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POMEGRANATE (*Punica granatum* L.) PEEL FLOUR AS FUNCTIONAL INGREDIENT FOR CHORIZO: EFFECT PHYSICOCHEMICAL AND SENSORY CHARACTERISTICS OF FUNCTIONAL MEAT PRODUCTS

– Research paper –

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Abstract: Functional meat products are necessary to improve the health of consumers without detrimental effects on high biological value protein consumption. The incorporation of natural antioxidants and dietary fibre from agro-industrial coproducts is a good alternative to improve the nutritional characteristics of meat products. Pomegranate peel flour was employed as a functional ingredient to replace part of the fat, in a raw meat product like chorizo, determining changes in instrumental colour and texture, sensory acceptation, and neophobia. Pomegranate peel flour presented high content of polyphenols with considerable antioxidant activity, and high content of dietary fibre as well. Fibre retained moisture, decreasing water activity of the chorizos, decreasing pH during storage. Pomegranate peel flour increased the colour tone of the chorizos and decreased colour intensity, with a tough but easy to crumble texture. Sensory acceptation of chorizos with pomegranate peel flour was higher than control, although taste and texture were scored lower than the control sample. Results show that incorporation of pomegranate peel flour decreased A_w and pH, besides increased the samples luminosity and tone. Chorizo with pomegranate peel flour were harder than control. Nonetheless, as a functional ingredient improved health benefits with a positive consumers' acceptance, non-neophobic, particularly in older consumers (40-50 years old). Pomegranate peel flour is a viable ingredient in the formulation of functional meat products.

Keywords: pomegranate, chorizo, antioxidants, fibre, sensory acceptation, food neophobia.

INTRODUCTION

Functional foods represent a food category with bioactive ingredients with beneficial characteristics like antioxidant, anticancer, and cholesterol-lowering that made them quite appealing by the consumers, since consumer's drivers are demanding the reformulation of food products to enhance physiological functionality with ingredients with largely clinical proven physiological function, as natural antioxidants and/or dietary fibre (Hathwar et al., 2012). First, functional foods contain particular components that are directly connected to a health benefit linked to a single product through a well-defined physiological effect, different from the "healthy" food concept related to low-fat or high fibre, without accepting the role of a single component. Fibre is an ingredient proposed in low-fat products (Tufeanu and Tița, 2016). Second, the novelty of the added ingredient does not necessarily imply changes in food sensory quality, where consumers trust the information about the functional effect will appear to be the same that the conventional product. And third, the addition, remoting, or modification of functional foods are often associated with a less natural food than a conventional one and thus avoided by those who value naturalness in food choices (Urala & Lähteenmäki, 2004). Strategies to obtain better meat products in terms of nutritive value, sensory characteristics and preservability employing fruits or vegetable by-products is now a good alternative and inexpensive source of bioactive compounds, specifically antioxidants, to reduce protein and lipids degradation, to preserve colour inhibiting oxidative stress; and dietary fibre, to improve

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physicochemical properties of these products. These compounds are at the same time helpful ingredients in the preservation of nutritional and diet-related disorders (Ursachi et al., 2020).

In meat and meat products, oxidized hem pigments are in a couple of lipid-pigment reactions, leading to colour changes, that is a major problem that affects products' shelf life as well as sensory properties, and although synthetic compounds can be employed to delay oxidation reactions, the increase of consumer's demand for natural bioactive compounds open the possibility to use different chemical plant-derived compounds that can be used as natural antioxidants (Aminzare et al., 2019). In this view, to decrease the effect of free radicals in meat systems compounds with antioxidant activity are employed, where plant-derived antioxidants are employed with this end, although many factors must be taken into consideration, as the questionable usability and profitability of these natural antioxidants and the scarcity of universally accepted that do not deteriorate the meat products organoleptic traits (Manessis et al., 2020). According to Mitterer-Daltoé et al. (2020), an important common conclusion is noted in consumers' studies: the little knowledge about additives and this lack of information makes it difficult to understand the subject, although the concern about the use of additives and other chemicals in their diets, but with a preference for natural additives, against synthetic. This opens the possibility to the use of natural antioxidants obtained from agro-industrial co-products, like fruit peels. Fruit process derived co-products represents a source of bioactive compounds, as fibre, antioxidants, and prebiotics (Hernández-Alcantara et al., 2016). Also, under-exploited fruits can be as well source of phenolic compounds with antioxidant activity (Jolayemi et al., 2020). These agro-industrial coproducts can be employed as replacers of animal saturated fat, where antioxidants and antimicrobial may enhance meat product quality as well, helping the meat industry to meet consumers demands for healthier and shelf-stable meat products (Hygreeva et al., 2014). The peel of pomegranate represents around 60% of the fruit weight, with a higher content of polyphenolic compounds in comparison to pulp and seed extracts. Hydrolysable tannins, flavonoids, and condensed tannins are the main compounds with higher antioxidant activity. Peel also contains vitamins A, C, and E and folic acid. Pomegranate peel is as well an excellent source of dietary fibre (Saroj et al., 2020).

