Breading Process Using Legumes: Chickpea (Cicer arietinum), Pea (Pisum sativum) and Fava Bean (Vicia faba)

Empanizado usando leguminosas: garbanzo (Cicer arietum), chícharo (Pisum sativum) y haba (Vicia faba)

Panado usando leguminosas: bico (Cicer arietinum), ervilha (Pisum sativum) e feijão (Vicia faba)

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Resumen

El presente estudio se basó en el uso de Carboximetilcelulosa (CMC) y solución de garbanzo como recubrimientos en piezas de Nuggets de pollo seguido de un proceso de empanizado con polvo de leguminosas deshidratadas (chícharo, haba y garbanzo) y con un proceso de freído. La intención del estudio fue la de medir la cantidad de aciete absorbido, el rendimiento de cocción, la jugosidad y la aceptabilidad final del producto en un grupo de consumidores. El objetivo principal fue proponer una nueva alternativa de proceso de empanizado usando uno de dos recubrimientos (carboximetilcelulosa y solución de garbanzo) en piezas de Nuggets de pollo empleando un polvo de leguminosas deshidratadas como empanizador; chícharo (Pisum sativum), habas (Vicia faba) y garbanzo (Cicer arietinum) seguido de un freído intenso, para reducir la cantidad de aceite absorbido mejorando las características sensoriales e incrementando, al mismo tiempo, la cantidad de proteína y fibra del producto final. Los resultados obtenidos fueron analizados mediante la prueba de Tukey y Análisis de varianza con un α de 0.05. Se observó que, de manera general, el empanizado con leguminosas tuvo una mayor retención de humedad, una mayor jugosidad y fue muy bien aceptado en comparación que el empanizado usando migas de pan ($p<0.05$). la adición de CMC como recubrimiento junto con el empanizado usando luguminosas para mantener la jugosidad y mantener el rendimiento de cocción. Finalmente, se observó que la combinación de CMC + empanizado con garbanzo, presentó los mejores resultados entre los productos empanizados con leguminosas.

Palabras clave: Carboximetilcelulosa, chícharo, haba, garbanzo, empanizado.

Abstract

The study was based on the use of a carboxymethylcellulose (CMC) and chick pea solutions as coating products on some pieces of chicken nuggets followed by a breading process with powdered dried legumes (peas, fava beans and chickpea), and a frying process. The intention was to measure the fat absorbed, the cooking yield, its juiciness and the acceptability of the final product in a group of consumers. The main objective study is to propose a new breading alternative from the use of two coating products (carboxymethylcellulose and chick pea solution) on some pieces of chicken nuggets and a breading of powdered dried legumes; peas (*Pisum sativum*), fava beans (*Vicia faba)* and chickpea (*Cicer arietinum*), followed by a fried process, in order to reduce the oil uptake and to improve the sensory characteristics of the final products increasing at the same time protein and fiber levels in food that normally won’t.

The results were analyzed through the Tukey´s test and the Analysis of Variance Analysis. It was observed that legume breading is a better alternative for fried products in comparison with bread crumbs breading ($p<0.05$) due to its moisture retention, its oil usage and its sensory characteristics. CMC coated products were also a good alternative in addition to legume breading in maintaining juiciness and cooking yield products as cooked. CMC coating+chickpea breading presented the best results among the legume breaded products.

Key words: carboxymethylcellulose, chickpea, fava bean, pea, breading.

