflict of interest.

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