Journal homepage www.jzs.univsul.edu.iq
Journal of Zankoy Sulaimani
Part-A- (Pure and Applied Sciences)

Effects of the adding of phenolic compounds on coating pickup and oil absorption of wheat flour based batters

Shokhan Hidayat Hamarashid

Department of Food Science and Human Nutrition, Faculty of Agricultural Science- Sulaimani, Bakrajo Street, Sulaimanyah- Iraq.
Email: shokhan.hamarashid@univsul.edu.iq

Article info
Original: 09/12/2017
Revised: 08/01/2018
Accepted: 06/02/2018
Published online:

Key Words:
Phenolic compound
Deep fat frying
Potato strips
Batter
Pick-up

Abstract

The effect of addition of different phenolic compounds including tannic acid, green tea extract containing 40% EGCG (epigallocatechin gallate) and onion extract including 20% quercetin, to batter formulations on the properties of deep-fat fried potato strips were evaluated. In the beginning, coating pick up of batter formulations were done before deep fat frying. Then, moisture content of samples after frying was found. Finally, the oil content of samples was determined after the frying process and drying. The deep fat frying was processed at 180°C. Green tea extract, and onion extract had no significant influence on moisture content in potato strips. On the contrary, the battered potato strips containing tannic acid had the lowest moisture content and differed significantly from the control. The lowest oil absorption was found in tannic acid batter coated potato strips, and the greatest in green tea extract batter coated potato strips but there was no significant different. Using the phenolic compounds in batter did not significantly ($p>0.05$) affect the coating pickup. The best result was obtained for the tannic acid batter because it had the highest batter pick up 46 % and the lowest oil absorbed by 36% compared to the other samples.

INTRODUCTION

Fried foods are a major part of diets around the world. Deep fat frying is an old food processing method, which is still popular today. Therefore, it can improve properties of food for example; it can change our sensory evaluation of food products. In the deep fat frying process, various changes happen. For instance, water content in a food product becomes evaporated, change in protein structure occurs by protein denaturation and starch gelatinization [1]. Most of the fried foods have a high oil content that is nearly 1/3 the weight of the product [2]. High fat diets are associated with many types of diseases such as obesity, diabetes and heart diseases. Therefore, people's demand for reducing oil in fried food is increasing. There are many techniques used to reduce the fat in fried foods. Using a fat re- placer is one of the techniques, as an increased use of a fat re- placer leads to reduced fat in the fried foods. However, using fat replacers may have an effect on some properties of food products such as texture and flavour. Furthermore, there are many different types of fat re- placer, but the main groups are carbohydrate-based- hydrocolloids, protein-based and fat-based [3]. In addition, batter is a regular layer that is applied before the frying process. It can promote food properties, which include texture, flavour and appearance. According to Chen (2009) [4] and Salvador (2005) [5] the characterization of food products can be provided by batter systems. Battered food is more tender and juicy than other foods because the batter formulation covers food properly. There are many factors to affect the properties of batter such as, the ingredients in the batter, the temperature and duration of

the frying process and the method of heating. Some ingredients are commonly used in the batter formulation such us wheat flour, leavening agent, salt and water. Batter consistency plays an important role on the performance of food products during frying. In particular, the properties of batter impact on coating pick up and quality of the food. Therefore, it is important to understand the interaction between flours, and other ingredients in batter systems during processing and relate these interactions to the functionalities. They might be important to the quality and sensory properties of fried food products. Another main important role of using batter to cover food is to decrease the amount of oil uptake during deep fat frying. Several studies have shown that some ingredients added to batter help to reduce oil uptake [6], [7], [8], [9], [10], [11] and [12]. Phenolic compounds are one of the types of additive that may be added to a batter system. In this situation, garlic extract, quercetin and an apple phenolic extract added to batter [7] and [13], the most important reason to use the phenolic compounds is in a variety of beneficial properties for human health. In recent years, consumers are demanding fast food with a high nutritional value whilst simultaneously hoping to reduce health risks. In fact, phenolic compounds have a high nutritional value. In particular, the addition of tannic acid, green tea rich polyphenol extract and onion extract to batter systems may lead to increasing the nutritional value of the potato strips, also reduce the oxidation of oil. Another main importance of adding phenolic compounds to batter is in reducing oil oxidation by degradation itself. Lipid deterioration and oil oxidation happen during the frying process, this can lead to increased health problems in many diseases. Sun-Waterhouse (2012) [13] found that the addition of phenolic antioxidants to the food product can reduce or prevent the deterioration of oil and lipid rancidity. Furthermore, the shelf life of a food product can be influenced by lipid oxidation [14]. The aim of this study was to test the effects of the addition of different types of phenolic compounds to a batter formulation that was composed of flour, salt and a leavening agent. The phenolic compounds studied were tannic acid; onion extract containing 20% quercetin and a green tea rich polyphenol extract (40% EGCG). The objectives of the present study were to determine the impact of these three phenolic compounds on the coating pickup to potato strips, and oil uptake during deep-fat frying and moisture content of wheat flour based fried batter in the potato strips.

