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QUALITY STUDY OF POTATO CHIPS FOR SALE IN THE URUGUAYAN MARKET

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ABSTRACT

Objective: To study the quality of potato chips for sale in the Uruguayan market.

Theoretical framework: For potato chips, the regulation controls moisture, peroxide value (VP) and acidity (%A). It was also considered important to evaluate the fatty material contained in the potatoes as frying oil, where polar compounds (PC) are controlled. The composition of CPs and total polymers (TP) was also evaluated. This set of measures took into account all the deterioration processes to which these lipids are subjected, so as to have a complete idea of their quality.

Method: Six different brands of potato chips for sale in the Uruguayan market and the oil absorbed during their elaboration were evaluated. The lipid content and moisture content of the potatoes were measured. In the oil, VP, %A, CP and its composition, PT, the composition in fatty acids and the content of cabbage were measured.

Results and conclusion: All the products analyzed comply with the current regulations, except for sample E, which presented high %A. Nevertheless, it was observed that in some cases the oils have an advanced deterioration. Likewise, the sample obtained through vacuum frying with a significantly lower lipid content than the others was highlighted.

Implications of the research: This paper seeks to inform the quality of these foods that are for sale in the market.

Originality/Value: The quality of food has a direct influence on the health of the population.

Keywords: Frying, Oxidative Stability, Normative, Chips.

ESTUDO DE QUALIDADE DE BATATAS FRITAS PARA VENDA NO MERCADO URUGUAIO

RESUMO

Objetivo: Estudar a qualidade da batata frita para venda no mercado uruguaio.

Quadro teórico: Para as batatas fritas, o regulamento controla a humidade, o valor de peróxido (VP) e a acidez (%A). Também foi considerado importante avaliar o material gorduroso contido nas batatas como óleo de fritar, onde os compostos polares (PC) são controlados. A composição de CPs e polímeros totais (TP) também foi avaliada. Este conjunto de medidas teve em conta todos os processos de deterioração a que estes lípidos estão sujeitos, de modo a ter uma ideia completa da sua qualidade.

Método: Foram avaliadas seis diferentes marcas de batatas fritas à venda no mercado uruguaio e o óleo absorvido durante a elaboração. O teor de lípidos e o teor de humidade das batatas foram medidos. No óleo, VP, %A, CP e sua composição, PT, foram medidas a composição em ácidos graxos e o conteúdo de repolho.

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Resultados e conclusão: Todos os produtos analisados estão em conformidade com os regulamentos atuais, exceto a amostra E, que apresentou alto %A. No entanto, observou-se que em alguns casos os óleos têm uma deterioração avançada. Da mesma forma, a amostra obtida por fritura a vácuo com um teor de lipídios significativamente menor do que os outros foi destacada.

Implicações da pesquisa: Este trabalho busca informar a qualidade desses alimentos que estão à venda no mercado.

Originalidade/Valor: A qualidade dos alimentos tem influência direta na saúde da população.

Palavras-chave: Fritura, Estabilidade Oxidativa, Normativo, Chips.

1 INTRODUCTION

Chips are a very attractive food because of their taste and texture. However, their high caloric content makes them objectionable from a nutritional point of view, a consequence of the high content of carbohydrates and lipids they contain. Another aspect that causes rejection of this type of food is the conception that frying is harmful to health, beyond its caloric contribution. The conception of how healthy a food can be is highlighted as one of the main aspects when deciding its consumption, this is further accentuated if it is identified as organic (Branco *et al*., 2019; Fernandes *et al*., 2021).

Raw potato can be considered as a fat-free food, but its content increases considerably during frying, these lipids come from the frying bath, so the quality of the oil used is of utmost importance for the quality and shelf life of these snacks.

The level of degradation of frying oils and fats can vary greatly depending on several factors: the process (temperature/time, frying method, container material); the type of oil (composition and presence of natural additives or aggregates); the food to fry (surface/volume ratio, coverage, moisture and composition of its lipid fraction) (Dobarganes *et al*., 1991).

