International Food Research Journal 20(2): 565-573 (2013)

Journal homepage: *http://www.ifrj.upm.edu.my*

Effect of coating of hydrocolloids on chickpea (*Cicer arietinum* L.) and green gram (*Vigna radiata*) splits during deep fat frying

Asmita S. Phule and *Uday S. Annapure

Food Engineering and Technology Department, Institute of Chemical Technology (ICT), Deemed University, Matunga (E), Mumbai-400019, India

Article history

Received: 17 July 2012
Received in revised form: 19 August 2012
Accepted: 23 August 2012

Keywords

Deep fat frying
food hydrocolloids
chickpea splits
green gram splits
oil reduction

Abstract

Deep-Frying is one of the most widespread methods of food processing. Cereals and pulses are being extremely used for the manufacture of fried foods all over the world. Due to the consumer awareness, the trend has shifted to low fat fried foods. There are various approaches to reduce fat content of fried foods. One of which is the use of hydrocolloids. In the present study, two selected hydrocolloids *viz* CMC (Carboxymethyl cellulose) and HPMC (Hydroxypropyl methylcellulose) were coated on Chickpea and Green gram splits in order to evaluate their effect on moisture retention and reduction in oil absorption in these pluses during deep fat frying. Coating of hydrocolloids was achieved using different concentrations (0.5, 1 and 2%), in aqueous solutions for different time of dipping (1, 3 and 5min) to check its effect on quality parameters. Chickpea and Green gram splits were soaked in water for 300min and 180min respectively. Frying was carried out at 170°C for 2min. Coating of hydrocolloids has been proved effective in oil reduction with better organoleptic qualities. Better reduction in oil was found with CMC for 5min (0.5%) and with HPMC for 3min (1%) of dipping. Fried splits were subjected for various analysis. HPMC is having better reduction in oil absorption than CMC during green gram processing. CMC found to be better oil reduction content in chickpea than green gram splits.

Introduction

Deep fat frying is one of the most widely used method in food industry for snack foods. It is the unit operation where simultaneous heat and mass transfer take place when a product is immersed into the hot oil at 150–200ºC temperature for a fixed time to achieve desired product characteristics (Aguilera and Hernandez, 2000). Fried foods are universally accepted due to their unique organoleptic properties including flavour, mouthfeel, color, texture and palatability, which are highly desired by consumers. The palatability and acceptability of fried foods product is due to fats and oils used. Fried products do contain large amount of fats, often reaching up to 40–45% of total product weight (Pinthus *et al*., 1993). Higher amount of fats in fried food products usually are associated with the health hazards such as obesity and high blood pressure leading to heart problems (Tavera-Quirozet *et al*., 2011). Hence, reducing oil content of fried products is the area of interest to many researchers (Priya *et al*., 1996; Mellema, 2003; Kim *et al*., 2008; Primo-Martín *et al*., 2010; Varela and Fiszman, 2011). The various factors such as initial moisture content, frying time, frying temperature, size, shape, chemical composition of raw material, quality of oil used, are responsible for the oil uptake in the fried food products during deep fat frying (Israel and pinthus, 1995).

There are many approaches such as prefrying treatments, surface treatments, gel strength, initial interfacial tension and porosity reported for reducing oil uptake during deep fat frying (Israel and Pinthus, 1995). Use of hydrocolloids is proved to be one of the approaches to achieve reduction in oil absorption during deep fat frying. Hydrocolloids have been used as multifunctional additives in food processing to improve functional properties such as viscosity, emulsion stability, and potential to bind water. Water binding capacity is an important property of the hydrocolloid responsible for less oil uptake during frying there is a strong relation between oil uptake and moisture loss during frying (Aguilera and Hernandez 2000; Altunakar *et al*., 2004). In addition to that, they