Resumo

Este estúdio baseou-se no uso de carboximetilcelulose (CMC) e solução de-bico como revestimentos em pepitas partes de galinha, seguido por um processo de panificante com leguminosas em pó desidratado (ervilhas, feijão e grão de bico) e um processo de fritura. A intenção deste estudo foi para medir a quantidade de aciete absorvida, o desempenho de cozimento, suculência e a aceitabilidade do produto final, em um grupo de consumidores. O principal objectivo foi o de propor um novo processo alternativo, utilizando um dos dois recubrimeintos cobertura com pão ralado (solução de carboximetilcelulose e grão de bico) em partes pepitas de galinha utilizando uma cobertura com pão ralado em pó desidratado leguminosa; ervilha (Pisum sativum), fava (Vicia faba) e bico (Cicer arietinum), seguido por uma fritura intensa para reduzir a quantidade de óleo absorvido melhorou as características sensoriais e aumentando, ao mesmo tempo, a quantidade de proteína e fibra do produto final . Os resultados foram analisados utilizando o teste de Tukey e análise de variância com □ 0,05. Observou-se que, geralmente, panificante com leguminosas tinha uma retenção de humidade mais elevado, mais suco e foi muito bem aceite comparados usando as migalhas de cobertura com pão ralado ($p <0{,}05$). a adição de CMC revestido com panificante usando luguminosas para manter suculência e manter o desempenho de cozimento. Finalmente, observou-se que a combinação de CMC + panificado com grão de bico, mostrou os melhores resultados entre produtos panados com leguminosas.

Palavras-chave: carboximetilcelulose, ervilha, feijão, grão de bico, cobertura com pão ralado.

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1. Introduction

Nowadays, there is a malnutrition problem due to the lack of protein in people's diet regarding mostly the expensive cost of meat and animal products. This is why there is a need to incorporate vegetable protein as a source of high quality amino acids in food and food products. Sometimes the current lifestyle has caused the need of consuming instant food at home or in fast food restaurants where the offer could be fried products as the breaded nuggets (Barbut, 2002)

The breaded and fried food is today a very commercialized option in processed products, nevertheless, this kind of products are at high risk for not maintaining their integrity on its shelf life or during the frying process, in which they can absorb a large amount of saturated fatty acids that can increase consumer's cholesterol and also the risk of other kind of vascular diseases as diabetes Mellitus, obesity and hypercholesterolemia among others (Ansarifar, Mohebi and Sahidi, 2012)

According to Das et al. (2013), breaded fried food products are preferred by consumers, due to the enhanced palatability given by a soft and wet interior plus the creation of a crispy and porous crust. The popularity of these products had increased through time, so that today there is a wide variety as chicken nuggets, pork products, and fish strips, among others.

Most of the breaded food products are meat or its derivate which after a process of inmersion or aspertion with a bonding solution (batter) followed by a breading (flour, salt, spices) and frying process, normally gives a good taste and texture to the final product. However, in this part of the process the product can absorb large amounts of oil which can be quickly transformed to saturated fatty acids if the frying process is not correct (Barbut, 2002)

As well, if the batter processes are not produced under strict quality criteria, the crispy crust could be damaged even during the transportation or any activity before the frying process, causing a bad appearance, and even worst, a short shelf life. These are the reasons why the good formulated of the breading is crutial for an excellent final product with an optimal store life and with no potential risk for health.

Technological innovations and consumers with more information are the reasons why the food industry is experiencing important changes. Consumers now have more knowledge about diet- health relationship (Olsson and Skoeldebrand, 1980) and they can demand higher quality in the products they consume.

In the same way, several studies have shown that legumes can improve nutritional status of the food that contains them, also, they can increase fiber intake and lower cholesterol level in consumer's blood. The aforementioned benefits, can reduce the risk of cancer, heart diseases and also the incidence of osteoporosis (Guillon and Champ, 1996).

Also, in comparison with wheat flour, legume flour has shown great amount of polar aminoacids such as lysine that contribute with the total intake of essential aminoacids. Also as Usha and Deshpande (1991) mentioned, legumes are a rich source of proteins, calories, fiber and vitamins.

As mentioned by Guerra and Pablo (2013), obesity, diabetes, dyslipidemias and arterial hypertension are cataloged as no transmissible chronic diseases, some of them related with the excessive consume of fat or cholesterol in the diet. As a whole together, they contribute to more than the 80% of the deaths and they are causing disabilities and a serious sanitary problem all around the world (González et a., 2015).