During the process, the oil or fat is subjected to the action of three factors that contribute to reduce its quality and modify its structure: the moisture provided by the food that causes its hydrolysis, the air that penetrates the oil through the surface (which results in the formation of oxidation compounds) and the high temperature at which the process takes place (whose consequence is thermal alteration or thermooxidation) (Dobarganes *et al*., 2002). As a result, volatile products, which are partially removed during frying, and new non-volatile compounds, accumulate in oil as the frying process progresses and are incorporated into food (Masson et al., 1997; Masson et al., 1999; Tyagi et al., 1996; Saguy et al., 1998; Dobarganes & Márquez-Ruiz, 1998; Romero et al., 1998; Bastida et al., 2003). The triglyceride-altering compounds that are formed are mainly: monomers, oxidized dimers and polymers, non-polar dimers and polymers, cyclic monomers, transisomers of fatty acids, volatile compounds (aldehydes, ketones, hydrocarbons, etc.), free fatty acids, mono and diglycerides (Abidi et al., 2001; Houhoula et alpurchased., 2002). These alteration compounds are grouped into polar compounds.

Once the potato chips are cooked, they are cooled and packaged for marketing. Due to the conditions of storage and commercialization, the processes of deterioration of the oil change, becoming the most important the autooxidation and the photooxidation, in both cases the formation of hydroperoxides occurs. The main tools for protecting food from these processes are the removal of oxygen within the container and the protection against UV rays of

the container. In addition, antioxidants preserved in the oil will also be of great importance to preserve the oil at this stage (Frankel, 2012).

The National Bromatological Regulation (NBR) (MSP, 2022) requires for potato chips a maximum limit of 5 % moisture and maximum values of 15 meq O_2/kg of peroxides and 1 % acidity, expressed in oleic, in the fat matter of the chips. For a frying oil, NBR requires that the linolenic acid in it does not exceed 2 % and polar compounds 25 %.

In this work we sought to evaluate the quality of potato chips for sale in the Uruguayan market, in order to evaluate how they impact the different processes that transit this food in the same one. To this end, 6 different brands of potato chips for sale in the Uruguayan market were evaluated. In addition to the parameters requested by the RBN for potato chips and for frying oil, the lipid content in potatoes, its composition in fatty acids and tocopherols were measured.

2 MATERIALS AND METHODS

2.1 Material

Six samples of potato chips purchased in the market were used. Two were made in Uruguay and the remaining were imported (Argentina, Peru, Spain and the United States). Of these 6 samples, one specific sample was prepared with vacuum cooking, the others were prepared by traditional frying.

2.2 Humidity

The humidity was determined by gravimetric measurement with drying of the samples in stove at 105 ± 2 ºC (IUPAC 1.121). The measurement was made in triplicate.

2.3 Lipid Content

The lipid content was obtained by gravimetric measurement after extraction with the solvent mixture Hexane:Isopropanol 3:2 (v/v) according to the method described by Hara & Radin (1978). This was done in triplicate.

2.4 Peroxides value

The peroxide value was determined on the oils extracted according to the ISO 3960 standard. This measure was performed in triplicate.

2.5 Free Acidity

The free acidity was measured in triplicate according to the IOC/T20./Doc.No34 standard.

2.6 Fatty Acid Composition of Oils

Oil is derivatized to its methyl esters according to IUPAC 2.301. The methyl esters were analyzed in a Shimadzu GC-14B gas chromatograph equipped with FID detector and a column SP 2330 (30 m x 0.25 mm x 0.20 µm) and nitrogen as carrier gas (P = 70 kPa). The injector was used at 260 ºC with a split ratio of 1:80. The temperature program was as follows: initial temperature 160 ºC, isothermal of 1 minute, then heating at 4 ºC/min to 220 ºC, where it was

maintained for 8 minutes. The detector temperature was 240 ºC. Methyl esters were identified by appropriate standards. The determination was made in triplicate.

2.7 Tocopherols

The tocopherol content was measured according to the method used by Andrikopoulos *et al.* (1997). The determination was made in triplicate.

