

Research Article

Using modified starch to decrease the oil absorption in fried battered chicken

Punchira Vongsawasdi^{1,*}, Montira Nopharatana², Wimonrat Srisuwatree¹,
Surachadaporn Pasukcharoenying¹ and Nattee Wongkitcharoen¹

¹Department of Microbiology, King Mongkut's University of Technology Thonburi, Bangkok, Thailand

²Department of Food Engineering, King Mongkut's University of Technology Thonburi, Bangkok, Thailand

*Corresponding author: punchira.von@kmutt.ac.th

This paper was originally submitted for presentation at SDSE2008.

Abstract: Batter is normally used prior to deep fat frying in order to improve the palatability and appearance of fried food. However, fried battered food contains a substantial amount of fat. The reduction of the fat content in fried food is desirable, mainly due to its relationship with obesity and coronary diseases. This study was carried out with the aim of investigating the effect of modified starch on the reduction of oil absorption in a battered product. Two types of modified starch which were crispfilm[®] (modified high amylose corn starch) and crispcoat[®] (a blend of high amylose corn starch and tapioca dextrin) were used to substitute 10 % (w/w) of wheat flour in the batter formula. The physicochemical properties of batter and oil absorption of the fried product were examined. The results showed that the addition of crispfilm[®] into batter provided the lowest oil absorption when compared with the batter containing crispcoat[®]. Crispfilm[®] containing batter had amylose content, peak viscosity, batter pick-up, moisture content and oil content of 31.87±0.25%, 1657.67±3.52cP, 32.93±1.53%, 25.25±0.87% and 20.29±0.62% respectively, whereas crispcoat[®] containing batter had properties of 29.87±0.45%, 1331.00±8.72cP, 29.38±1.6%, 39.39±0.37% and 30.50±1.58%, respectively. From the results it is implied that crispfilm[®] containing batter was proven to be more effective in reducing oil uptake in the fried product. The oil absorption had linear inverse relationship with amylose content of the batter ($r^2=0.999$) but linear proportion with moisture loss of the fried product ($r^2=0.995$).

Keywords: food, cooking, physicochemical properties, additives, batter, deep-fat frying

Introduction

Consumption of fried battered food, especially fish, seafood, poultry and vegetables has become very popular as batter and the frying process can improve the organoleptic characteristics of the food including, appearance, flavour, taste and texture. However, fried battered food usually contains a considerable amount of oil which causes obesity and coronary diseases. The absorbed oil also decreases product shelf-life through the oxidation process. Rimac-Brncic *et al.* [1] concluded that the degree of oil absorption is significantly affected by process conditions, oil origin, composition of oil, pretreatment of food and physicochemical characteristics of food. As cited by Altunakar, Sahin and Sumnu [2], the crust formed during frying apparently functions to reduce water loss which in turn, lessens oil absorption. Kunanopparat, Siri wattanayotin and Bhumiratana [3] reported that amylose played an important role in crust formation. Therefore, a batter formulation with special ingredients including high amylose starch was examined to investigate the effect on oil absorption in fried food. Recently, modified starch has become a vital part of the food industry because its functional properties impart some important aspects to the final products. Various forms of modified starches prepared from oxidation, substitution, dextrinization and pregelatinization have been investigated in the preparation of fried battered food [4]. A number of researchers found that the use of dextrans in fried battered seafood could maintain crispness of the products after frying [5-6]. However, no scientific information on the effect of modified starches containing high amylose on oil absorption of battered and deep fat fried products has been reported. The aim of this study was to investigate the effect of modified starch on the reduction of oil absorption in a battered product.

Methodology

Materials

Modified starch under the commercial brand; crispfilm[®] (modified high amylose corn starch) and crispcoat[®] (a blend of high amylose corn starch and tapioca dextrin) and batter bind S[®] were obtained from the National Starch and Chemical Company, Bangkok. Wheat flour, seasoning, palm oil, skinless boneless breast of chicken meat (SBB) and all other ingredients were purchased from a local market.

Sample preparation

Chicken meat was hand-cut into 3x5x1 cm strips. Each sample was weighed before dipping in to batter in order to obtain a uniform weight of 16 ± 1 g.

