EVALUATION OF SOME EDIBLE COATINGS FOR REDUCING OIL UPTAKE OF SOME FRIED FOODS DURING DEEP-FAT FRYING

By

OSMAN, M. F.

FOOD TECHNOLOGY DEPT., FAC. OF AGRICULTURE-KAFR EL- SHEIKH UNIVERSITY, EGYPT

ABSTRACT

Sodium alginate, xanthan gum, carboxymethyl cellulose, gelatin, locust bean gum and agar-agar were used as coating formulations to reduce oil uptake and water loss of deep- fat fried potato strips and eggplant slices as a popular foods in Egypt. Sodium alginate coating was the best for reducing oil uptake, followed by xanthan gum. While carboxymethyl cellulose followed by locust bean gum were the best for reducing water loss during frying. Agar- agar coating was not suitable as a coating because it was agglomerated during coating process. All coated samples were accepted by the non- trained panelists. The foods coated with sodium alginate had the highest overall acceptance for organoleptic quality.

Keywords: edible coating; potato; eggplant; frying; oil uptake.

INTRODUCTION

Potato strips and eggplant are the most popular fried foods widely used in Egypt. Potato is one of the world's major agricultural crops and it is consumed daily by millions of people from diverse cultural backgrounds. Deep-fat frying can be defined as the process of drying and cooking through contact with hot oil (Sahin *et al.*, 1999). Deep- fat frying is the most common processing in food preparation, as evidenced by the worldwise annual production of more than 20 million tons of frying oil *(Gertz, 2004)*.

Some Fried products contain large amounts of fat, often reaching up to 40 – 45% of total product weight *(Pinthus et al., 1995)*.

Over the last decade the desirability of reducing fat content of deep fried foods has been recognized. Therefore, consumer trends are moving toward healthier and low- fat foods, creating the need to develop technologies to reduce the amount of oil in end fried products *(Bouchon et al., 2003)*.

Many approaches to reduce oil absorption in fried products have been reported in the literature. For instance, the blanching step previous frying of potato chips improves the color, texture, and could reduce, in some cases, the oil uptake by gelatinization of the surface starch *(Califano and Calvelo, 1987)*. Drying of potatoes before frying using microwave, hot- air treatment and baking has resulted in a significant reduction in oil content of different products *(Lamberg et al., 1990; Moreira et al., 1999; Krokida et al., 2001 and Moyano et al., 2002)*. Besides, vacuum frying may be an option for fried potatoes with low oil content, desired texture and flavor characteristics (Garayo and Moreira, 2002). Soaking of potato strips in NaCL solutions reduced oil uptake in French fries *(Bunger et al., 2003)*.

Mallikarjunan et al., (1997) working with mashed potato balls reported a reduction, compared to uncoated balls, of 14.9, 21.9 and 31.1% in moisture loss and of 59.0, 61.4 and 83.6% in fat uptake for samples coated with corn zein, hydroxypropylmethyl cellulose (HPMC) and methyl cellulose (MC) films, respectively.

Several hydrocolloids with thermal gelling or thickening properties, like proteins and carbohydrates, have been tested to reduce oil and water migration in deep- fat fried foods *(Debeaufort and Voilley, 1997; Williams and Mittal, 1999)*.

There are many options available to reduce fat uptake by application of coatings or batters. For instance, *Williams and Mittal, (1999)* used gellan gum to coat samples so that the resulting film reduced the oil uptake during frying.

Food coatings may become a good alternative to solve this problem. The effectiveness of a coating is determined by its mechanical and barrier properties, which depend on its composition, microstructure, and by the characteristics of the substrate *(Garcia et al., 2002)*.

The objective of this work was to evaluate the moisture retention and fat reduction capabilities of different edible coatings with some modifications (addition of glycerol and soy protein isolate) in potato strips and eggplant slices during deep- fat frying.

MATERIALS AND METHODS

***MATERIALS*:**

Potato tubers (*Solanum tuberosum*) variety Nicola, eggplant (*Solanum melongena*) variety Balady were obtained from Horticulture Dept., Agriculture Research Center at Sakha, Kafr elsheikh at 2006 season. Sunflower oil were purchased from Tanta Company for Oils and Soaps, Tanta City, Egypt.

Sodium alginate (SA), xanthan gum (XG), carboxymethyl cellulose (CMC), gelatin (GEL), Locust bean gum (LBG) and agar-agar were obtained from Mifad Company, Giza, Egypt. Soy protein isolate was donated from Prof. Dr. Nabil Mehanna, Dairy Science Dept., Fac. of Agric., Kafr El- Sheikh University.

Glycerol and calcium chloride were purchased from El-Gomhoria Co. for Chemicals and Drugs. These chemicals were of analytical grade and were permitted for food processing applications.