The objective of this work is to determine the effect of pomegranate peel flour on physicochemical characteristics of chorizo, as a functional meat product, besides the effect of the added fibre on the sensory characteristics and food neophobia.

MATERIALS AND METHODS

Pomegranate peel flour characterization

Pomegranate peel was collected in markets in Mexico City in the period from July to September 2020, where only pomegranate arils are consumed, and hence peels are commonly discarded. Pomegranate production in México during 2019 was 8,000 tons. Peels (leathery exocarp and fleshy mesocarp) were washed and were cut in ca. 2 cm length stripes and dried in a Weston 74-1001-W oven (Weston Products LLC, Strongsville, USA) at 65 °C during 10-12 h. Dried peels were grounded and sieved to obtain homogeneous particle size powder, named flour. Different collected batches were mixed to obtain a single lot and stored in hermetic plastic containers until use (Chavez-Zepeda et al., 2009).

Pomegranate peel flour chemical composition was determined according to the AOAC Official Method 925.10 for moisture, AOAC Official Method 942.05 for ashes, AOAC Official Method 920.39 for ethereal extract, AOAC Official Method 984.13 for protein (conversion factor= 6.25), and AOAC Official Method 991.43 for dietary fibre (AOAC, 1999).

The total polyphenols content was determined in an ethanolic extract employing one mL of sample mixed with one mL of Folin-Ciocalteau reactive, mixed, and diluted to 10 mL with 0.7 M sodium carbonate. After 2 h in the dark at room temperature the absorbance at 765 nm was calculated with a catechol (0-100 mg/mL) standard curve.

ABTS radical cation was produced by reacting the stock solution (7 mM) of 2,2′-Azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) diammonium salt with 2.45 mM potassium persulfate, standing the mixture in the dark at room temperature. The ABTS solution was diluted with ethanol (70%, v/v) to adjust an absorbance (measured at 734 nm) to 0.700±0.020. Polyphenol's extraction was made macerating 10 g of pomegranate peel flour with 10-fold of 70 % ethanol at 40 °C for 2 h. After the addition of 1.0 mL of diluted ABTS solution to 10 mL of diluted pomegranate peel ethanolic extract or Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid) standards (0-15 mM) in ethanol,

reading the absorbance one minute after first mixing and up until minute 10 of reaction, to report the percent of inhibition as function of antioxidants substances and Trolox as standard (Re et al., 1992).

Chorizo formulation

Three different batches of raw chorizo were elaborated. Pork lean meat (75 %) was grounded and mixed with frozen lard (18 %) in a Torrey meat grinder with a 0.42 cm plate (Torrey, Monterrey, Mexico). Spices were added (2 % guajillo chili powder, paprika powder 0.1 %, oregano powder 0.1 %, garlic powder 0.5 %), with salt (2%), and white vinegar (2.3 %), mixed to obtain a homogeneous paste, and stuffed in cellulose casings (2.54 cm diameter), tying 10-12 cm segments. A proportion of lard was replaced in treatments with pomegranate peel flour (2 and 4 %). Chorizos were stored at 4 °C for 30 days, sampling at days 1, 8, 15, 22, and 29.

pH and water activity

Chorizo pH was determined directly in samples employing knife probe pH electrode in a potentiometer HI 2550 (Hanna Instrument, Woonsocket, USA). Water activity was measured in an AquaLab 4TE water activity meter (METER Food, Pullman, USA).