Batter formulations were composed of 1.25:1 solid to water ratio. The solid content of control batter formulation contained 76.10% of wheat flour, 20% of batter bind S, 6% of seasoning and 0.90% of baking soda. In the experimental formulations, 10% of wheat flour was replaced with either 10% of crispfilm[®] or 10% of crispcoat[®]. The batter was prepared by mixing the dry ingredients with cold water ($15 \pm 1^\circ\text{C}$) using a mixer (Kenwood, HM 320, UK) at the lowest speed for 10 min.

Frying

Samples were deep fried in a commercial bench-top deep fat fryer (Fritel, Belgium) containing 4 L of oil. Palm oil was preheated at $180 \pm 10^\circ\text{C}$ for 30 min. prior to the commencement of frying. Two pieces of the sample were placed in a wire basket to ensure good contact between the sample and the frying oil medium. Samples were then fried for 5 min. After frying each batch, the oil was filtered to remove batter debris and the oil was replaced after 6 hr. frying time.

Amylose content determination

Amylose content was determined by iodine binding according to the method of Juliano [7]. A calibration curve was derived using a set of maize starches with 0 to 75% amylose.

Determination of pasting properties

Pasting properties of batter formulations were determined using the Rapid Viscosity Analyzer (Newport Scientific, RVA-3, Australia). Standard profile STD1 supplied with the instrument was used with the mixture of 3 g of sample and 25 ml of distilled water. The slurry was held at 50°C for 1 min. and then heated to 95°C at a rate of $11.84^\circ\text{C}/\text{min}$. After holding at 95°C for 25 min., the sample was cooled to 50°C at a rate of $11.84^\circ\text{C}/\text{min}$ and held for 4.4 min. The rotation speed was maintained at 160 rpm during the process. Peak viscosity (PV), trough and final viscosity (FV) were recorded while breakdown and setback were calculated using the thermocline software.

Batter pick-up determination

Batter pick-up was the amount of batter adhering to chicken during immersion coating prior to frying and calculated as the weight of coating picked up by the chicken meat multiplied by 100.

$$\text{Batter pickup} = \left(\frac{B}{B+S} \right) \times 100$$

where B is mass of the coating, and S is mass of the chicken.

Determination of moisture loss and fat content

Moisture loss in the batter coating was analyzed immediately after frying. The batter coating was removed from the chicken and cut into small pieces. Six grams of each sample were dried in a hot air oven at $105 \pm 2^\circ\text{C}$ [8]. The dried samples were subsequently extracted with petroleum ether in a Soxhlet apparatus (Buchi, Switzerland) over a 12 h period [9].

Texture analysis

A TA-XT2i Texture Analyser (Stable Micro System, UK) equipped with 25 kg of load cell was used to evaluate the texture of fried coating. A cutting blade was attached to the instrument and the sample was placed on the HDP/90 Heavy Duty Platform with a slotted blade. The cross head speed was 1 mm/s. The values of maximum peak force and number of peaks were recorded.

Colour determination

The colour of the coatings after frying was measured using a colour meter (Hunter Lab,

Ultra Scan XE/IX7, USA). The parameters determined were L (0 = black and 100 = white), a (+a = greenness and -a = redness) and b (+b = blueness and -b = yellowness).

Sensory evaluation

The sensory qualities of batter-fried products were evaluated by a twelve member panel who were trained for a period of 1 month to become familiar with sensorial attributes of fried battered chicken. Panelists were asked to evaluate the samples in terms of colour (0 = dark or white to 5 = golden-yellow), flavour (0 = extremely oily to 5 = natural fried battered chicken), texture (0 = soft or hard to 5 = crispy) and acceptability (0 = dislike very much to 5 = like very much). The acceptability score of 3.0 was taken as the lower limit of acceptability.

Statistical analysis

Data analysis was based on ANOVA and presented as mean values with standard deviations. Duncan's multiple range test was used to determine significant differences between the mean values of treatments ($\alpha=0.05$). All analyses were performed in triplicate.

Results and Discussion

Amylose content

The amylose content of all batter formulas were significantly different ($p \leq 0.05$) as shown in Figure 1. Crispfilm[®] containing batter had the highest amylose content of $31.87 \pm 0.25\%$ whereas crispcoat[®] containing batter and the control sample had amylose content of $29.87 \pm 0.45\%$ and $28.47 \pm 0.25\%$, respectively. High amylose content in the crispfilm[®] and crispcoat[®] batter resulted from the composition of modified starch added to replace wheat flour. Modified starch in the crispfilm[®] formulation is a high amylose corn starch while that in the crispcoat[®] formulation is a mixture of high amylose corn starch and tapioca dextrin.