METHODS:

Preparation of edible coating formulations:

Six edible coating suspensions were prepared as follows: Sodium alginate coating was prepared according to the method described by *Matuska et al., (2004)* as follows: sodium alginate, 2% (w/w) was dissolved in distilled water, heated to 70 ^{0}C for 5 min., then, cooled to room temperature. This solution was modified by addition of 5% (v/v) glycerol as plasticizer after cooling.

Xanthan gum coating was prepared by dissolving 0.3% (w/w) xanthan gum in distilled water *(Mei et al., 2002)*. This solution was modified by addition 0.5% (w/w) soy protein isolate, heated to 60 ^{0}C for 10 min., then, cooled to room temperature. Glycerol 5% (v/v) was added after cooling.

Carboxymethyl cellulose (1%, w/v) was dissolved in distilled water, then 0.5% (w/v) soy protein isolate was added, heating on hotplate with stirring at 70 ^{0}C for 5 min., then, cooled to room temperature (25 ^{0}C) *(Baldwin et al., 1996)*. This solution was modified by addition of 5% (v/v) glycerol.

Five grams of gelatin were dissolved in 95.38 ml water, heated on stirring hotplate at 80 ^{0}C for 5 min., then, cooled to room temperature at 25 ^{0}C *(Arvanitoyannis et al., 1998)*. This coating solution was modified by addition 5% (v/v) glycerol.

Locust bean gum (0.7 g) was dissolved in 75 ml distilled water, the solution was heated on stirring hotplate at 70 ^{0}C for 30 min., cooled to room temperature at 25 ^{0}C *(Aydinli and Tutas, 2000)*. This coating was modified by addition 0.5% (v/v) glycerol after cooling.

Agar- agar was prepared by dissolving 2.0 g of agar-agar in 100 ml distilled water, heated at 80 ^{0}C for 10 min., then, 5% (v/v) glycerol was added and cooled to 40 ^{0}C until used. These coating solutions were used immediately after preparation.

Preparation of potato strips and eggplant slices:

Potato tubers and eggplant of uniform size and absence of external injuries were chosen and washed in distilled water. Potato tubers were peeled using a sharp stainless steel knife and the flesh was cut into 0.6 x .08 x 8.0 cm lengthwise. Eggplant were peeled and cut into slices with 1 cm- thick and 5.0 cm diameter.

Coating procedure of samples:

Potato strips (ten strips for each treatment) and eggplant slices (5 slices for each treatment) were dipped into the coating solutions for 3 min. and drained for 5 min. at room temperature using air dryer. The samples coated with sodium alginate were dipped into 2% (w/v) calcium chloride solution as a hardening agent. Control samples were dipped into distilled water.

Deep-frying conditions:

Sunflower oil (175 – 190 ^{0}C) was used as the frying medium. Uncoated and coated potato strips (ten strips of each treatments) were fried for 3 min., while, eggplant (five slices) were fried for 4 min. The samples were drained after frying on a tissue paper for 5 min. and allowed to coal at room temperature (25 ^{0}C).

Chemical analysis:

Moisture and ether extract contents of the samples before and after frying were determined according to the methods outlined by *A. O. A. C. (2000)*. The samples were weighed before and after frying using balance (Setra, BL- 410 S, U.S.A). After frying, the samples were dried at 102 ^{0}C for 18 hrs. The mass was then measured, and the samples were placed into plastic bags and then stored in a refrigerator at 6 ^{0}C.

For the oil extraction, samples were ground using a mortar. Oil was extracted using petroleum ether (40 – 60 ^{0}C) in soxhlet apparatus for 8 hrs.

The parameters were calculated from the following equations according to the methods described by *Albert and Mittal (2002)*.

- Fat reduction percentage due to coating = [(fat content of uncoated sample – fat content of coated sample)/ fat content of uncoated sample] x 100

- Water increase percentage due to coating = [(water content of coated sample – water content of uncoated samples)/water content of uncoated sample] x 100

- Water loss percentage during frying = [(initial water content – water content after frying)/initial water content] x 100

- Decrease in water loss percentage due to coating = [(water loss of uncoated sample – water loss of coated sample)/water loss of uncoated sample] x 100

- Fat uptake (%) = {[(final fat content x mass after frying) – (initial fat content x mass before frying)]/ dry mass} x 100

-Reduction of fat uptake percentage due to coating = [(fat uptake of uncoated sample – fat uptake of coated sample)/fat uptake of uncoated sample] x 100

- Index = Reduction of fat uptake/ decrease of water loss

Specific gravity:

Specific gravity of coating solutions was determined according to the *A. O. A. C. (2000)* methods using pycnometer.