Instrumental colour

Colour, as hue angle and saturation index, was determined in a Hunter-Lab Color Flex EZ colorimeter (Hunter Lab, Reston, USA). Samples colour in CIE-Lab coordinates was measured rotating samples 90° to obtain the average of 4 consecutive readings. From CIE-Lab parameters, the hue angle (H, Eq. 1) and saturation index (S, Eq. 2) were calculated according to Little (1975), as:

$$\text{Hue angle (H)} = \text{Tan}\frac{a^*}{b^*} \quad \text{Eq. 1}$$

$$\text{Saturation index (S)} = \sqrt{a^{*2}+b^{*2}} \quad \text{Eq. 2}$$

Instrumental texture

Texture profile analysis was performed in a TA XT Plus texture analyser (Stable Micro Systems, Surrey, England). Chorizo samples were cut in 2 cm height cylinders and compressed 50% at 5 mm/s crosshead speed, reporting hardness, cohesivity, and springiness (Bourne, 1978).

Experimental design and data analysis

To determinate the effect of pomegranate peel flour during storage time, the following model (Eq. 3) was proposed:

$$Yij = m + \alpha i + \beta j + \epsilon \quad \text{Eq. 3}$$

Yij= is the response variable (pH, water activity, instrumental colour, instrumental texture) at the i-th pomegranate peel flour concentration (0, 2 or 4%) at the j-th time of storage (1, 8, 15, 22, and 30 days). Model has an overall mean (μ), αi is the main effect of pomegranate peel flour content, βj is the main effect during the storage period, and ϵ is the experimental error presuming a normal distribution with μ and σ^2 (Der and Everitt, 2001). Experimental data were analysed in SAS Statistical Software v. 9.1.3 (SAS System, Cary, USA) using PROC ANOVA procedure and Duncan's mean test to determine the significant difference among means.

Sensory evaluation

Sensory acceptance of chorizo with the two levels of pomegranate peel flour was determined adapting the method reported by Clark and Johnson (2002). A total of 35 participants were recruited from students and faculty members (20 females, 15 males), who said consume habitually meat products as chorizo. Panellists were informed that in some samples a functional ingredient was added, in this case flour form pomegranate peel to enhance chorizo nutritive value. Three samples (15-20 g) of control and each one of the different pomegranate peel flour treatments was presented identified each one with a random 3-digit number, and participants were asked to rate, according to their personal preference, a position anywhere along the 7-points scale for taste, colour, texture, and overall acceptation. The rating score was calculated as the distance from the left anchor to the mark (in cm), and an acceptability criterion of $\geq$3.5 was established as mean score, corresponding to the central point of the scale, representing "neither unacceptable nor acceptable". Significative difference between control and chorizo samples containing pomegranate peel flour was determined with g a paired t-test in SAS Statistical Software v. 9.1.3 (PROC TTEST command and PAIRED statement, α= 0.05, 95% confidence level).

Consumption of healthy foods and food neophobia

To know the consumption of healthy foods the survey proposed by Roininen et al. (1999) was applied to 250 persons (age 30 to 50 years old, 139 females, 111 males), along with the Pliner and Hobden (1992) food neophobia questionnaire. The food neophobia questionnaire focuses on new food consumption habits as kinds of new foods, frequency of consumption, among others. A card with information about the health benefits of pomegranate peel on raw meat products as chorizo, as a functional food with fibre. An anchored 5 points scale was employed, with 1 (fully disagree) and 5 (fully agree), but in question marked with an R, the scale was considered backward since they are

negative nouns. In this view, the scores for neophobia were from 10 to 50, and for the consumption of healthy foods was from 8 to 40. Healthy foods consumption and neophobia level were analysed with PROC FREQ command in SAS Statistical Software v. 9.1.3 to determine the independence of sex or age using the Cronbach's alpha coefficient in the C2 test.

RESULTS AND DISCUSSION

Pomegranate flour composition

Pomegranate peel flour chemical composition and polyphenols content plus antioxidant activity are listed in Table 1. The peel pomegranate flour is low in components such as protein, ashes, and moisture, but is high in fibre and polyphenols content. At the experimental conditions, pomegranate peel flour presented 41.94 % of dietary fibre. The presence of fiber in meat products. The fibre in raw meat products delete improves quality and enhances yield (Ranjitha et al., 2018; Zinina et al., 2019).