*Corresponding author.
Email: *us.annapure@ictmumbai.edu.in*
udayannapure@gmail.com

accomplish good barrier property against oxygen, carbon dioxide and lipids which could reduce oil absorption during deep-fat frying (Altunakar *et al*., 2004; Bravin *et al*., 2006). Typically, they function as thickening and gelling agents, stabilizers, and emulsifiers (Dogan *et al*., 2005; Altunakar *et al*., 2006). Some of the most useful hydrocolloids are cellulose derivatives such as methyl cellulose (MC), hydroxypropyl cellulose (HPC), hydroxypropyl methyl cellulose (HPMC) and carboxyl methyl cellulose (CMC) having good water solubility and film-forming properties (Singthong and Thongkaew, 2009), thermal gelation and film forming properties of CMC and HPMC make them suitable to reduce oil absorption, and has been studied by many of researchers mostly in the batter system (Israel and pinthus, 1995; Priya *et al*., 1996; Altunakar *et al*., 2004; Akdeniz *et a*l., 2005; Holikar *et al*., 2005; Chen *et al*., 2008; Singthong and Thongkaew, 2009; Primo-Martín *et al*., 2010). The frying oil used itself is a costly ingredient of fried products. Use of hydrocolloids reported to reduce the oil uptake during frying hence addition of small amount (2%) of hydrocolloid will definitely reduce the overall cost due to less absorption of oil into the product.

Major claims into literature on oil reduction using biopolymers in coating and batter systems are patented (Altunakar *et al*., 2004). Among these biopolymers CMC and HPMC are being used in coating batter and dough system to reduce oil absorption during frying (Altunakar *et al*., 2006; Bravin *et al*., 2006; Dogan *et al*., 2006). Amongst the traditional fried products, dehusked chick pea and green gram splits are being commonly used as fried snacks. However, very scanty information is available in the literature pertaining to reduction in oil uptake of dehusk splits of legumes and pulses with coating of CMC and HPMC. Hence, this work address the optimization of soaking time of chickpea and green gram splits with developing low fat fried splits with coating of different hydrocolloids (CMC and HPMC) at different concentrations (0.5, 1 and 2%) by dipping method.

Materials and Methods

Chickpea (variety *Vijay*) (*Cicer arietinum* L.) was purchased from an agricultural farm of Marathwada Agricultural University, Parbhani, India. Grains were cleaned and stored at room temperature (29-32°C) in small jute bags until used. Green gram splits (variety *S-8*) (*Vigna radiata*) and Palm oil from Palm gold yog, as frying oil were purchased from local market of Mumbai. Carboxymethyl cellulose (CMC) and hydroxypropyl methyl cellulose (HPMC) were purchased from Hi-Media Laboratories Pvt. Ltd., Mumbai, India.

Proximate composition

Proximate analysis of chickpea flour, moisture loss was expressed on a dry basis and calculated using the difference between the original moisture content before frying and the final moisture content. Same method was followed for soaked as well as fried splits.Total oil, protein, ash and fiber content were done by methods (AOAC 1995). Carbohydrates were calculated by difference.

Optimization of soaking time for chickpea and green gram

Chickpea seeds were cleaned and dehusked in a hammer mill (Marshal ASPER IS:996) at laboratory level The chickpea and green gram splits (500gm) were soaked in plain water (in the ratio of 1:3w/v) for 60 to 480 min at room temperature (28±2°C) to optimize soaking time. Excess water drained off and splits were centrifuged in a basket centrifuge at 1700 rpm for 2min. Optimization of soaking time was estimated on the basis of water absorbed and sensory score of fried chickpea and green gram splits after frying.

Percent water absorption

Percent water absorption was calculated by difference between moisture content of raw splits and after soaking of splits at 60-480min.

$$\%\ Water\ absorption = \ (X - Y)$$

where: X- soaked splits moisture content, Y- Raw splits (Initial) moisture content

Coating with hydrocolloids

An aqueous solution of each hydrocolloid (CMC and HPMC) at 0.5, 1 and 2% (w/v) was used for the coating of chickpea and green gram splits. Hydrocolloids was dissolved in cold water and to make a homogenized solution it was heated at 70±2°C for 5min. Approximately 250 g of chickpea and green gram splits were dipped in 1lit. hydrocolloids solutions with different concentration (0.5, 1 and 2%) for 1min, 3min and 5min. Excess hydrocolloid solution was drained off.