Arteriosclerosis, hyperlipidemia and hypercholesterolemia are diseases related to the high consume of saturated fat and cholesterol, reduction in physical activity, among other detonating elements. Hence, the urgency of establishing a healthy low fat diet is evident through the use of new products that do not affect the quality, texture, flavor and appearance of the food. The present study proposed the use of a new process for breading creation from legume, preserving the mentioned characteristics (World Health Organization, 2012).

Nowadays, with the creation of several organizations such as the International Diabetes Federation, The American Diabetes Association, the World Health Organization's Diabetes Programme, the American Heart Association, la Fundación para la Diabetes, la Asociación Mexicana de Diabetes, la Sociedad Española de Diabetes among others, there has been a generalized concerned, within the population, for the prevention of Diabetes and other chronic diseases (Institute for Clinical and Economic Review, 2016)

Also, for this purpose, researches worldwide are proposing several prevention alternatives for example; incorporation of vegetable's bioactive compounds in the creation of food products (Oh and Yun, 2014), use of vegetable oil alternatives in food preparation (The Peanut Institute, 2013) and decreasing oil intake in fried food (Astrup et al., 2011).

This is why, objective in the present study is to propose a new breading alternative from the use of two coating products(carboxymethylcellulose and chick pea solution) on some pieces of chicken nuggets and a breading of powdered dried legumes; peas(*Pisum sativum*), fava beans (*Vicia faba*)and chickpea (*Cicer arietinum*), followed by a fried process, in order to reduce the oil uptake and to improve the sensory characteristics of the final products increasing at the same time protein and fiber levels in food that normally won't.

2. Material and methods

2.1 Materials

Approximately four kilograms for each treatment (conventional frying and baked) of fresh in-bone chicken breasts were procured from the local market. Chicken breast were then washed with tap water. All subcutaneous fat and adhering connective tissue were removed from the muscle and was deboned. The resultant meat was separated and cut into chunks of 3-4 cm sizes. Carboxymethylcellulose (Deiman, México) was used as a coating film instead of egg. Chick pea (*Cicer arietinum*) and fava bean (*Vicia faba*) flour were purchased from a local market. Pea (*Pisum sativum*) flour were made in the laboratory by grinding dehydrated pea in a blender until it was finely ground (60 mesh) and packed in plastic bags at room temperature till further use. Also, chick pea solution was prepared in laboratory by boiling 50 g of dehydrated chick peas in 100 ml of water for 15 min. the solution was then filtrated and the solution was also used as a bind for the breading. Vegetable oil (Nutrioli) was used to fried chicken breast and ground bread (Bimbo) was used as a breading control.

2.2 Proximate composition

Moisture, ash, protein, fat and crude fiber of each simple were determined by AOAC (2000) methods. Fat was determined based on AOAC method 963.15 using Soxhlet extraction with petroleum ether as a solvent. Method 923.03 by AOAC (2000) was used to obtained dry ash. Crude fiber was determined by neutralization using AOAC (2000) 962.09 method. Protein content (%Nx6.25) was obtained by Micro-Khejdahl method (method 960.52) by AOAC (2000) and finally moisture content were determined by AOAC (2000) method 934.01 using air oven method.

2.3 Battering and breading process

Salt (1.3%) and pepper (0.7%) were added to the chicken breast chunks. Coating paste was prepared by adding 0.2 g of carboxymethylcellulose to 100 ml of warm water and mixed thoroughly until the solution was homogenized. The resultant paste was applied to three kilograms of chicken chunks. Another coating paste made by a 50% chick pea solution was applied to three kilograms of chicken chunks.

Afterwards, one kilogram of carboximethylcellulose coated product was added to chick pea flour, pea flour and fava bean flour (one kilogram per legume flour) until no blank spots were observed in product surface. The same procedure was applied to one kilogram of chick pea solution coated product.

Separately, one kilograms of chicken chunks were coated using chick pea solution and one kilograms of chicken chunks were coated with carboxymethylcellulose. Both coated products were breaded with bread crumbs as controls. Sample preparation are summarized in the following Table (Table 1).