Sensory analysis:

Uncoated and coated fried foods were subjected to organoleptic quality. Samples were served to panel of 14 judges.

The panelists were asked to evaluate color, taste, odor, texture, appearance and overall acceptance on a 1 to 10 hedonic scale as described by *Simpson et al., (1965).*

Anatomical studies:

For preparing transverse sections the potato samples were taken after frying process. Specimens were killed and fixed in formalin : alcohol : acetic acid mixtures (FAA, 1: 18: 1, v/v/v), washed and dehydrated in gradient concentrations of ethanol. The dehydrated specimens were infiltrated and embedded in paraffin (52 – 54 °C m.p.). the embedded specimens were sectioned on a rotary microtome at a thickness of 10- 12 µm. Sections were mounted on slides and deparaffinised. Staining was accomplished with safranine and light green, cleared in xylol and mounted in Canada balsam *(Ruzin, 1999).*

Statistical analysis:

The obtained data were statistically analyzed using General Linear Models Procedure Adapted by Statistical Package for the Social Sciences *(SPSS, 1997).*

RESULTS AND DISCUSSIONS

Effect of edible coatings on oil reduction and water increase before frying process:

As for potato strips, it was noticed from Table (1) that significant differences were found in oil reduction due to coating types before frying. Samples coated with locust bean gum had the highest fat reduction followed by potato strips coated with carboxymethyl cellulose and agar- agar. Xanthan gum and gelatin coating were the lowest in reducing oil content before frying.

Agar-agar coating was the highest among all of the used coatings in increasing water content in potato strips before frying, followed by sodium alginate coating. Carboxymethyl cellulose was recorded the lowest effect in water content before frying.

As for eggplant slices, the results in Table (2) shows that locust bean gum was significantly highest in oil reduction before frying. No significant differences were found between xanthan gum and gelatin in oil reduction before frying and both of them

Table (1): Effect of edible coating types on (%) of oil uptake and water loss for potato strips during deep- fat frying.

PARAMETERS / COATING TYPES	FAT REDUCTION DUE TO COATING	WATER INCREASE DUE TO COATING	WATER LOSS DURING FRYING	DECREASE IN WATER LOSS DUE TO COATING	FAT UPTAKE	REDUCTION OF FAT UPTAKE DUE TO COATING	INDEX
Sodium alginate	0.80^{c} + 0.013	3.17^{b} + 0.116	18.84^{b} + 0.081	49.42^{d} + 0.173	10.23^{f} + 0.058	63.46^{a} + 0.173	.284^{a} + 0.006
Xanthan gum	0.30^{d} + 0.011	0.50^{e} + 0.013	18.80^{b} + 0.116	49.53^{d} + 0.075	16.53^{e} + 0.116	40.96^{b} + 0.116	327^{b} + 0.004
Carboxymethyl cellulose	1.15^{b} + 0.087	0.04^{f} + 0.001	14.75^{e} + 0.087	60.40^{a} + 0.116	20.42^{c} + 0.069	27.07^{e} + 0.058	.448^{e} + 0.005
Gelatin	0.40^{d} + 0.011	1.24^{d} + 0.034	17.77^{c} + 0.098	52.30^{c} + 0.087	17.78^{d} + 0.104	36.50^{c} + 0.173	.698^{e} + 0.011
Locust bean gum	1.80^{a} + 0.063	2.53^{c} + 0.075	16.70^{d} + 0.069	55.17^{b} + 0.098	18.02^{d} + 0.058	35.64^{d} + 0.081	.646^{d} + 0.004
Agar -agar	1.20^{b} + 0.075	3.95^{a} + 0.110	16.72^{d} + 0.087	55.11^{b} + 0.064	22.36^{b} + 0.092	20.14^{f} + 0.081	365^{f} + 0.003
Uncoated	-	-	37.25^{a} + 0.099	-	28.00^{a} + 0.144	-	-

Values = means ± standard deviation. Means of treatments having the same case letter(s) within a column are not significantly different ($p > 0.05$).

Table (2): **Effect of edible coating types on (%) of oil uptake and water loss for eggplant slices during deep- fat frying.**