Table 1. Chemical composition, polyphenols content and antioxidant activity of pomegranate peel flour

Parameter	Percent
Moisture (%)	4.08±0.11
Ashes (%)	3.50±0.01
Total protein (%)	3.34±0.13
Ethereal extract (%)	0.97±0.04
Dietary fiber (%) total fiber	41.94±0.01
Total polyphenols (mg of catechol eq/g of the sample)	108.82
TEAC (Trolox equivalent antioxidant capacity (µg Trolox/g)	1.379.49

Despite the differences in peel chemical composition due to inherent factors, for example, fruit variety and/or stage of maturation (Coronado-Reyes et al., 2020), or peels drying method (Mphahlele et al., 2016), or extraction protocol (Singh et al., 2018; Magangana et al., 2020). Abdel-Salam et al. (2018) studied the chemical composition of 4 different cultivars of Granada, finding significant differences in the content of active compounds. the more important components of pomegranate peel flour as functional ingredients are fibre and polyphenols content. Gullon et al. (2016) found that the most abundant phenolic compounds in pomegranate peel were punicalagin and ellagic acid. Sorrenti et al. (2019) reported as well high phenolic compounds content and a high antioxidant capacity in pomegranate peel extract.

Both components are considered as a part of the ingredients that can be employed to modify meat products improving the nutritional and health qualities of meat products, as functional foods (Fernández-Gínes et al., 2005). In addition, plant-derived by-products are considered as a source of potential functional ingredients as antioxidant dietary fibres that can be employed in meat products formulation (Das et al., 2020).

Gullon et al. (2020) suggest that pomegranate peel could be an alternative to replace chemical preservatives in meat products, improving nutritional value. Another application of pomegranate peel extracts can be inedible films as the carrier of bioactive compounds as antimicrobials, antifungal, and antioxidants (Ko et al., 2021). Also, application on pharmacy, environment, and bioenergetics has been proposed (Villacis-Chiriboga et al., 2020).

pH and water activity

The inclusion of this ingredient resulted in significant ($P<0.05$) lower chorizos pH values, as compared to the control sample. The pH decreased significantly ($P<0.05$) during storage (Table 2). The acidity of pomegranate peel flour reduces pH, but during storage, the growth of lactic acid bacteria in this kind of product also could decrease the pH of the samples. Hygroscopic products can absorb water in different ways, as sorption forming hydrate, diffusion of water molecules within their structure or binding by surface energy, immobilizing water (Elgasim and Al-Wesali, 2000). Husein et al. (2019) reported that pomegranate peel flour reduced sausages pH by 2.5% during storage. During storage time, the water activity of samples containing pomegranate peel flour was significant ($P<0.05$) lower than the control sample. More flour resulted in lower water activity, which decreased significantly ($P<0.05$) (Table 2).

Fiber and hygroscopic components of peels strongly retained water, decreasing the water activity, whereas the relatively higher fibre content in pomegranate peel flour explains this result. In the same manner, the content of phenolic acids (Mphahlele et al., 2016) or ascorbic acid (Coronado-Reyes et al., 2020), or gallic and ellagic acids (Ben Nasr et al., 1996) supports the lower pH in samples containing pomegranate peel flour.

Instrumental colour

Chorizo colour was affected by the incorporation of pomegranate peel flour (Table 3). The more peel flour in formulation, the significant ($P<0.05$) higher luminosity values were observed.

Table 2. Changes in water activity and pH for the chorizo formulated with pomegranate peel flour as functional ingredient during 30 days of storage