Frying conditions

Table 2 indicates uncoated splits were fried at different temperature (150°C, 170°C and 190°C) and soaking time (60-480min) for optimization of its frying conditions (Kita *et al*., 2007).

Oil content of the fried splits

Oil content in samples was determined by the soxhlet method using petroleum ether (60-80°C) as solvent (AOAC 1995).

Oil uptake ratio of the fried Splits

Oil uptake ratio (UR) was calculated by using the following formula described by Pinthus *et al*.,(1993)

$$Oil\ uptake\ ratio(UR) = \frac{OC}{M(BF) - M(AF)}$$

where: OC – Oil content after frying, M - moisture of splits, BF – Before frying, AF - After frying moisture of splits. All values are in percent (%).

Physical properties

Bulk density was calculated as suggested by Subramanian *et al*., (2007). The diameter and length of the splits was measured using vernier calliper (Metr.-ISO Aerospace stainless hardened). The mass of the splits was determined and bulk density then calculated using the following formula, assuming a cylindrical shape of splits

$$Bulk\ Density = 4m / (\pi x\ D * D * L)$$

where: m- mass, D – diameter, L – length.

For true density determination, a circular container of known volume 5ml volumetric flask was filled with the sample of fried splits and gently tapped. The excess flour was levelled off and the content was weighed. The true density was calculated as the ratio of mass of contents to volume of container. Average of five replications was reported. During the experiments care was taken to fill the container completely to avoid compaction (Nimkar and Chattopadhyay, 2001; Haciseferogullaria *et al*., 2003). Porosity (ϕ), was calculated by using the following formula

$$\phi = 1 - [\,pb/ps]$$

Where: ϕ- Porosity, pb – Bulk density, ps – True density

Color analysis

Color of chickpea splits and green gram samples was measured using a Hunter Lab colorimeter (Model D 25) with optical Sensor (Hunter Associates Laboratory, Reston, Va., USA). Fried sample of uniform size was loaded in a quartz cell and placed above the light source. The colour of the samples were measured in the scale of L* (lightness and darkness), a* (redness and greenness) and b* (yellowness and blueness). Total color difference (ΔE) was calculated by applying the equation.

Texture analysis

Texture analysis was performed according to Suarez *et al*., 2008 with slight modifications. A texture measurement of the fried splits was performed at 25°C by a puncture test performed in a Texture Analyzer TA.XT2 (Stable Micro System, Surrey, UK). Force vs. distance curves were generated with the puncture test for the sample over a Kramer shear probe where the distance between 0.15mm, the punch diameter and the cross-head speed was 0.02mm and 0.60mm/sec, respectively. The parameter maximum force (MF) was obtained from the force vs. distance curves using the software Texture Expert (v 6.06) of the Texture Analyzer. MF was defined as the force at which the probe penetrates the outer layer of the surface of the product in sample holder.

Sensory evaluation

Sensory evaluation of fried splits was conducted by ten expert/trained panellists. Randomly coded samples were served to panel member individually. Five sensory attributes were evaluated (appearance, color, texture, mouthfeel and overall palatability) using nine point hedonic scale (Suarez *et al*., 2008).

Statistical analysis

Statistical analysis of data was performed using a student's T-test and a system developed by SAS Institute Inc. (1993). When analysis of variance (ANOVA) revealed a significant effect ($P < 0.05$), data means were compared using a least significant difference (LSD) test.