PARAMETERS / COATING TYPES	FAT REDUCTION DUE TO COATING	WATER INCREASE DUE TO COATING	WATER LOSS DURING FRYING	DECREASE IN WATER LOSS DUE TO COATING	FAT UPTAKE	REDUCTION OF FAT UPTAKE DUE TO COATING	- INDEX
Sodium alginate	0.10^{d} + 0.002	0.46^{c} + 0.043	21.59^{b} + 0.231	33.08^{e} + 0.191	149.96^{f} + 0.241	28.70^{a} + 0.087	0.868^{a} + 0.006
Xanthan gum	1.30^{b} + 0.013	0.75^{b} + 0.058	21.81^{b} + 0.173	32.39^{f} + 0.173	152.59^{e} + 0.289	27.45^{b} + 0.144	0.847^{a} + 0.009
Carboxymethyl cellulose	0.20^{d} + 0.002	0.76^{b} + 0.042	16.78^{d} + 0.133	47.99^{a} + 0.144	183.96^{b} + 0.116	12.54^{e} + 0.173	0.261^{c} + 0.006
Gelatin	1.30^{b} + 0.025	0.48^{c} + 0.011	21.36^{b} + 0.191	33.79^{d} + 0.121	149.56^{f} + 0.093	28.89^{a} + 0.231	0.855^{a} + 0.009
Locust bean gum	1.80^{a} + 0.009	1.10^{a} + 0.013	18.56^{c} + 0.151	42.47^{b} + 0.173	174.35^{d} + 0.202	17.11^{c} + 0.064	0.403^{b} + 0.043
Agar -agar	0.70^{c} + 0.006	0.95^{ab} + 0.043	18.83^{c} + 0.248	41.63^{c} + 0.133	178.97^{c} + 0.133	14.91^{d} + 0.144	0.358^{b} + 0.003
Uncoated	-	-	32.26^{a} + 0.151	-	210.33^{a} + 0.173	-	-

Values = means ± standard deviation. Means of treatments having the same case letter(s) within a column are not significantly different ($p > 0.05$).

were the second. Agar- agar was the third, while sodium alginate and carboxymethyl cellulose were found the lowest effect.

Locust bean gum and agar –agar were significantly the highest in water increase of eggplant slices before frying. No significant differences were found among agar- agar, xanthan gum and carboxymethyl cellulose (Table 2). Also, no significant differences were found between sodium alginate and gelatin in water increase before frying and both of them were recorded the lowest effect.

Generally, coating formulations can reduce the oil content and increase water content in potato strips and eggplant slices before frying. It may be due to the coating can increase the sample weight and caused mathematical increase water and decrease oil contents.

Effect of edible coatings on water loss during frying of potato strips:

The results in Table (1) cleared that there are significant differences in water loss during frying processes between uncoated and coated potato strips. Coating type has a highly significant affect on the decrease of water loss. Water loss in samples coated with carboxymethyl cellulose was significantly the lowest comparing with all of the used coatings. It recorded water loss after frying reaching about 14.75% compared to 37.25% for control sample. Also, it reduced water loss by 60.40% during frying. It may be due to the presence of soy protein isolate in the coating which provided high water retention and low oil uptake (Garcia *et al.*, 2002). Also, glycerol improves the effect on reducing weight loss because it was related to the decrease of intermolecular attraction and increase of polymer chain mobility. In general, it may also fill increase of pores and vacancies within the polymer matrix. Garcia *et al.*, (2002) found that coatings with cellulose derivatives without plasticizer applied on potato slices reduced oil uptake and led to higher retention of moisture content during deep fat frying.

No significant differences were found in water loss and the decrease in water loss during frying processes between locust bean gum and agar-agar and both of them were the second. Gelatin coating was the third. While sodium alginate and xanthan gum coatings were the fourth in reducing water loss in potato strips during frying.

Effect of edible coatings on water loss during frying of eggplant slices:

The presented data in Table (2) indicated that, significant differences in water loss and decrease in water loss between uncoated and coated foods. Coating materials reduced water loss in eggplant slices compared to control samples. Carboxymethyl cellulose was the best among all of the used coatings in reducing water loss after frying process. It reduced water loss by 47.99% followed by locust bean gum by 42.47%. The abilities of other coating types for reducing water loss were found to be: agar-agar > gelatin = sodium alginate > xanthan gum. *Mallikarjunan et al., (1997)* attributed the reduction in oil uptake and water loss to the formation of protective layer on the surface of the samples during the initial stages of frying process and due to thermal gelation above 60 ^{0}C. This protective layer inhibits the transfer of moisture and fat between the sample and the frying medium.

Effect of edible coatings on oil uptake during frying of potato strips:

The obtained results in Table (1) showed that, oil uptake during frying process of potato strips coated with different types of edible coating was significantly lower than that of uncoated samples. Sodium alginate was significantly the best among all of the used coatings; it reduced oil uptake by 63.46%. This may be due to the presence of thin layer around the sample, which lowered oil permeability. Also, the coating network structure becomes more compact with presence of glycerol leading to decreasing water permeability (Garcia *et al.,* 1998). Xanthan gum coating was significantly the second in reducing oil uptake; it decrease oil uptake by 40.96%, while other coatings reduced oil uptake by 36.50, 35.64, 27.07 and 20.14% for gelatin, locust bean gum, carboxymethyl cellulose and agar- agar; respectively. The thermal gelation of gellan gum during frying temperature, it forms an oil-resistant film around the deep- fried foods (Sworn, 2000). This film forming behavior of gellan gum may be another reason for the observed reduction in oil uptake during frying. This effect may be explained the role of xanthan gum and locust bean gum in reduction oil uptake during frying.