Table 1. Sample preparation

	Samples							
Ingredients	C1	C2	S1	S2	S3	S4	S5	S6
Salt	X	X	X	X	X	X	X	X
Pepper	X	X	X	X	X	X	X	X
CMC	X		X		X		X	
CPS		X		X		X		X
FBF			X	X				
CPF					X	X		
PF							X	X
BC	X	X						

CMC= Carboxymethylcellulose, CPS= Chick pea solution, FBF= Fava Bean Flour, CPF= chick pea flour, PF= Pea Flour, BC= Bread Crumbs, C= Control, S= Sample.

2.4 Frying process

The breaded chicken chunks were fried using a conventional open pan using cooking gas. Vegetable oil was heated until 170°C was reached and the half of the coated products were dropped to the hot oil. The frying time for each batch was 7 minutes and when the product internal temperature reach 74°C. To maintain uniform cooking, every minute the meat was stirred well and reverse. After the frying time was concluded, the meat was removed from the hot oil and placed in a vessel for draining the excess fat.

Fresh oil was used for each batch.

2.5 Baked process

The resultant chicken breast chunks were placed in a tray with wax paper and baked in a conventional oven at 200 °C for 15 minutes and when the product internal temperature reach 74 °C. Every 7.5 minutes the meat was flip to maintain uniform cooking. Afterwards, the meat was removed from oven and placed in a vessel.

2.6 Physical analysis

2.6.1 Cooking yield

The method used was described previously by Serdaroglu and Degimencioglu (2004) and was determined by measuring the weight of three pieces of breaded chicken breast for each treatment and calculating weight differences before and after cooking and using the following equation (Equation 1)

$$\text{cooking yeld } (\%) = \frac{\text{cooked weight}}{\text{raw weight}} \text{x}100 \qquad \text{Ec. (1)}$$

2.6.2 Moisture retention

Moisture retention method was used as described by El-Magoli et al. (1996). The value represents the amount of moisture in the cooked product per 100 g of raw simple. It was calculated according the following equation (Equation 2).

$$\text{Moisture retention } (\%) = \frac{\text{percent yield x moisture in cooked product}}{100} \qquad \text{Ec. (2)}$$

2.6.3 Oil usage

Uptake of oil by the product was determined by weighting the oil before and after the frying process and calculated by the following equation (Equation 3)

$$\text{oil usage } (\%) = \frac{\text{weight oil before frying} - \text{weight oil after frying}}{\text{weight of raw breaded piece}} \qquad \text{Ec. (A.3)}$$

2.6.4 Juiciness

To determined juiciness of the product the method proposed by Mallikarjunan and Mittal (1994) was used. Approximately 0.6 g of fried product were placed on a Whatmanfiter paper. Compression of 20 KPa for 1 minute was applied and afterwards, the product was removed and the filter paper was weighed again and the juiciness was calculated using the following equation (Equation 4)

$$\text{Juiciness } (\%) = \frac{\text{weight filter paper after pressing} - \text{weight fiter paper before pressing}}{\text{weight fried product}} \qquad \text{Ec.(A.4))}$$

2.6.5 Sensory evaluation

Both baked and breaded product were subjected for sensory evaluation for color, odour, flavour and overall acceptability. The test was carried out by 30 untrained panelists using 5-point Hedonic scale. Samples were served in a well-lit room on coded White enamel plates. The mean score for each attribute is registered. Ten grams of the samples were serve at 55°C as proposed by (Das et al., 2013).

2.7 Statistical analysis

Physical analysis was made by triplicates and the date obtained were analyzed by an analysis of variance (ANOVA) with a 95% significance level and a comparison between families by Tukey's test using Minitab v. 14.

3. Results and Discussion

3.1 Proximate analysis

Results for proximate composition of the four types of breaded chicken are presented in Table 2.