Materials And Methods

A. Materials

Potatoes (*Solanum tuberosum* L. cv. Maris Piper) were bought from Asda supermarket, Reading/ UK. Most of the time, they were used on the day of purchase for the experiments. Otherwise they were used within a 24 hours period and kept in refrigerated storage at 4-8 °C. Wheat flour (White plain flour) bought from a local market, which contained protein 10.3%, Carbohydrates 70.6%, Fat 1.3% of which saturated 0.2%, Fiber 3.1% and sodium trace equivalent of salt 0.1%. Salt (Saxa,UK) was purchased from a local market in Reading. The leavening agent, consisting of disodium diphosphate (Na2H2P2O7), sodium hydrogen carbonates (NaHCO3) and Maize starch was also produced in the UK. Sunflower oil was used for the frying process and this was also bought from Asda, Reading. Petroleum ether (Fisher chemical, 40- 60 °C, Lot: 1345007) was used as the main solvent in the Soxhlet extraction. The three types of a phenolic compound used, Tannic acid (S.L.R. C76H52O46, Mol. Wt.1701.22), Onion extract (20% Quercetin) and green tea rich polyphenol extract containing 40% EGCG (epigallocatechin gallate) were donated by the Food and Nutritional Sciences department of the University of Reading.

B. Preparation of batter

The batter was composed of wheat flour, leavening agent and tap water by 1:1.5 weight of ingredients / weight of water [15]. Besides this, samples were prepared by adding the different phenolic compounds (Table: 1). Samples were prepared individually and mixed manually until all compounds were thoroughly blended without any aggregation.

Table1. Formulations for batter system

	Formulations (g)			
Ingredients	**1**	**2**	**3**	**Control**
Wheat flour	86.9	86.9	86.9	91.9
Salt	5	5	5	5
Leavening agent	3.1	3.1	3.1	3.1
Tannic acid	5	-	-	-
Onion extract	-	5	-	-
Green tea extract	-	-	5	-

C. Potato preparation

Potato was used as a modal food in this study [9], [12] and [13]. They were washed, peeled and cut manually. The potatoes were cut into strips (7×7 length, 5 width mm <cutting size>) [9] and then weighed individually before use in the experiments.

2.4. Batter pickup

According to Varela and Fiszman (2011) [16], 'batter pickup' is defined as the quantity of batter that adheres to the modal food. To measure batter pick up here, the uncoated potato strip was weighed, then it was immersed in batter for 10 seconds and weighed again [17]. The batter pick up was determined as follows:

$$\text{Batter pickup (\%)} = \frac{weight\ of\ coated\ potato - weight\ of\ uncoated\ potato}{weight\ of\ uncoated\ potato} X100$$

D. Frying process

The potato strips were fried using sunflower oil whose composition was 92% lipids, of which 11% was saturated, 20% monounsaturated, and 61% poly unsaturated fatty acids. The potato strips were fried in a batch system of four pieces fried in the same pan at a time. After frying each batch, the level of oil in the pan was checked for any decrease in volume. In a pan, the quantity of oil was much higher than the potato strips by 1:6 (potato strip: oil) [12]. The temperature was controlled at 180°C and the time of frying for all potato strips between 2-5 minutes depending on the variety of batter formations and the amount of batter adhesion to the potato strips [9] and [12], there being differences of heat transfer between batter formulations. After frying each four pieces of potato strips, the oil was changed. Therefore, keeping optimum cleanliness and preventing interference between potato strips coated with different batter formulations.