Effect of edible coatings on oil uptake during frying of eggplant slices:

As shown from Table (2) sodium alginate and gelatin coatings were significantly the best among all of the used coatings in reducing oil uptake during frying of eggplant slices, it reduced oil uptake by 28.70 and 28.89%; respectively.

Xanthan gum coating was significantly the second in reducing oil uptake, it reduced oil uptake by 27.45% followed by locust bean gum by 17.11%. Agar- agar coating was the fourth (14.91%), then carboxymethyl cellulose (12.45%). *Annapure et al., (1999)* found that 0.5% of carboxymethyl cellulose alone reduced the oil content in sev.(sev. Is an Indian traditional snack food, most commonly prepared from chickpea flour) by 13.21%.

Generally, it was found that carboxymethyl cellulose followed by locust bean gum coatings were significantly the best in reducing water loss in potato strips and eggplant slices during frying process. Addition of soy protein isolate and glycerol as plasticizer may be reduced water permeability during the coating. Also, sodium alginate followed by xanthan gum coatings were significantly the best in reducing oil uptake during frying of potato strips; while no significant difference was found between sodium alginate and gelatin coatings in reducing oil uptake during frying of eggplant slices.

Anatomical structure:

Micrographs of Light microscopic observations of uncoated and coated potato strips cross-sections were used to obtain more information on the effect of deposition technique on coating structure as shown in Fig. (1). A protective layer on the surface of coated samples appeared. This layer inhibit the transfer of moisture and oil between the sample and the frying medium. The highest thickness of the layer was found in sodium alginate coating. Also, Fig. (1b) shows that sodium alginate coating was getting dehydrated during the frying process and remained attached to the surface of the product, explaining the lower lipid content of the coated product; while the other coatings may be had

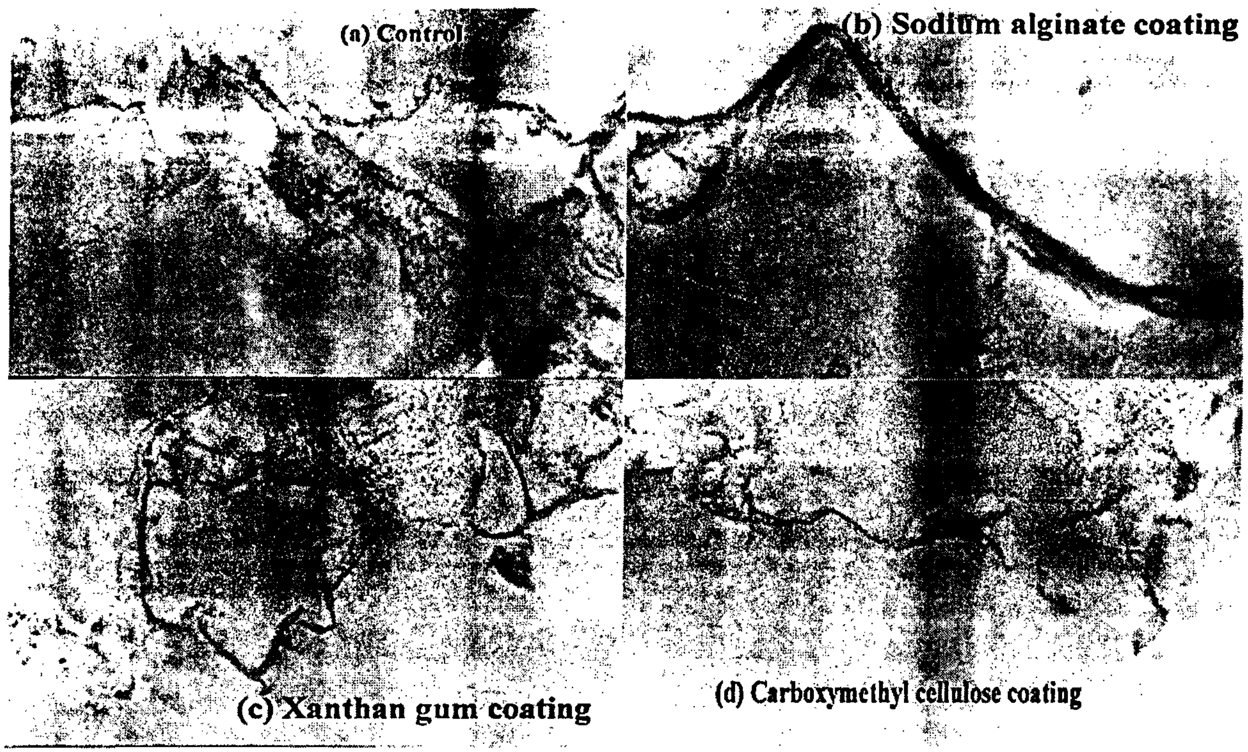

Figure (1): Micrographs of uncoated and coated potato tissues after frying process using light microscope (a -control, b- sodium alginate, c- xanthan gum and d- carboxymethyl cellulose).

low integrity and fragility structure. Coating integrity reduced barrier properties of coatings and may limit coating applications (*Donhowe and Fennema, 1993*).