2.8 Polar Compounds

The IUPAC 2.507 method was used in a scaled version, for the use of lower volumes of solvent, this version has already been described in Segura *et al.* (2019). The polar fraction of the samples was preserved for further composition analysis by HPLC. The measurements were made in triplicates.

2.9 Total Polymers

The content of total polymers in the oils extracted was determined according to IUPAC method 2.508.

2.10 Composition of Polar Compounds

The polar fraction obtained in 2.8 was analyzed according to the method described in 2.9 to obtain the composition of it. Analyzes of each sample were performed in triplicate.

2.11 Data Analysis

The software InfoStat ver.2020 (InfoStat Transfer Center, FCA, Universidad Nacional de Córdoba, Argentina URL: http://www.infostat.com.ar) was used for the calculation of means. Analysis of variance (ANOVA) was performed and the Tukey test was applied, with a confidence level of 95 %.

3 RESULTS AND DISCUSSION

In **Table 1**, the values of the parameters required by the RBN for potato chips, moisture, peroxide value (VP) and free acidity are shown. Except for the acidity of sample E, all comply with the current regulations.

Table 1. Lipid content and moisture content of potato chips, and peroxide value (VP), acidity according to oleic acid (% A) and tocopherols of oils extracted from potato chips.

Sample	Humidity (%)	Lipids (%)	VP (meq O_2/kg)	Acidity (%)	Tocopherols (ppm)
A	$3,1^{d} \pm 0,2$	$32,0^{d} \pm 1,1$	$9,3^{c} \pm 0,1$	$0,61^{c} \pm 0,02$	257 ± 3
B	$2,8^{c,d} \pm 0,1$	$26,6^{b} \pm 0,5$	$5,7^{b} \pm 0,3$	$0,25^{a} \pm 0,04$	508 ± 48
C	$1,6^{a} \pm 0,1$	$32,0^{d} \pm 0,3$	$3,9^{a} \pm 0,2$	$0,26^{a} \pm 0,03$	577 ± 75
D	$4,2^{e} \pm 0,1$	$13,1^{a} \pm 0,9$	$9,6^{c} \pm 0,2$	$0,63^{c} \pm 0,01$	381 ± 16
E	$2,2^{b} \pm 0,3$	$37,0^{e} \pm 0,7$	$3,4^{a} \pm 0,1$	$3,7^{d} \pm 0,1$	338 ± 19
F	$2,5^{b,c} \pm 0,1$	$29,8^{c} \pm 0,4$	$3,7^{a} \pm 0,1$	$0,46^{b} \pm 0,01$	258 ± 7

Note: Different letters show significant differences ($p<0.05$) between samples for each analysis according to the Tukey test.
Source: Authors (2023).

A high acidity value in this type of oil could be due to control problems in the frying process, this effect is observed when the process is carried out at temperatures other than the recommended (180-190 ºC) or by frequent interruptions in the frying process (Gupta, 2004). Frying at below-recommended temperatures also tends to result in increased oil absorption from the food, which is reflected in a high lipid content. As shown in **Table 1**, the lipid content of sample E is significantly higher than the others, which would be in accordance with the above.

Considering the lipid content and moisture content of potatoes, sample D stands out, with a higher moisture and lower fat content. This potato has the particularity, as reported by the manufacturer, of being obtained by a vacuum frying process. Therefore, the lower oil absorption is in agreement with the bibliography found regarding this process (Garayo & Moreira, 2002; Mariscal & Bouchon, 2008; Da Silva & Moreira, 2008; Yagua & Moreira, 2011; Crosa *et al.*, 2014, Belkova *et al*., 2018; Juvvi *et al*., 2020).

With respect to PV, it is interesting to note that samples A and D had significantly higher values than the rest, although within the allowed, this shows that these potatoes have suffered a greater oxidative deterioration. The same one in the case of sample A, traditional frying, should have been produced after frying. In the case of sample D, this could also be the case or during the frying process, since it uses temperatures below 180 ºC due to being vacuum, if the temperature is below 140 ºC peroxide accumulation can be found during the process (Kamal-Eldin *et al.*, 2003).