E. Moisture content analysis

Moisture or water content on all samples was found by using an oven drying process at 105°C until the samples reached a constant weight [18]. The moisture content was calculated by using the following equation:

$$\text{Moisture (\%)} = \frac{Initial\ weight\ of\ sample - final\ weight\ of\ sample}{Initial\ weight\ of\ sample} X100$$

F. *Fat Content analysis*

Soxhlet extraction was used to determine the oil content in the dried sample after processing [1], [5], [7], [8], [9], [12] and [16]. The technique needs a thimble paper of 24cm which is weighed before the potato strips are placed on it, and then put into a porous container. After reaching a temperature of more than 60°C, Petroleum ether starts boiling. The Petroleum ether vapour was cooled by condenser. This extraction technique takes six hours. The solvent was evaporated after oil extraction by using Rotavapor (BUCHI R110, UK). The oil content was calculated using the following equation:

$$\text{Oil content (\%)} = \frac{weight\ of\ extracted\ oil}{weight\ of\ sample} X100$$

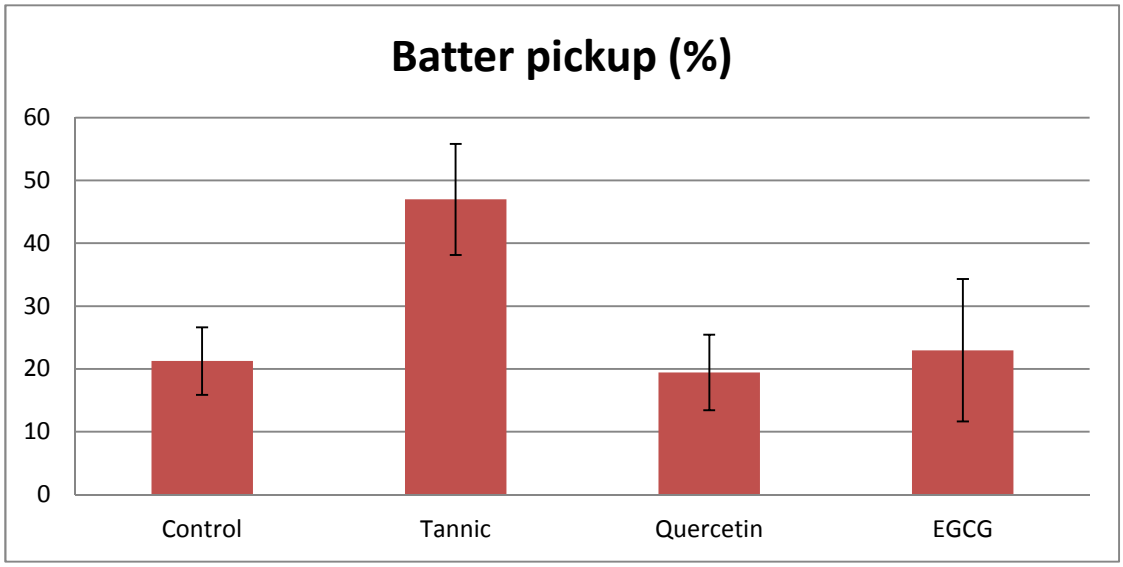
Statistical analysis

The experimental results recorded were means with standard deviation (SD). A comparisons between means were found in experiments assessed by t-test ($p < 0.05$) in Microsoft excel. The T- Test was performed to determine the difference among means in moisture content, oil content and batter coating pickup of deep fat fried potato strips coated with batters of different formulations. Tests of significant differences were determined by t- test in range tests at $p < 0.05$.