Table 2. Results for proximate compositions of the four types of breaded chicken

		Breading					
		Chick pea		Pea		Fava bean	
		Coating					
	Control	CMC	CPS	CMC	CPS	CMC	CPS
Moisture	50.81+0.75a	57.98+0.78x,b	52.67+0.42y,b	53.50+0.32x,b	50.2+0.39y,a	55.30+0.42x,b	52.65+0.81y,b
Protein	10.56+0.34a	16.65+0.57x,b	16.2+0.15x,b	14.32+0.3x,b	13.83+0.27y,b	15.83+0.43x,b	15.28+0.3x,b
Ash	2.54+0.56a	3.3+0.21x,b	2.9+0.29y,a	3.2+0.28x,b	3.2+0.56x,b	3.1+0.14x,b	3.0+0.21x,b
Crude fiber	0.81+0.34a	1.3+0.34x,b	0.79+0.38y,a	1.2+0.19x,b	0.98+0.23x,a	1.34+0.51x,b	1.32+0.54x,b
Fat	11.03+0.78a	9.67+0.65x,b	9.40+0.46x,b	10.56+0.36x,a	10.13+0.38x,b	9.8+0.12x,b	10.78+0.95y,b

a-b. Mean values between control and either samples in the same row which is not followed by the same letter are significantly different ($p<0.05$). Mean + standard deviation (n=3) x-y. Mean values between the two types of coating for the same breading in the same row which is not followed by the same letter are significantly different ($p<0.05$)

CMC: Carboxymethylcellulose coating. CPS. Chickpea solution coating.

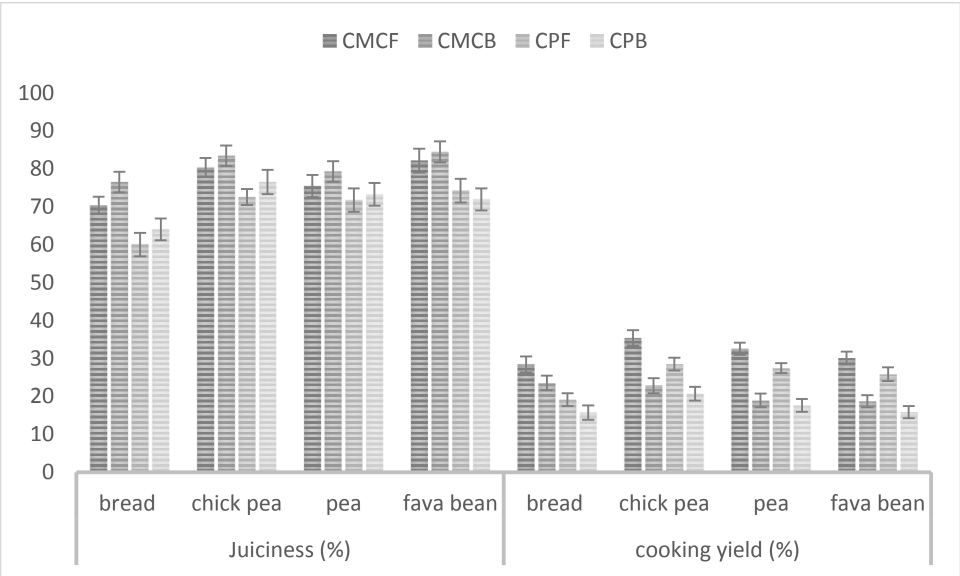
As a result of the proximate analysis, it was observed that level of protein was significantly ($p<0.05$) higher in all three legumes breading than in control. The aforementioned was, in accordance with a research made by Levitin and McMahon (2015), in which they stablish that legumes are a good source of protein due to the nitrogen-fixing bacteria in the root nodules converting the atmospheric nitrogen into protein.

For all legume samples, levels of fat decreased significantly (p<005) probably due to the tight outer structure of legumes that seems to be impermeable to substances such as water and gases, prevent oil intake into the product. The above was mentioned previously by Argel and Paton (1999)

3.2 Cooking yield

Cooking yield is considered as a measure of weight change during the cooking process. Results for product cooking yield is seen in Figure 1.

Figure 1. Cooking yield (%) and Juiciness (%) for chicken products.