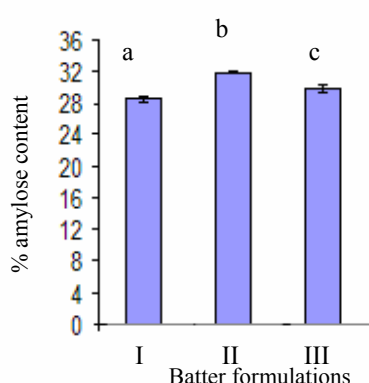


Figure 1. Amylose content of batter formulations (I = control, II = crispfilm[®] formulation, III = crispcoat[®] formulation) (The letters [a,b,c] are significant difference ($p \leq 0.05$)).

Pasting properties of batter

The shape of pasting curves obtained from all batter formulations was similar (Fig.2). However, Table 1 demonstrates that batter formulation significantly affected pasting properties ($p \leq 0.05$). The pasting temperatures of the crispfilm[®] formulation and control formulation were significantly higher than that of the crispcoat[®] formulation ($p \leq 0.05$). This implied that the crispcoat[®] formulation could be cooked at a lower temperature. The peak viscosity which indicated the water-binding capacity of the mixture significantly decreased when either crispfilm[®] and crispcoat[®] was substituted in the batter. The control sample showed the significantly highest trough viscosity of 1278.50 ± 3.50 cP. The breakdown values of crispcoat[®] formulations were significantly lower than that of the control and crispfilm[®] formulation ($p \leq 0.05$) which indicated that the ability to withstand heat and shear stress of batter containing crispcoat[®] was better than that of the control batter and batter containing crispfilm[®]. Setback values of crispfilm[®] and crispcoat[®] formulations were significantly lower than that of the control formulation. This inferred that modified starch substitution in batter formulation could lessen the syneresis problem.

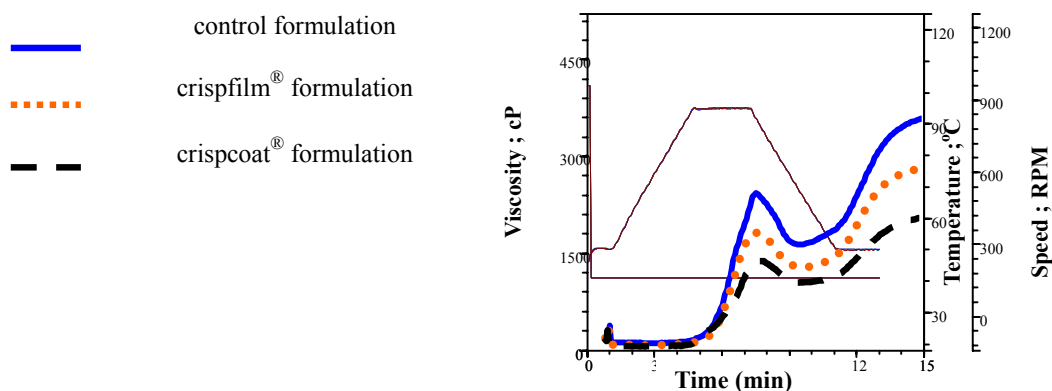


Figure 2. Pasting properties of batter formulations by Rapid Viscosity Analyzer (RVA).

Table 1. Pasting properties of batter formulations.

Pasting parameters*	Control formulation	Crispfilm [®] formulation	crispcoat [®] formulation
Peak viscosity (cP)	$1921.67^a \pm 8.33$	$1657.67^b \pm 3.52$	$1331.00^c \pm 8.72$
Trough viscosity (cP)	$1278.50^a \pm 3.50$	$1160.67^b \pm 4.51$	$1035.00^c \pm 26.87$
Final viscosity (cP)	$2859.67^a \pm 34.65$	$2567.34^b \pm 19.60$	$2011.00^c \pm 12.0$
Breakdown (cP)	$646.50^a \pm 13.44$	$497.00^b \pm 6.93$	$336.00^c \pm 21.21$
Setback (cP)	$1515.00^a \pm 32.53$	$1406.67^b \pm 17.62$	$1028.00^c \pm 20.52$
Pasting temperature(°C)	$86.02^a \pm 3.66$	$88.22^a \pm 1.34$	$82.88^b \pm 0.47$