Results And Discussion

Effect of the phenolic compounds on batter pickup

The effect of the addition of phenolic compounds on the batter pick-up of potato strips is presented in Figure 1. The value of batter coated uptake of tannic acid, green tea extract, onion extract and control were 46 %, 22 %, 19 %, 21%) respectively. The tannic acid added batter had the highest value of batter pickup. It can be said that the increasing in the viscosity causes increasing of batter pickup. Therefore, batter coating up and viscosity have a direct correlation [7]. The addition of phenolic compounds leads to increase the batter coating pickup value (Figure: 1) compared to controls except onion extract (20% Quercetin), which was the lowest value of all but it was significant. In contrast, not significant differences were detected between controls and phenolic compounds added batter formulations. Although, the value of batter pick up of the onion extract (20% Quercetin) was slightly smaller than controls samples, the viscosity of it was still higher than the control.

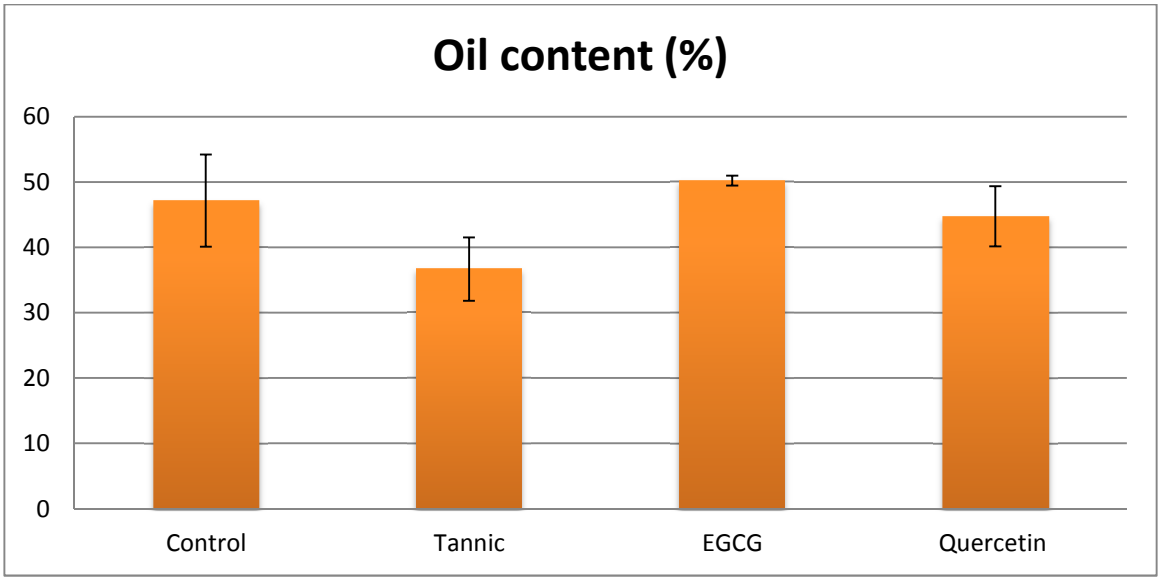


Figur-1: Impacts of the phenolic compounds on batter pick up of fried potato strips.

Oil uptake

The impact of adding tannic acid, onion extract and green tea extract on batter formulations on the oil uptake of the potato strips during frying was investigated (Figure: 2). The results shows that the batter containing green tea extract (40% EGCG) had the highest value of oil uptake during frying 50% that was higher than control batter samples by 3% but it did not significant different from control. With reference to Schwarz (2001) [20] green tea extract has a high antioxidant activity, but it does not make a difference of oil uptake so, in this study that was absorbed a high amount of oil during frying. It would result in hydrophobic characterisation in green tea extract. Therefore, increasing oil absorption would be due to increasing hydrophobic characterisation on the surface [11]. On the other hand, batter with tannic acid absorbed less oil than the other batter 36 % but there was no lower significantly than other batter. Rose (2013) [21] found that flour containing tannins decreased oil absorption during fried process. In addition, the ability of tannic acid to absorbed less oil than other might be referring to a hydrophilic character on tannic acid [21]. Tannic acid

has a hydrophilic character, this helps to increase the ability to bind water in batter and absorbed less oil. Possibly, the ability of proteins to absorb oil is reduced due to the relationship between tannins and protein [21].Priya (1996) [11] reported that between oil and water if a surface tension decreased, it can result in increased oil absorption. In other words, the increasing of oil uptake on green tea extract batter would result in reducing a surface tension between oil and water. However, this was not significantly different from the control batter. The reduction of oil uptake in the case of tannic acid may be related to these viscosity-building effects. The highest oil content was observed when green tea extract was added to the batter formulation as compared with the control and other phenolic compound added batters [1]. This might be due to its high moisture content, which could not provide an efficient barrier for oil uptake.