CMCF = fried product coated with carboxymethylcellulose, CMCB = baked product coated with carboxymethylcellulose, CPF = fried product coated with chickpea solution, CPB = baked product coated with chickpea solution

It can be seen below, overall products breaded with bread crumbs was observed to have lower cooking yields (from 60 to 84.4%) and hence, legume breaded product had the highest yield. These results could be explained by the principle described by Gamble et al. (1987) in which they suggested that for the water steam scape, the food product must have a selective weakness in its structure. So, if the breading material is strong enough, moisture loss could be reduced. Therefore, legume had a strong structure because they have a defective seed coat that do not imbibe water (Reyes-Moreno and Paredes-López, 1993)

Also, it can be observed that carboxymethylcellulose (CMC) had the highest cooking yield ($p<0.05$) in comparison with chick pea solution. The Aforementioned could be due to CMC had a good adhesion as Hanson and Fletcher (1963) proved in their work. Chickpea solution was used as coating product because its emulsifying ability as describe in research made by Ladjal-Ettoumi et. al. (2016).Carboxymethylcellulose is proven to reduce moisture loss when applied as an edible film in meat products (Khan et al., 2013) and also it can be used as a coat to reduce oil uptake in fried foods (Xue and Ngadi, 2009).

Overall, chickpea and fava bean breading had the highest yield probably because their hard structure does not let the water steam to escape from the food product. Cooking process were also compared and it was observed that there was no significant difference between fried and baked product, probably due to the breading effect and also because in frying process moisture loss is often related to oil uptake of the product.

3.3Juiciness

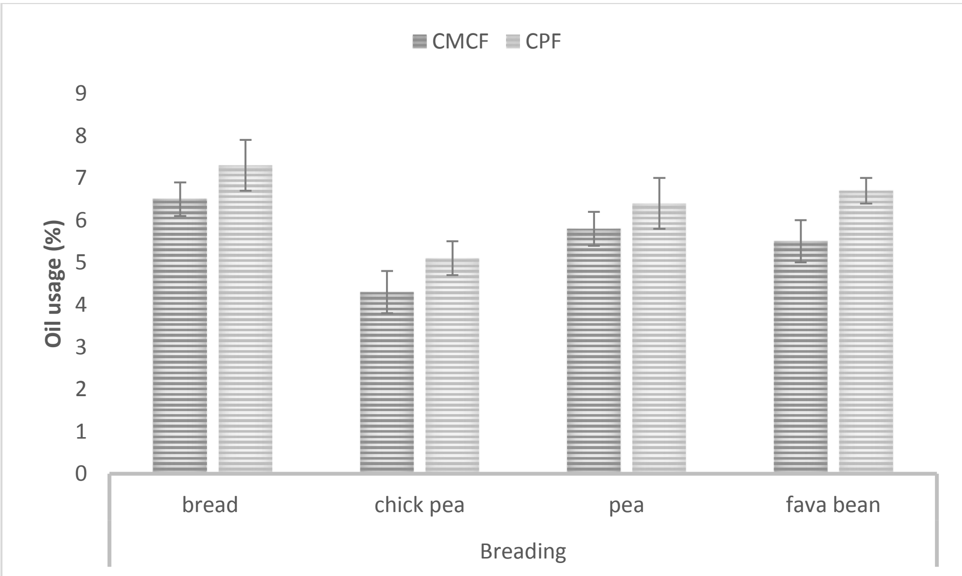
Juiciness is the amount of liquid retained by the product and the juicier the product, the quality improved. In Figure1 results for juiciness are presented. It can be observed that chickpea breading proved to have the highest juiciness (from 20 to 35%). This could be related to the structure of the chickpea crumbs due to its hard shell and the diminished mass transfer from the product to the breading. Also, product's juiciness could be related to the amount of water that is retained by the flour. In the same way, Sreerama et al. (2012) found that there is a direct relation with the amount of polar aminoacids and its water holding capacity. Therefore, due to protein denaturation, water molecules are linked to the exposed hydroxyl groups and entirely depend of flour composition (Singh, 2011) Fried products were observed to have the highest levels of juiciness ($p<0.05$) in accordance to the results from Saguy and Pinthus (1995) work in which they found that the crust formation in fried products is a limiting in heat and mass transfer. Also, the afore mentioned could be explained with the water holding capacities (WHC) of the legume which plays a major role in food processing due to its influence in functional and sensory properties of the food containing them. Similar results were found in the research made by Ma et al. (2011) they observed that pea flour had the higher levels of WHC in comparison with other legumes flours when the flours were heated. Also, there was no significative difference ($p<0.05$) between CMC fried and baked products. The later results were in agreement with the ones presented by Gamakhany et al. (2014) in which they concluded that CMC coated fried products had higher moisture levels in comparison with blank samples.