The fatty acid composition of oils extracted from potatoes is shown in **Table 2**. As reported by suppliers and bibliographic data (Firestone, 2013), it is observed that samples A, C, D and E were fried in sunflower oils, B in high oleic sunflower oil and F in cotton oil. All of them comply with the condition of a maximum of 2 % linolenic or polyunsaturated acid with equal or greater amount of double bonds established by the RBN for frying oils.

Table 2. Fatty acid composition of oils extracted from potato chips.

Fatty acid	Samples					
	To (%)	B (%)	C (%)	D (%)	E (%)	F (%)
16:0	8.6	3.7	6.0	5.9	6.5	20.8
16:1	na	na	na	na	na	0.4
6:00 PM	4.0	3.1	3.8	3.7	3.8	2.4
18:1	29.2	85.1	43.5	33.3	33.6	23.0
18:2	57.8	6.6	46.2	55.4	55.1	51.6
18:3	na	na	0.1	0.3	na	0.6
8:00 PM	na	0.3	0.2	0.3	0.1	0.3
10 PM	0.4	0.9	0.7	0.7	5.1	na

Note: nd: not detected
Source: Authors (2023).

Considering the origin, when comparing the content of tocopherols found in the extracted oils (**Table 1**) with the bibliographic data (Firestone, 2013) a content lower than theoretical, except for sample B is observed. This could be related, first, to the refining of the oils, where some of these compounds are lost, and second, to the deterioration processes suffered during the frying process and the storage period of the potato chip. From this point of view, the samples that show greater conservation of their natural antioxidants are B and C, which also showed a low VP.

As mentioned, polar compounds (PC) and polymers contained in oils were studied, both typical analyzes of frying oil control. The results are shown in **Figure 1**.

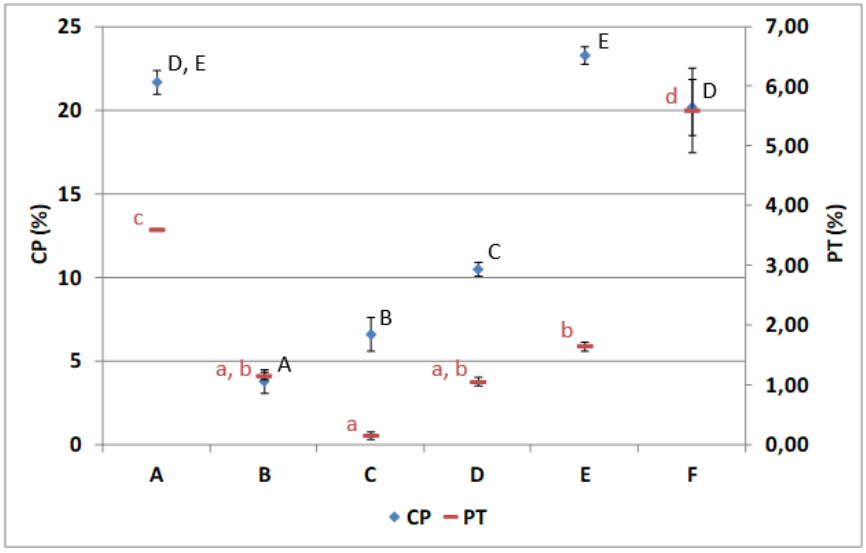

Figure 1. Polar compounds (CP) and total polymers (PT) of oils extracted from potato chips. Different letters show significant differences ($p<0.05$) between samples for each analysis according to the Tukey test.
Source: Authors (2023).

It is observed that, although no oil exceeds the limit established by the RBN for frying oils (25 %), samples A, E and F showed a CP value significantly higher than the others and close to the limit. Samples A and F also showed the highest polymer values. Polymers are formed mainly in the heating of oils, so it can be said that these potatoes, A and F, were fried in an oil with a prolonged use or with a poor management of frying practices (Aladedunye & Przybylski, 2009).