Figur-2: Effects of added polyphenols on oil content of deep fat fried battered dried potato strips.

Although, tannic acid had a highest value of batter pick up compared to the other phenolic compounds added to the batter formulation, the tannic acid batter had the lowest level of oil content than the other samples that added onion extract and green tea extract. This means the tannic acid added batter decreased oil absorption compared with other phenolic compounds added to batter formulation. In this study, whole grain flour used to preparation the different batter formulation. The flour contained 10.3% protein. In fact, protein raises the absorption of oil. Nevertheless, tannic acid has a strong connection to bind the portion. Reducing oil absorption in tannic acid added batter due to the ability of tannin to binding the protein [21]. The statistical result showed that the batter containing phenolic compounds was not significantly different from control.

Moisture content

In the present study, water content in a different batter showed different characteristics depending on the type of phenolic compounds added to the batter formulation. The amount of moisture content has many influences on batter coating and oil content. Moreover, that is not only effect for those because of the moisture content have impact on the appearance and texture of food production [22]. With reference to Akdeniz (2006) [7], Moisture loss and oil uptake had a reverse relationship. It means losing a high amount of water during deep fat frying process leads to more oil absorption of the food product. This means the high amount of moisture content may cause reduced oil absorption during deep fat frying process. The effect on different phenolic compounds added to batter on moisture content was found and is shown in figure 3. The moisture content on batter including green tea extract (40% EGCG) was the highest value 62 %, followed control, onion extract (20% Quercetin) batter, and tannic acid batter values 60%, 59 %, 52 % respectively. However, the moisture content on batter with added onion extract and green tea extract was not significantly different from control but the moisture content in tannic acid added batter was significantly lower than the control. Rimac-Brncic (2004) [12] reported that some additive to a batter system may alter the capacity of water holding, it will have influence of absorbed oil. The ability of holding water capacity leads to retention of water in the food

product and then causes by preventing of losing water and it is altered by oil. Even though, green tea extract added batter increased oil absorption during deep fat frying, it had the highest value of moisture content. Moreover, moisture content of tannic acid and onion extract were lower than control. These did not ability to retention water during deep fat frying. Consequence, the green tea rich polyphenol (40% EGCG) added batter absorbed oil more than onion extracted (20% Quercetin) and tannic added batter.