* means with different letters (a,b,...) in the same row are significantly different ($p \leq 0.05$)

From the results, substitution of modified starch caused a decrement of peak viscosity, trough viscosity, final viscosity, breakdown and setback. These trends in viscosity changes as a function of amylose content agreed with a report on pasting characteristics of wheat

starches [10]. Srirot and Piyachomkwan [11] explained that the swelling ability of starch granules in high amylose containing starch was low, thus resulting in lowered viscosity. Blazek and Copeland [10] found that an increase in amylose would produce a gel, in which there was a higher degree of amylose aggregation with more closely spaced junction zones and a tighter network, which could result in a decrease in gel viscosity.

Measurement of batter pick-up

Figure 3 shows that batter composition significantly affected the amount of coating picked up by the chicken strips ($p \leq 0.05$). Percentage of pickup of the control formulation ($39.62 \pm 1.72\%$) was significantly higher than those of the batter with crispfilm[®] ($32.93 \pm 1.53\%$) and crispcoat[®] ($29.38 \pm 1.60\%$). This was because the control formulation had higher viscosity which corresponded to higher batter pick up. This finding agreed with published data of Salvador, Sanz and Fiszman [6] who reported that the higher batter viscosity was associated with the higher batter pick-up.

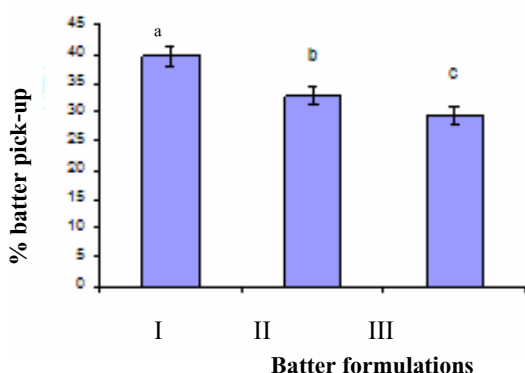


Figure 3. The percentage of batter pick-up of batter formulations (I = control, II = crispfilm[®] formulation, III = crispcoat[®] formulation) (The letters (a,b,c) are significant difference ($p \leq 0.05$))

Moisture loss and fat content of fried crust

The moisture loss and fat content of the crust after frying are presented in Fig.4. The control formulation showed the highest moisture loss and oil content of $43.94 \pm 0.49\%$ and $35.09 \pm 1.53\%$, respectively. Crispfilm[®] formulations had the lowest moisture loss and oil content of $25.25 \pm 0.87\%$ and $20.29 \pm 0.62\%$, respectively. The results could be explained based on amylose content. During deep frying, amylose, which plays an important role in the gelatinization process, forms a gel and coats the food. This film forming characteristic allows amylose to act as a protective barrier, thus reducing moisture loss and lessening space for oil absorption [12]. For this reason, crispfilm[®] formulations which had high amylose content presented the lowest moisture loss and fat content. The results of this study corresponded with a number of published research findings. Kunanopparat, Siriwanayotin and Bhumiratana [3] found that the crust from high amylose dough had low water diffusivity and low oil absorption. Moreira, Xiuzhi and Youhong [13] reported that high moisture content of tortilla resulted in high oil absorption of the fried product.