Specific gravity of coating formulations:

Specific gravity (at 30 °C) of the used edible coatings were determined and the data was presented in Table (3). It is clear from the results that specific gravity of sodium alginate coating was the highest followed by gelatin. While the others were: carboxymethyl cellulose > xanthan gum > locust bean gum > agar-agar.

Table (3): Specific gravity of coating solutions (at 30 °C) g/cm^3

Coating types	Specific gravity (at 30 °C) g/cm^3
Sodium alginate	1.0113
Xanthan gum	1.0055
Carboxymethyl cellulose	1.0060
Gelatin	1.0103
Locust bean gum	1.0050
Agar- agar	1.0038

Sensory analysis:

Potato strips:

The presented data in Table (4) show that, for the overall acceptance, no significant difference was found between uncoated fried potato strips and coated with sodium alginate and both of them were the best from point of view the judges. Also, no significant differences were found between potato strips coated with xanthan gum and carboxymethyl cellulose and both of them were the second followed by the samples coated with agar- agar. No significant difference was found between the samples coated with gelatin and locust bean gum and both of them were the fourth.

As for eggplant slices:

From the data in Table (5) it can be concluded that no significant difference in overall acceptance was found between the eggplant slices coated with sodium alginate

Table (4): Organoleptic properties of potato strips coated with different types of edible coatings after deep- fat frying.

Coating types \ Organoleptic properties	Color	Taste	Odor	Texture	Appearance	Overall acceptance
Sodium alginate	$8.06^{b} \pm 0.14$	$8.29^{a} + 0.05$	$8.31^{a} + 0.11$	$8.19^{a} + 0.05$	$8.38^{a} + 0.11$	$8.23^{a} + 0.02$
Xanthan gum	$8.31^{a} + 0.11$	$8.31^{a} + 0.14$	$8.18^{a} + 0.06$	$8.31^{a} + 0.04$	$7.31^{d} + 0.06$	$8.08^{b} + 0.05$
Carboxymethyl cellulose	$8.38^{a} + 0.05$	$8.00^{b} + 0.12$	$8.38^{a} + 0.05$	$7.75^{b} + 0.09$	$8.18^{b} + 0.05$	$8.14^{b} + 0.06$
Gelatin	$7.38^{d} + 0.06$	$7.88^{b} + 0.06$	$7.95^{b} + 0.09$	$7.56^{b} + 0.06$	$7.56^{c} + 0.09$	$7.67^{d} + 0.10$
Locust bean gum	$7.75^{c} + 0.87$	$7.88^{b} + 0.26$	$7.75^{b} + 0.14$	$7.38^{c} + 0.06$	$7.50^{cd} + 0.06$	$7.65^{d} + 0.09$
Agar- agar	$7.69^{c} + 0.15$	$7.55^{c} + 0.12$	$8.25^{a} + 0.06$	$7.75^{b} + 0.11$	$8.00^{b} + 0.16$	$7.86^{c} + 0.06$
Control	$8.38^{a} + 0.06$	$8.23^{a} + 0.08$	$8.31^{a} + 0.14$	$7.63^{b} + 0.05$	$8.43^{a} + 0.08$	$8.20^{a} + 0.12$

Values = means ± standard deviation. Means of treatments having the same case letter(s) within a column are not significantly different ($p > 0.05$).

Table (5): Organoleptic properties of eggplant slices coated with different types of edible coatings after deep- fat frying.