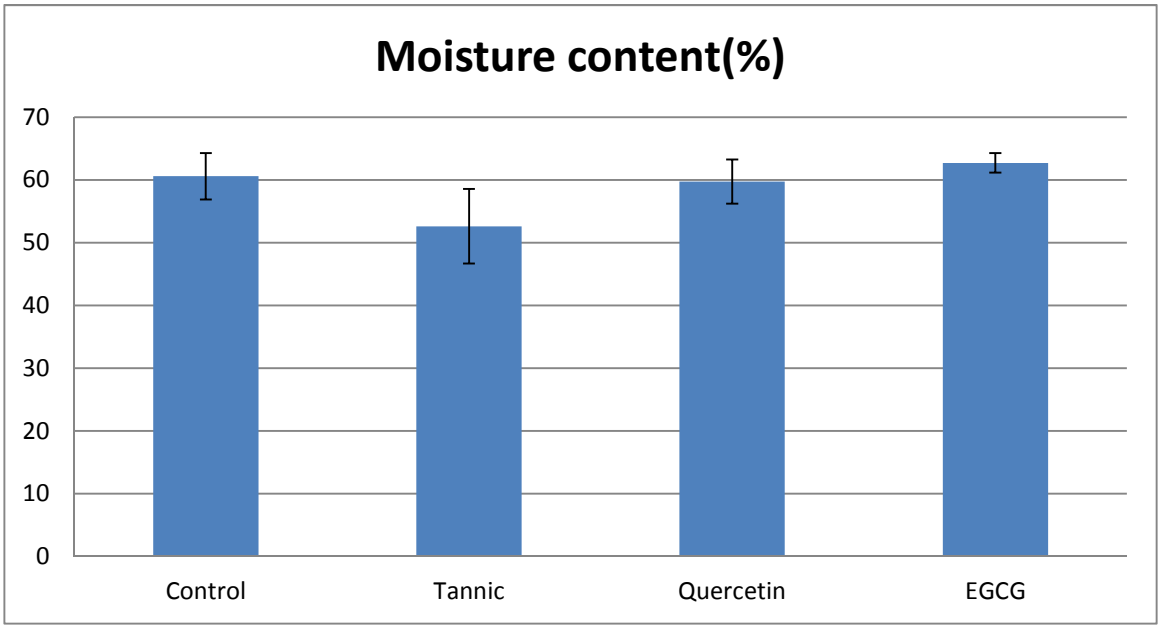


Figure-3: Effects of the different polyphenols on moisture content of deep fat fried battered potato strips.

The green tea rich polyphenol extract (40% EGCG) added to batter had the highest moisture content, but it showed an increase in a high amount of oil during frying process (Figure.3). As mentioned above, batter with added tannic acid had the highest highest value of batter pick up, the lowest amount of oil uptake would be the result the main tannic acid that is the tannin protein interaction. Due to the relationship the tannins has ability to binding proteins because some tannins display a strong affinity for protein [23]. Therefore, wheat flour is rich in protein with the affinity of tannins can inhibit oil absorption [21]. According to Frazier (2013) [23], the affinities of tannins to bind the protein has several implications important in human health. For instance that binding is important to protect low- density lipoproteins (LDLs). Furthermore, it had been reported by Arts (2002) [24], the linking between tannins and proteins has impact on the total antioxidants capacity.

Conclusion

Adding different phenolic compounds to batter formulation were influential on properties, coating pickup, oil absorption during deep fat frying, and moisture content. However, onion extract reduced batter coating but not significantly different. Tannic acids lose more water during deep fat frying compared to the other samples and significantly different from control. Nevertheless, the lowest oil uptake was found in tannic acid added batter, as would be an expected result between the protein relationships in tannins. On the contrary, oil uptake batter formulations with added phenolic compounds, not significant different. So, phenolic compounds can be recommended to be used in batter formulation for foods especially potato strips. In particular, tannic acid can be selected the best one compared with green tea and onion extract to add to batter. Therefore, it can produce a healthier potato by the protein interaction phenomenon and absorb less oil than other.

References

[1] Sahin, S., Sumnu, G., Altunakar, B., "Effects of batters containing different gum types on the quality of deep-fat fried chicken nuggets" Journal of the Science of Food and Agriculture, No. 85, pp.2375–2379.(2005).

[2] Mellema , M., "Mechanism and reduction of fat uptake in deep-fat fried foods. Trends in Food Science & Technology, Vol.(14), pp.364–373. (2003).

[3] Akoh, C. C., "Fat Replacers". Food Technology,No.52, pp.47-52. (1998).

[4] Chen, S., Chen, H., Chao, Y., Shinn Lin, R., "Effect of batter formula on qualities of deep-fat and microwave fried fish nuggets". Journal of Food Engineering, No. 95, pp.359–364. (2009).

[5] Salvador, A., Sanz, T., Fiszman, S. M., "Effect of the addition of different ingredients on the characteristics of a batter coating for fried seafood prepared without a pre-frying step" Food Hydrocolloids, No. 19, pp.703–708. (2005).

[6] Baixauli, R., Sanz, T., Salvador, A., Fiszman, S. M., "Effect of the addition of dextrin or dried egg on the rheological and textural properties of batters for fried foods" Food Hydrocolloids, No. 17, pp.305–310. (2003).

[7] Akdeniz, N., Sahin, S., Sumnu, G. "Functionality of batters containing different gums for deep-fat frying of carrot slices". Journal of Food Engineering, pp.522-526. (2006).

[8] Dogan, S. F., Sahin, S., Sumnu, G., "Effects of soy and rice flour addition on batter rheology and quality of deep-fat fried chicken nuggets". Journal of Food Engineering Vol.(71), pp.127–132. (2005).