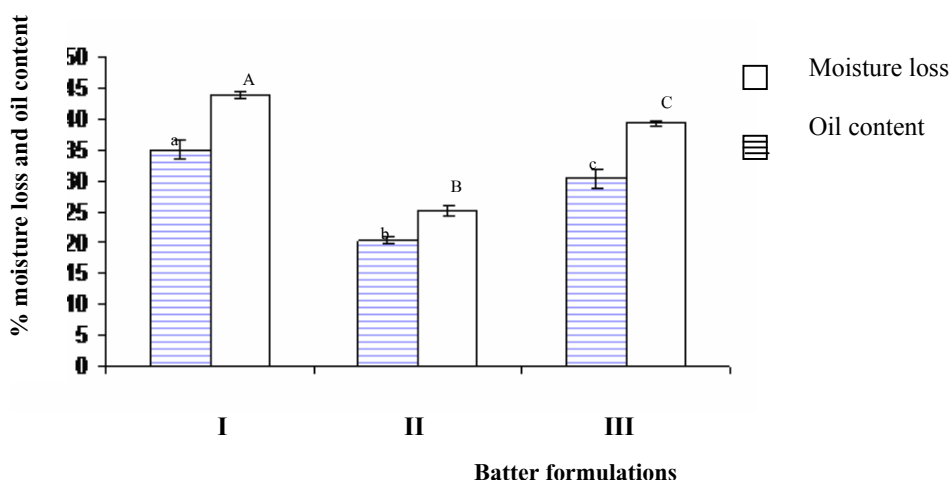


Figure 4. Moisture loss and oil content of batter formulations. (I = control, II = crispfilm[®] formulation, III = crispcoat[®] formulation) (A,B,C and a,b,c are significant difference at $p \leq 0.05$ for moisture loss and oil content, respectively)

Texture analyses

Table 2 shows the effects of different batter formulations on texture of deep fat fried chicken strips. The hardness of crispfilm[®] formulation was 12.99 ± 2.01 N and significantly higher than that of crispcoat[®] (10.27 ± 0.85 N) and control formulations (7.55 ± 1.52 N). A similar trend was found with crispness. Crispfilm[®] formulation had crispness of 4.8 ± 1.31 while that of crispcoat[®] and the control formulation were 3.8 ± 1.10 and 2.0 ± 0.71 , respectively. The results indicated that adding modified starch could improve texture development of the fried product. This was because crispfilm[®] formulation had high amylose content which could form more perfect film for coating food, which in turn prevented moisture loss and oil absorption. Owing to less oil absorption, the food texture was harder and crispier.

Table 2. Texture characteristics of deep fat fried chicken strips prepared from various batter formulations.

Formulation	Hardness* (N)	Crispness* (peak counts)
Control formulation	$7.55^a \pm 1.52$	$2.0^a \pm 0.71$
Crispfilm [®] formulation	$12.99^b \pm 2.01$	$4.8^b \pm 1.31$
Crispcoat [®] formulation	$10.27^c \pm 0.85$	$3.8^b \pm 1.10$

* means with different letters (a,b,...) in the same column are significantly different ($p \leq 0.05$)

Colour

Table 3 shows that lightness (L), redness (a) and yellowness (b) of all samples showed no significant differences ($p > 0.05$). This demonstrates that the substitution of modified starches in batter formulations does not significantly affect product colour ($p > 0.05$).

Table 3. Colour of deep fat fried chicken strips prepared from various batter formulations.

Formulation	L^{ns}	a^{ns}	b^{ns}
Control formulation	47.64 $\pm$ 1.19	10.11 $\pm$ 1.85	18.09 $\pm$ 0.76
Crispfilm [®] formulation	47.64 $\pm$ 1.79	10.00 $\pm$ 1.15	17.78 $\pm$ 1.02
Crispcoat [®] formulation	47.18 $\pm$ 2.63	9.98 $\pm$ 0.55	17.54 $\pm$ 1.34

^{ns} means in the same column are not significantly different ($p>0.05$)

Sensory evaluation

Sensory results show that batter formulations had no significant effects on colour and flavour of the fried battered products ($p>0.05$). All samples demonstrated golden-yellow tones with natural fried battered aroma. No oily or rancid odour was detected. However, modified starches significantly affected texture and, in turn, the acceptability of the fried battered products ($p\leq 0.05$). Crispfilm[®] and crispcoat[®] formulations had the same crispy level within the score range of 4.2-4.5. The acceptability score of these two batter formulations were 4.0-4.2, which meant that they were liked by the panelists.

Table 4 Sensory evaluation of deep fat fried chicken strips prepared from various batter formulations.