Organoleptic properties / Coating types	Color	Taste	Odor	Texture	Appearance	Overall acceptance
Sodium alginate	8.42^{b} + 0.07	8.00^{b} + 0.13	8.60^{ab} + 0.16	8.77^{a} + 0.06	8.62^{a} + 0.07	8.48^{a} + 0.17
Xanthan gum	8.75^{a} + 0.13	8.39^{a} + 0.05	8.45^{bc} + 0.06	8.53^{b} + 0.08	8.43^{a} + 0.08	8.51^{a} + 0.11
Carboxymethyl cellulose	8.34^{b} + 0.08	8.00^{b} + 0.14	8.25^{d} + 0.16	8.00^{c} + 0.06	8.00^{b} + 0.12	8.12^{b} + 0.07
Gelatin	7.65^{d} + 0.03	7.82^{b} + 0.07	8.67^{a} + 0.04	7.83^{c} + 0.08	7.78^{b} + 0.10	7.95^{bc} + 0.09
Locust bean gum	8.39^{b} + 0.05	8.00^{b} + 0.09	8.35^{cd} + 0.11	8.00^{c} + 0.06	8.00^{b} + 0.09	8.15^{b} + 0.05
Agar- agar	8.00^{c} + 0.06	7.33^{c} + 0.08	7.72^{e} + 0.07	7.87^{c} + 0.04	8.00^{b} + 0.06	7.78^{c} + 0.09
Control	7.00^{e} + 0.06	8.00^{b} + 0.06	8.32^{d} + 0.07	8.37^{b} + 0.08	8.00^{b} + 0.06	7.94^{bc} + 0.08

Values = means ± standard deviation. Means of treatments having the same case letter(s) within a column are not significantly different ($p > 0.05$).

and xanthan gum and both of them were the best from point of view the judges among all of the used coatings. Also, no significant differences were found among carboxymethyl cellulose, locust bean gum, gelatin and uncoated samples and all of them were the second.

Conclusion

By suitable selection of edible coatings, it is possible to control the moisture content and fat transfer between frying medium and the fried foods. Among the tested coatings, the most effective coating formulation to reduce oil uptake in both potato strips and eggplant slices were sodium alginate followed by xanthan gum. Sodium alginate coating reduced oil uptake by 63.46 and 28.70% in potato strips and eggplant slices; respectively. While, carboxymethyl cellulose was the best because it reduced the percent of moisture loss by 60.40 and 47.99% in both potato strips and eggplant slices; respectively. All samples were accepted by the panelists, but the samples coated with sodium alginate and uncoated samples were preferred in potato strips. Also, samples coated with sodium alginate and xanthan gum were preferred in eggplant.

REFERENCES

Albert, S. and Mittal, G. (2002). Comparative evaluation of edible coatings to reduce fat uptake in a deep- fat cereal product. Food Research International, 35: 445 – 458.

Annapure, U. S.; Singhal , R. S. and Kulkarni, P. R. (1999). Screening of hydrocolloids for reduction in oil uptake of a model deep fat fried product. Fett/lipid, 6(101): 217 – 221.

A. O. A. C. (2000). Association of Official Method of Analysis. Official Analytical Chemists. 17^{th} Ed., Washington, DC., USA.

Arvanitoyannis, I; Nakayama, A. and Aiba, S. (1998). Edible films made from hydroxypropyl starch and gelatin and plasticized by polyols and water. Carbohydrate polymers, 36: 105 – 119.

Aydinli, M. and Tutas, M. (2000). Water sorption and water vapor permeability properties of polysaccharide (locust bean gum) based edible films. Lebensmittel- Wissenschaft und – Technologie, 33: 63 – 67.

Baldwin, E; Nisperos- Carriedo, M; Chen, X. and Hagenmaier, R. (1996). Improving storage life of cut apple and potato with edible coating. Postharvest Biology and Technology, 9: 151 – 163.

Bouchon, P; Aguilera, J. and Pyle, D. (2003). Structure oil-absorption relationships during deep- fat frying. J. Food Science, 68: 2711 – 2716.

Bunger, A; Moyano, P. and Rioseco, V. (2003). NacL soaking treatment for improving the quality of French- fried potatoes. Food Research International, 36, 161 – 166.

Califano, A. and Calvelo, A. (1987). Adjustment of surface concentration of reducing sugars before frying of potato strips. J. of Food Processing and Preservation, 12: 1 – 9.

Debeaufort, F. and Voilley, A. (1997). Methyl cellulose- based edible films and coatings: 2- Mechanical and thermal properties as a function of plasticizer content. J. of Agric. and Food Chem., 45: 685 – 689.

Donhowe, I. G. and Fennema, O. R. (1993). The effects of plasticizers on crystallinity, permeability, and mechanical properties of methylcellulose films. J. of Food Processing and Preservation, 17:247- 257.

Garayo, J. and Moreira, R. (2002). Vacuum frying of potato chips. J. of Food Engineering, 55: 181 – 181.

Garcia, M. A; Ferrero, C; Bertola, M; Martino, M. and Zaritzky, N. (2002). Edible coatings from cellulose derivatives to reduce oil uptake in fried products. Innovative Food Science and Emerging Technologies, 3: 391 – 397.

Garcia, M. A; Martino, M. and Zaritzky, N. (1998). Plasticized starch- based coatings to improve strawberry (*Fragaria x Ananassa*) quality and stability. J. Agric. Food Chem., 3758 – 3767.