Storage time (days)	Water activity			pH		
	Control	2% grapefruit peel flour	4 % grapefruit peel flour	Control	2% grapefruit peel flour	4 % grapefruit peel flour
1	0.8640±0.004 a, A	0.8498±0.003 b, A	0.8348±0.005 c, A	5.09±0.01 b, D	5.07±0.01 c, D	5.17±0.02 a, D
8	0.8175±0.003 a. B	0.8033±0.001 b, B	0.7883±0.003 c, B	4.76±0.02 b, C	4.74±0.02 c, C	4.84±0.01 a, C
15	0.7620±0.001 a, C	0.7478±0.002 b, C	0.7328±0.001 c, C	4.80±0.01 b, B	4.78±0.01 c, B	4.88±0.02 a, B
22	0.7349±0.002 a, D	0.7207±0.003 b, D	0.7056±0.002 c, D	4.82±0.02 b, B	4.80±0.02 c, B	4.90±0.01 a, B
30	0.7153±0.004 a, E	0.7011±0.004 b, E	0.6860±0.001 c, E	4.80±0.01 b, A	4.78±0.01 c, A	4.88±0.02 a, A

a, b, c… Means with same letter in same row are not significantly (P>0.05) different for treatment
A, B, C… Means with same letter in same column are not significantly (P>0.05) different for storage time.

The luminosity of chorizos decreased significantly (P<0.05) during storage. Similar results were reported by Sharma and Yadav (2020) in chicken meat patties with 2% pomegranate peel flour. Zago et al. (2020) in Tuscan sausages with 1% pomegranate peel also reported a similar tendency in instrumental colour. The same tendency was observed for hue samples. Control samples were significant (p<0.05) less hue than samples with pomegranate peel flour. Hue also decreased significantly (P<0.05) during storage. The saturation index was significant (P<0.05) higher in control samples, decreasing significantly (P<0.05) during storage as well. Pomegranate peel flour, as a source of fibre, increased moisture content in chorizo, therefore the higher content of pomegranate peel flour increased samples luminosity. The incorporation of pomegranate peel flour also increased the colour tone of the chorizos (predominantly red due to pork meat myoglobin and paprika pigments), decreasing the colour saturation (vividness) as well. This is because fibre addition to meat products decreased red coloration, with the concomitantly increasing of hue angle (Garcia et al., 2002; Fernández-Ginés et al., 2003). Elfalleh et al. (2012) reported that pomegranate peel has a high presence of pigments (flavonoids and tannins), enhancing chorizo coloration, in addition, to control oxidation process, as reported by Shahamirian et al. (2019), who used pomegranate rind powder extracts in frozen beef burgers.

Instrumental texture

The incorporation of pomegranate peel flour significantly (P<0.05) increased chorizo hardness. Hardness increased significantly (P<0.05) during storage. The cohesiveness decreased significantly (P<0.05) with the incorporation of pomegranate peel flour, and significantly (P<0.05) decreased during storage. For springiness, control samples presented significant (P<0.05) higher values, with a significant (P<0.05) tendency to decrease during storage (Table 4). Fibre resulted in harder and less elastic textures (Fernández-Ginés et al., 2003) since the relatively higher amount of pomegranate peel flour resulted in a tough but easy to crumble texture. Hleap-Zapata et al. (2020) reported that increasing turmeric fiber in chorizo led to hardening the final product with a concomitantly decrease in moisture. Sharma and Yadav (2020) reported a harder texture in chicken meat patties with 2% of pomegranate peel flour.

Sensory acceptability

In the sensory evaluation, chorizo samples obtained significantly (P<0.05) lower (-0.69) scores for taste than control samples. There was no significant (P>0.05) difference in colour preferences between the chorizos containing pomegranate peel flour and control chorizo. The average score for chorizo containing 4% of pomegranate peel flour was significant (P<0.05) lower (-0.63) than the control. Nonetheless, the overall acceptance of samples with 4% of pomegranate peel flour was significant (P<0.05) higher than chorizo with no pomegranate peel flour incorporation (Table 5). Zago et al. (2020) reported no differences in the general acceptation of Tuscan sausages with 1% of peel pomegranate. This means that although the taste and texture of chorizo samples containing the higher amount of pomegranate peel flour (4%) were a bit less accepted (score difference was negative and lower than one), the total appreciation of this chorizo was higher than control. The incorporation of fibre in meat products compensates texture, flavour, and mouthfeel of fat in meat products (Garcia et al., 2002), wherein general samples containing fibre presented similar sensory score to control (Fernández-Ginés et al., 2003) or improved the sensory acceptance of raw meat products (Bis-Souza et al., 2020). In particular, the incorporation of pomegranate rind powder extract enhanced the acceptability of meat products (Shahamirian et al., 2019).