Formulation	Parameters			
	Colour ^{ns}	Flavour ^{ns}	Texture*	Acceptability*
Control formulation	4.3 $\pm$ 0.4	4.2 $\pm$ 0.3	3.5 ^a $\pm$ 0.6	3.2 ^a $\pm$ 0.6
Crispfilm [®] formulation	4.4 $\pm$ 0.5	4.2 $\pm$ 0.7	4.5 ^b $\pm$ 0.5	4.2 ^b $\pm$ 0.6
Crispcoat [®] formulation	4.2 $\pm$ 0.4	4.1 $\pm$ 0.5	4.2 ^b $\pm$ 0.4	4.0 ^b $\pm$ 0.2

* means with different letters (a,b,...) in the same column are significantly different ($p\leq 0.05$)

^{ns} means in the same column are not significantly different ($p>0.05$)

The relationship of oil absorption and the parameters which related to batter fried product

Linear relation of oil absorption and the parameters which related to batter fried products are shown in Table 4. The results elucidated that all RVA parameters of the starch paste did not correlate with oil absorption with R^2 ranging from 0.002-0.124. Inverse correlation was observed between oil absorption and amylose content ($R^2=0.999$) while moisture content correlated positively with oil absorption ($R^2=0.995$). High correlation coefficients indicated that amylose content and moisture loss related to oil absorption and their relations could be used to predict oil absorption.

Table 5. Linear equations of oil absorption and the factors which related to fried battered chicken.

Relations*	R ²
O = 0.006 PV + 18.397	0.060
O = 0.016 TV + 10.270	0.098
O = 0.009 BV + 24.396	0.030
O = 0.003 FV + 22.083	0.021
O = 0.001 SET + 26.844	0.002
O = 38.041 PT - 212.552	0.124
O = -4.101 AC + 150.959	0.999
O = 0.775 MC + 0.567	0.995

* O = oil absorption, PV = peak viscosity, TV = trough viscosity, BV = breakdown, FV = final viscosity, SET = setback, PT = pasting temperature, AC = amylose content and MC = %moisture loss.

Conclusions

Substitution of modified starch in the batter formulation could decrease oil absorption in fried battered chicken strips. Crispfilm[®] containing batter contained the highest amylose content. The crust of the crispfilm[®] formulation showed the lowest moisture loss and, sequentially, provided the lowest oil absorption. Oil absorption was inversely correlated with amylose content ($R^2 = 0.999$) but positively correlated with moisture content ($R^2 = 0.995$).

Acknowledgements

The authors would like to thank National Starch and Chemical Company, Thailand for providing modified starch samples. This research has been financially supported by the Royal Thai Government.

References

1. Rimac-Brcic, S., Lelas, V. Rade, D. and Simundic, B. (2004). Decreasing of oil absorption in potato strips during deep fat frying. **J. of Food Engineering**. 64: 237-241.
2. Altunakar, B., Sahin, S. and Sumnu, G. (2004). Functionality of batters containing different starch types for deep-fat frying of chicken nuggets. **Journal of European Food Research and Technology**. 218: 318-322.
3. Kunanopparat, T. Siriwattanayotin, S. and Bhumiratana, S. (2001). Effect of amylose content on oil uptake of deep fat fried dough. **KMUTT Research and Development Journal**. 24: 221-234.
4. Beirendonck, K.V. (2001). Batter and coating systems. **Food Ingredients and Analysis International**. 23: 26-28.

5. Baixauli, R., Sanz, T. Salvador, A. and Fiszman, S.M. (2003). Effect of the addition of dextrin or dried egg on the rheological and textural properties of batters for fried food. **Food Hydrocolloids**. 17: 305-310.
6. Salvador, A., Sanz, T. and Fiszman, S.M. (2004). 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**. 19: 703-708.
7. Juliano, B.O. (1971). A simplified assay for milled-rice amylase. **Cereal Science**. 19:334.
8. AOAC. (1990). *Official Methods of Analysis*. 15th ed. The Association of Official Analytical Chemists. Arlington. Virginia, USA. 1298p.
9. AACC. American Association of Cereal Chemists. (1967). *Cereal Laboratory Methods*. 30–20.
10. Blazek, J., Copeland, L. (2008). Pasting and swelling properties of wheat flour and starch in relation to amylose content. **Carbohydrate Polymers**. 71: 380-387.
11. Srirot, K. and Piyachomkwan, K. (2003). *The technology of starch*. The Kasetsart University Publishing Company. Bangkok. 126-178.
12. Dana, D. and Saguy, I.S. (2006). Review: Mechanism of oil uptake during deep fat frying and the surfactant effect-theory and myth. **Advances in Colloid and Interface Science**. 128-130: 267-272.
13. Moreira, R.G., Xiuzhi, S. and Youhong, C. (1997). Factors affecting oil uptake in tortilla chips in deep-fat frying. **Journal of Food Engineering**. 31: 485-498.