Gertz, C. (2004). Eur. J. Lipid Sci. Technol; 106: 713.

Krokida, M. K; Oreopolou, V.; Maroulis, Z. B; and Marinos-Kouris, D. (2001). Deep- fat frying of potato strips- quality issues. Drying technology, 19: 879 – 935.

Lamberg, I; Hallstrom, B. and Olsson, H. (1990). Fat uptake in a potato during/ frying process. Lebensmittel- Wissenschaft und – Technologie, 23: 295 – 300.

Mallikarjunan, P; Chinnan, M. S; Balasubramaniam, V. M. and Phillips, R. D. (1997). Edible coatings for deep- fat frying of starchy products. Lebensmittel- Wissenschaft und – Technologie, 30: 709 – 714.

Matuska, M; Lenart, A. and Lazarides, H. (2004). On the use of edible coatings to monitor osmotic dehydration kinetics for minimal solids uptake. J. Food Engineering xxx.

Mei, Y; Zhao, Y; Yang, J. and Furr, H. (2002). Using edible coating to enhance nutritional and sensory qualities of baby carrots. J. Food Science, 67(5): 1964 – 1967.

Moreira, R; castell – Perez, M. and Barrufet, M. (1999). Deep- fat frying: international and applications (350p), Gaithersburg: Md. Aspen.

Moyano, P. C; Rioseco, V. K. and Gonzalez, P. A. (2002). Kinetics of crust color changes during deep- fat frying of impregnated French fries. J. of Food Engineering, 54: 249 – 255.

Pinthus, E; Weinberg, P. and Saguy, I. (1995). Oil uptake in deep-fat frying as affected by porosity. J. of Food Sci., 60: 767 – 769.

Ruzin, S. E. (1999). Plant microtechnique and microscopy. First Edit., Oxford Univ., press, USA.

Sahin, S; Sastry, S. K. and Bayindirili, L. (1999). Heat transfer during frying of potato slices. Lebensmittel- Wissenschaft und – Technologie, 32, 19–24.

Simpson, J. E., Adair, C. R., kohler, G. R., Dawson, E. H., Hogan, J. T., Batcher, O. M. and Halick, J. V. (1965). Quality evaluation studies of foreign and domestic rices. USDA Technol. Bull, 1331. p. 184.

Statistical Package for the Social Sciences, SPSS (1997). SPSS based 7.5 for windows, User's Guide; SPSS inc.

Sworn, G. (2000). Gellan gum. In G. O. Phillips & P. A. Williams (Eds.), Handbook of hydrocolloids (pp. 118 – 135). Cambridge, England Woodhead Publishing Ltd.

Williams, R. and Mittal, G. (1999). Water and fat transfer properties of polysaccharide films on fried pasty mix. Lebensmittel-Wissenschaft und – Technologie, 32: 440 – 445.

الملخص العربى

تقييم بعض مواد التغطية الغذائية لخفض كمية الزيت الممتص لبعض الأغذية أثناء القلى العميق

محمد فوزى عثمان – قسم تكنولوجيا الأغذية – كلية الزراعة-
جامعة كفرالشيخ – مصر

تم استخدام مواد تغطية غذائية من مواد ألجانات الصوديوم، صمغ الزانثان ، الكربوكسى ميثايل سليللوز ، الجيلاتين ، صمغ بذرة الخرنوب وكذلك الآجار آجار وذلك لتغطية أصابع البطاطس وكذلك حلقات الباذنجان كغذاء شعبي فى المطاعم المصرية بهدف تقليل كمية الزيت الممتص وكذلك فقد الرطوبة أثناء القلى العميق.

حيث أظهرت النتائج أن أغطية ألجانات الصوديوم كانت الأفضل بين كل مواد التغطية لخفض كمية الزيت الممتص لكل من أصابع البطاطس وحلقات الباذنجان يليها أغطية صمغ الزانثان. بينما وجد أن أغطية الكربوكسى ميثايل سليللوز يليها أغطية صمغ بذرة الخرنوب كانتا الأفضل فى خفض كمية الرطوبة المفقودة أثناء التحمير لكلا العينتين. كما وجد أن أغطية الآجار آجار كانت غير مناسبة لتغطية العينات بسبب تجمعها فى صورة كتل أثناء عملية التغطية على العينات. وتم قبول العينات المغطاة والمقلية حسيا" من المحكمين وكانت المغطاة بألجانات الصوديوم مع الغير مغطاة الأفضل بين كل العينات فى أصابع البطاطس بينما كانت حلقات الباذنجان المغطاة بألجانات الصوديوم وصمغ الزانثان هما الأفضل بين باقى العينات.