Table 3. Changes in colour for the chorizo formulated with pomegranate peel flour as functional ingredient during 30 days of storage

Storage time (days)	Luminosity			Hue			Saturation index		
	Control	2% grapefruit peel flour	4 % grapefruit peel flour	Control	2% grapefruit peel flour	4 % grapefruit peel flour	Control	2% grapefruit peel flour	4 % grapefruit peel flour
1	30.92±2.72 b, A	29.97±1.00 c, A	31.71±1.78 a, A	0.8057±0.004 c, A	0.8186±0.001 b, A	0.8422±0.004 a, A	37.88 1±88 a, A	35.46±1.89 b, A	35.18±1.88 c, A
8	30.44±1.37 b, B	29.50±1.01 c, B	31.24±0.94 a, B	0.7809±0.003 c, B	0.7927±0.001 b, B	0.8185±0.005 a, B	35.15±1.79 a, B	32.70±2.72 b, B	32.44±0.98 c, B
15	29.32±1.87 b, C	28.38±1.37 c, C	30.12±1.53 a, C	0.7690±0.002 c, C	0.7804±0.005 b, C	0.8078±0.008 a, C	33.38±1.86 a, C	30.91±1.63 b, C	30.66±1.73 c, C
22	28.73±9.40 b, D	27.78±0.99 c, D	29.52±1.37 a, D	0.7747±0.003 c, D	0.7868±0.002 b, D	0.7868±0.002 a, D	33.00±0.98 a, D	30.54±1.09 b, D	30.29±1.02 c, D
30	28.30±9.00 b, E	27.35±1.86 c, E	29.09±1.66 a, E	0.7574±0.001 c, E	0.7685±0.001 b, E	0.7685±0.001 a, E	31.44±1.37 a, E	28.96±1.64 b, E	28.72±0.75 c, E

a, b, c… Means with same letter in same row are not significantly (P>0.05) different for treatment
A, B, C… Means with same letter in same column are not significantly (P>0.05) different for storage time

Table 4. Changes in instrumental texture for the chorizo formulated with pomegranate peel flour as functional ingredient during 30 days of storage

Storage time (days)	Hardness (N)			Cohesiveness			Springiness		
	Control	2% grapefruit peel flour	4 % grapefruit peel flour	Control	2% grapefruit peel flour	4 % grapefruit peel flour	Control	2% grapefruit peel flour	4 % grapefruit peel flour
1	3.77±0.72 c, E	5.00±0.15 b, E	8.87±0.42 a, E	0.3054±0.096 a, A	0.2761±0.001 b, A	0.2970±0.014 c, A	0.2631 0.015 a, A	0.2616±0.014 b, A	0.2468 0.004 c, A
8	6.42±0.69 c, D	7.66±0.35 b, D	11.53±0.41 a, D	0.2935±0.025 a, B	0.2642±0.002 b, B	0.2851±0.021 c, B	0.2393 0.008 a, B	0.2378±0.001 b, B	0.2230 0.003 c, B
15	7.33±0.55 c, C	8.57±1.54 b, C	12.43±0.99 a, C	0.3217±0.053 a, C	0.2924±0.014 b, C	0.3133±0.012 c, C	0.2416 0.084 a, C	0.2401±0.017 b, C	0.2252 0.016 c, C
22	9.45±0.80 c, B	10.68±021 b, B	14.55±0.97 a, B	0.3426±0.001 a, D	0.3133±0.020 b, D	0.3342±0.016 c, D	0.2493 0.007 a, D	0.2478±0.007 b, D	0.2329 0.012 c, D
30	9.79±0.25 c, A	11.03±0.47 b, A	14.89±0.63 a, A	0.3417±0.029 a, D	0.3124±0.002 b. D	0.333±0.007 c, D	0.2412 0.024 a, D	0.2397±0.015 b, D	0.2249 0.002 c, D

a, b, c… Means with same letter in same row are not significantly (P>0.05) different for treatment
A, B, C… Means with same letter in same column are not significantly (P>0.05) different for storage time

Table 5. Paired t-test for sensory acceptability ratings of (n= 35).