Carboxymethylcellulose was also the best coating in all samples. Products coated with CMC has shown to have higher levels of juiciness due to its well-known properties as an edible coat in food products (Das et al., 2013).

3.4Oil usage

Results for oil usage is presented in Figure 2. Breading with bread crumbs has significantly ($p<0.05$) the higher oil usage (6.2-7.5%) in comparison with chickpea breaded products (4.1-5%) with CMC and chickpea solution respectively.

Figure 2. Oil usage (%).



CMCF= Fried product with carboxymethylcellulose, CPF= fried product with chickpeasolution.

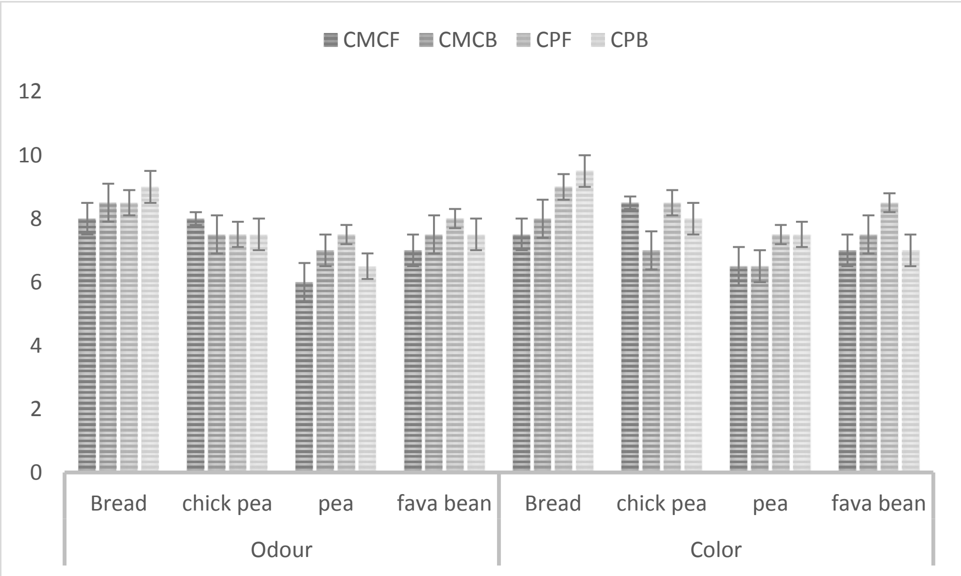
Oil usage or oil absorption is related with several factors according to Gamble et al. (1987). Crust microstructure is of the interest of this type of breading. Thus, legumes possess low porosity, oil absorption is reduced, hence chickpea has the lowest porosity, followed by fava bean and pea. Also, lower levels of oil usage could be related to bulk density of the seed; as seen in a study made by Ettoumi and Chibane (2015), they proved that chickpea flour is denser than lentil and pea flours.

3.5Sensory evaluation

3.5.1 Colour

Sample colour evaluation is presented in Figure 3.

Figure 3. Colour and odour evaluation.



CMCF = fried product coated with carboxymethylcellulose, CMCB = baked product coated with carboxymethylcellulose, CPF = fried product coated with chickpea solution, CPB = baked product coated with chickpea solution.

It can be observed that bread crumbs breaded products was evaluated as the best colour product in comparison with the rest breaded products. This could be as a result of the formation of the golden colour attributed to the Maillard reaction of the bread's sugar in combination with low water content and high temperatures (Olson and Skjoeldebrand, 1980). Among legume breading, chickpea has proven to have the best colour evaluation ($p<0.05$) and chickpea solution was the best colour evaluated coating product ($p<0.05$) as well as fried products.