The composition of the polar compounds was also analyzed (**Figure 2**), where it was found that these three samples with high CP values differed in the distribution of them.

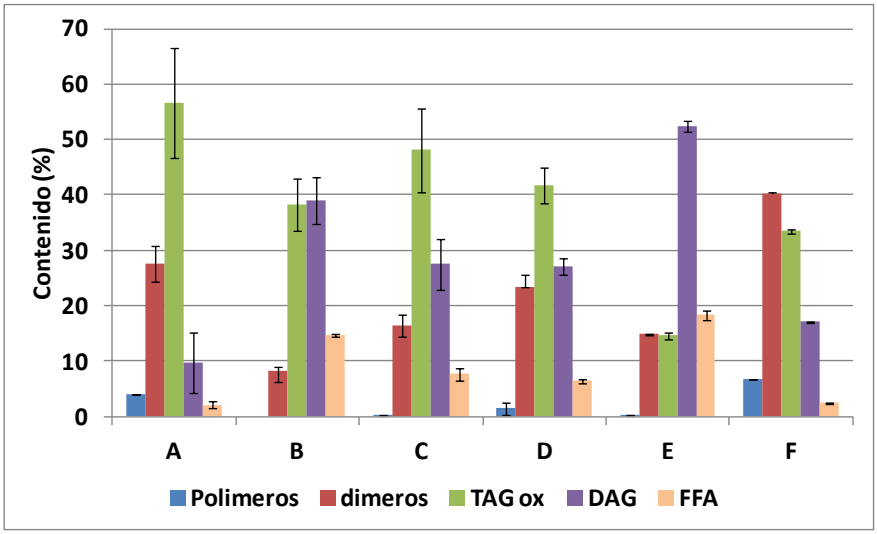

Figure 2. Composition of the polar compounds of oils extracted from potato chips. TAG ox: oxidized triacylglycerides; DAG: diacylglycerides; FFA: free fatty acids.
Source: Authors (2023).

In the case of sample A, it presented a high proportion of ox GAT, which is in agreement with the high VP and the reduction in tocopherols found. Therefore, it could be said that their handling during storage was not adequate or they are close to the end of their useful life. An

observed aspect, related to this, is that the package of these potatoes is partially transparent, so the incidence of UV rays may be the main cause of the observed deterioration.

As for F, it presented a high proportion of dimers and polymers, which had already been observed in the measure of total polymers. This confirms that the oil in which these potatoes were fried was in an advanced state of deterioration.

In sample E, a higher proportion of HGD and FFA was found, which is consistent with the high acidity value presented. This hydrolytic deterioration, as already mentioned, could be due to poor handling in the frying process. The accumulation of these compounds in frying oil decreases the shelf life of the fried product (Gupta, 2004).

4 CONCLUSION

This work aimed to evaluate the quality of potato chips for sale in the Uruguayan market, in order to evaluate how they impact the different processes that transit this food in the same one. It was found that most of the potatoes analyzed meet the requirements of the RBN. Nevertheless, it was observed that in some cases the oils contained in them have an advanced deterioration. It is mainly caused by poor control in the frying process or by poor handling in the storage and packaging of the product.

Therefore, it is possible to highlight the impact on the quality and shelf-life of these products of frying under the appropriate conditions and discarding the oil before reaching high levels of deterioration. As well as taking precautions in the packaging of fried food, both the atmosphere inside the package (exposure to oxygen) and the material of the package, and the conditions in which the packaged products are stored, mainly exposure to light and heat.

Carrying out this type of studies sporadically collects information about what our population consumes and from there the influence it can have on their health. It is also possible to discuss whether the existing regulations are adequate to ensure the safety of food offered by the market.

Future studies could assess the influence of the origin of the oils used in frying and the region of production of potato chips. Another aspect that may be interesting to study, in the case of imported foods, is where the packaging is carried out, at origin or at destination, making the bulk import.

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