	Mean score		Mean difference	95% confidence interval for difference	
	With pomegranate peel flour	Control		Lower	Upper
Taste					
2%	5.42	4.47	0.95 *	0.435	1.446
4%	4.56	5.25	-0.69 *	-1.126	-0.012
Colour					
2%	3.94	3.82	0.12	-0.386	0.627
4%	4.11	3.99	0.12	-0.331	0.559
Texture					
2%	5.15	4.68	0.47	-0.183	1.116
4%	4.52	5.15	-0.63 *	-1.161	-0.006
Overall acceptance					
2%	6.47	6.92	-0.45	-1.283	0.430
4%	7.51	6.61	0.90 *	0.166	1.621

* Value for the different percent of pomegranate peel flour (2% or 4%) was significantly different ($P < 0.05$) from control equivalent.

The incorporation of pomegranate peel from 1-3% increases the stability of meat products (El-Nashi et al., 2015). In the same manner, Kumar et al. (2021) found that the general acceptability of goat meatballs with 3% of pomegranate peel was between moderately desirable to slightly desirable.

Healthy foods consumption and food neophobia

Among the consumers, the survey revealed that there was a significant ($P<0.05$) difference in the consumption of healthy foods, with a 61.7% of interest, where women presented a significant ($P<0.05$) higher interest (66.5% against only 60.3% for males) for this kind of novel meat products. In the age group, older people presented a higher preference as well for healthy foods than the younger ones. Healthier foods consumption presented a promising tendency because of the interest in chorizo with functional ingredients as pomegranate peel antioxidants and fibre, especially for adults (40-50 years old) (Table 6). Before gender, age is probably the factor that influences eating behaviours, since although nutritional requirements change with age, eating habits often do not change consequently, since older adults could be at nutritional risk and tend to be more indisposed to try novel foods (van den Heuvel et al., 2019). Nutritional information provided during the survey increased chorizo acceptation, with a relatively higher percent of 81.6% of interest to try new foods with functional ingredients as pomegranate peel flour (Table 6). In general, factors as food choice motives, socio-demographic characteristics, "consumers' health", plus the consumption of functional foods and dietary supplements are not a good predictor of the purchase of intention for enriched processed meat products (Teixeira and Rodrigues, 2021). In the same manner, recently the number of new foods has increased due to diverse new technologies including safer, nutritious, and healthier foods that enhance environmental sustainability since the quality of these products and their effect on nutrition and health are important to prevent nutrition-related diseases and improve mental wellness (Giordano et al., 2017). If the high antioxidant properties of pomegranate derivatives, provide to this ingredient a great potential as appropriate substitutes for synthetic antioxidants in high-fat meat products, as well as consumer's demand for natural preservatives and ingredients (Shahamirian et al., 2019), the use of pomegranate peel flour is an excellent alternative as functional ingredients in meat products.

Table 6. Novel foods consumption profile and level of neophobia towards chorizo as a functional food with pomegranate peel flour

Type of consumer	$\chi 2$	P	High interest (%)	Low interest (%)
Male	6.54	0.0032	60.3	29.7
Female	36.85	0.0001	66.5	30.5
30-40 years old	16.95	0.0001	68.4	31.6
40-50 years old	27.81	0.0001	76.7	23.3
General consumers	37.99	0.0001	61.7	38.3
Functional food	$\chi 2$	P	Neophilic (%)	Neophobic (%)
Chorizo with pomegranate peel flour	88.80	0.0001	81.6	18.4

CONCLUSIONS

Pomegranate peel flour is a functional ingredient that can be employed to replace part of the fat in a raw meat product, like chorizo, since the polyphenols and dietary fibre content improve texture and enhance coloration, helping in product shelf life (decreasing water activity and promoting lower pH). Due to the polyphenolic compounds content, pomegranate peel flour can be considered as a natural antioxidant with antimicrobial and antifungal properties. Although taste and texture were scored lower than the control sample, overall acceptance of pomegranate peel flour chorizos was higher than control. Non-neophobic consumers accepted this type of functional meat product when nutritional information about the benefits of natural antioxidants and dietary fibre were provided. Results show that incorporation of pomegranate peel flour as a functional ingredient improved health benefits with a positive consumers' acceptance, particularly in older consumers (40-50 years old). Pomegranate peel flour is a viable ingredient in the formulation of functional meat products.

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