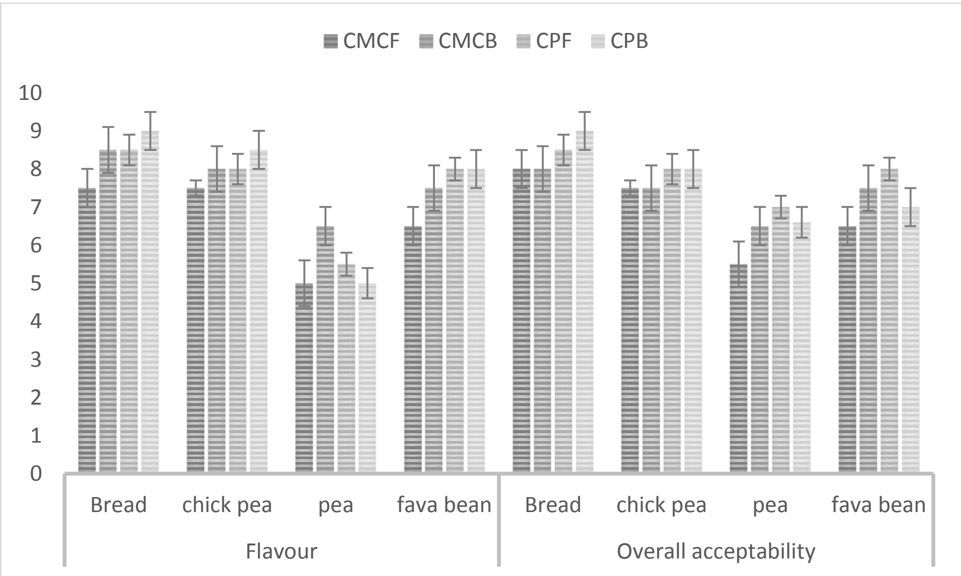
3.5.2Odour

Results for odour are presented in Figure 3. There was no significate difference between legume breaded chicken chunks (p>0.05) also there was no difference among fried and baked legume breaded products. A significative difference between crumbs breaded products and legume breaded product was presented hence, crumb breaded products were more acceptable than legume breaded ones.

3.5.3Flavour

Pea breaded chicken chunks presented the lowest flavour evaluation (p<0.05). On the other hand, crumbs breaded products had the highest acceptance in flavour terms (Figure 4). There was no difference(p>0.05) between fava bean and chickpea breaded products. Although, fried chunks had a higher flavour evaluation than baked products these results were probably observed due to alkylpyrazines formation when chicken meat is cooked at high temperatures (Jayasena et al., 2013), chickpea fried products have proven to had the best flavour evaluation of all, even higher than fried crumbs breaded products. Also, products with carboxymethylcellulose, had the lowest (p<0.05) flavour evaluation.

Figure 4. Flavour and overall acceptability evaluation.



CMCF = fried product coated with carboxymethylcellulose, CMCB = baked product coated with carboxymethylcellulose, CPF = fried product coated with chickpea solution, CPB = baked product coated with chickpea solution.

3.5.4Overall acceptability

Using crumb breaded products as controls, chickpea breaded products had the highest evaluation ($p<0.05$) among the other legume breaded products and this could be due to an existing acceptance of breaded fried products (Figure 4). Also, food coated with chickpea solution were well evaluated by the panellists in comparison with CMC coated products. Similar results were observed in the research made by Khan et al. (2013) in which meat quality improved in the coated products. Former results were probably appreciated due to a gel like texture in the product. And fried chickpea coated products presented the highest evaluation ($p<0.05$).

4. Conclusion

We concluded that legume breaded products could be a good alternative in fried products area in account of its poor oil intake and its higher levels of cooking yields. Additionally, CMC coating plus legume breaded products are an excellent alternative for high moisture and poor oil uptake meat products without affecting its sensory characteristics. CMC coating+chickpea breading blend presented the best results.

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