[9] Garc´ıa, M. A., Ferreroa,C., Be´rtola, N., Martino, M., Zaritzky, N., 20. "Edible coatings from cellulose derivatives to reduce oil uptake in fried products". Innovative Food Science and Emerging Technologies 3, pp.391–397. (2002).

[10] Nor, M. F., Mohamed, S., Idris, N. A., Ismail, R., "Antioxidative properties of Pandanus amaryllifolius leaf extracts in accelerated oxidation and deep frying studies" Food Chemistry, Vol. (110), pp. 319–327. (2008).

[11] Priya, R., Singhal, R.S., Kulkarni, P. R., "Carboxymethylcellulose and hydroxypropylmethylcellulose as additives in reduction of oil content in batter based deep-fat fried boondis" Carbohydrate Polymers, No. 29, pp. 333-335. (1996).

[12] Rima-Brn_ci_c, S., Lelas, V., Rade, D., _Simundi_c,B., "Decreasing of oil absorption in potato strips during deep fat frying" Journal of Food Engineering, No. 64, pp.237–241. (2004).

[13] Sun-Waterhouse, D., Xue, D., Wadhwa, S., "Effects of Added Phenolics on the Lipid Deterioration and Antioxidant Content of Deep-Fried Potato Fritters" Food Bioprocess Technol, No. 10, 1-10. (2012).

[14] Chirinos, R., Human, M., Betalleluz-Pallardel, I., Pedreschi, R., Campos, D., "Characterisation of phenolic compounds of Inca muna (Clinopodium bolivianum) leaves and the feasibility of their application to improve the oxidative stability of soybean oil during frying". Food Chemistry, No. 128, pp.711–716. (2011).

[15]Amboon, W., Tulyathan, V., Tattiyakul, J., "Effect of Hydroxypropyl Methylcellulose on Rheological Properties, Coating Pickup, and Oil Content of Rice Flour-Based Batters". Food Bioprocess Technology, pp. 601–608. (2012).

[16] Varela, P., Fiszman, S. M., "Hydrocolloids in fried foods. A review. Food Hydrocolloids, pp.1801-1812. (2011).

[17] Chen, H. H., Kang, H. Y., Chen, S. D., "The effects of ingredients and water content on the rheological properties of batters and physical properties of crusts in fried foods". Journal of Food Engineering, No. 88, pp.45–54. (2008).

[18] AOAC." Official methods of analysis (14th ed.)". Method 28.074. Washington, DC: Association of Official Analytic Chemists. (1984).

[19] Moreira, R. G., Barrufet, M. A., "A new approach to describe oil absorption in fried foods: a simulation study". Journal of Food Engineering, Vol. (35), pp.1-22. (1997).

[20] Schwarz, K., Bertelsen, G., Nissen, L. R., Gardner, P. T., Heinonen, M. I., Hopia, A., Huynh-Ba, T., Lambelet, P., McPhail, D., Skibsted, L. H., Tijburg, L., "Investigation of plant extracts for the protection of processed foods against lipid oxidation. Comparison of antioxidant assays based on radical scavenging, lipid oxidation and analysis of the principal antioxidant compounds" Eur Food Res Technol, No. 212 , pp.319–328. (2001).

[21] Rose, D. J., Williams, E., Mkandawire N. L., Weller C. L., Jackson, D. s., "Use of whole grain and refined flour from tannin and non-tannin sorghum (Sorghum bicolor (L.) Moench) varieties in frybread" Food science and technology international, Vol. (0), No. 0, pp. 1–7. (2013).

[22] Gamonpilas, C., Pongjaruvat, W., Methacanon, P., Seetapan, N., Fuongfuchat, A., Klaikherd, A., "Effects of cross-linked tapioca starches on batter viscosity and oil absorption in deep-fried breaded chicken strips". Journal of Food Engineering, Vol.(114), pp.262–268.(2013).

[23] Frazier, R. A., "Interactions of Tea Tannins with Proteins and Their Impact on Food Quality and Health. Food and Bioprocessing", Vol. (10), pp.1469- 1490. (2013).

[24] Arts, I. C., Hollman, P. C., "Polyphenols and disease risk in epidemiologic studies". American Society for Clinical Nutrition,No. 81, pp.317S- 325S. (2005).