Results and Discussion

Table 1 shows the proximate composition of pulses chosen for study. Therefore the protein content of chickpea and green gram were found to be 19.21% and 22.16% respectively. Oil content in chickpea splits was 3.28% whereas oil content in green gram was 1.71% Lower fat and higher protein content was observed in raw splits. The results were significantly different from each other when checked by student's

Table 1. Proximate composition of chickpea and Green Gram splits

Proximate constituents	Chickpea splits (%)	Green gram splits (%)
Moisture	7.10 ± 1.1	10.2 ± 1.2
Fat	3.28 ± 0.02	1.71 ±0.002
Protein	19.21±1	22.16±1.1
Ash	2.68 ± 0.05	3.81 ±0.03
Fiber	0.27 ± 0.002	0.30 ± 0.001
Carbohydrates(by difference)	65.03±3.1	59.12 ± 1.5

Values are mean ± SD of three determinations

Table 2. Effect of soaking time and initial moisture content on oil uptake and sensory qualities of chickpea and green gram splits of different temperature

				Frying temperature											
				150ºC				170ºC				190ºC			
Splits	Soaking time (Min)	Percent water absorption (%)	Initial moisture (%)	Final moisture (%)	Oil content (%)	Oil uptake (UR)	Sensory score	Final moisture (%)	Oil content (%)	Oil uptake (UR)	Sensory score	Final moisture (%)	Oil content (%)	Oil uptake (UR)	Sensory score
Chickpea	60	43.1± 1.2^{a}	50.2±1.7^{a}	2.5±1.1^{a}	19.12±0.9^{a}	0.400^{a}	3.5±0.2	1.8±0.8^{a}	24.5±1.1^{a}	0.506^{a}	5±0.5	1.3±0.5^{a}	24.8±2.3^{a}	0.507^{a}	5.4±0.1
	120	44.9± 1.5^{b}	52.0±1.1^{b}	2.35±1.0^{b}	21.1±1^{b}	0.425^{b}	4.1±0.1	1.39±0.9^{b}	25.0±1.3^{b}	0.484^{b}	5.5±0.3	1.13±0.5^{b}	25.5±2.1^{b}	0.501^{b}	4.9±0.01
	180	45.6 ±1.1^{c}	52.7±2.2^{b}	2.1±0.09^{c}	21.57±1.3^{c}	0.426^{b}	4.5±0.3	1.01±0.4^{c}	25.26±1^{b}	0.489^{c}	5.9±0.4	1.09±0.1^{b}	25.58±3.3^{b}	0.496^{c}	5.2±0.02
	240	46.7±1.1^{d}	53.8±2.5^{c}	1.7±0.01^{d}	22.02±1.1^{d}	0.423^{b}	4.3±0.2	0.8±0.3^{d}	25.39±2.1^{b}	0.479^{d}	6.3±0.3	0.66±0.2^{c}	25.79±1.1^{b}	0.485^{d}	5.4±0.1
	300	47.1±1.7^{e}	54.2±2.1^{d}	1.2±0.02^{e}	22.19±1.1^{e}	0.419^{c}	5.1±0.2	0.77±0.2^{e}	25.5±1.5^{c}	0.477^{d}	8.1±0.2	0.41±0.3^{d}	26.35±3^{c}	0.490^{e}	4.1±0.0
	360	47.4±1.3^{e}	54.5±1.1^{d}	1.09±0.02^{f}	23.41±1.3^{f}	0.438^{d}	5±0.1	0.39±0.1^{f}	26.41±2.1^{d}	0.488^{e}	7.6±0.4	0.1±0.01^{e}	26.71±2.4^{c}	0.491^{e}	4.3±0.2
	420	47.6± 1.5^{e}	54.7±1.5^{d}	0.9±0.0^{f}	24.15±1^{g}	0.449^{e}	5.4±0.3	0.18±0.1^{g}	26.65±1.2^{d}	0.489^{f}	7.4±0.31	0.09±0.0^{e}	26.85±2.2^{c}	0.492^{e}	4.2±0.0
	480	47.6±1.1^{e}	54.7±2.5^{d}	0.72±0.0^{h}	24.97±1.1^{h}	0.463^{f}	5.6±0.3	0.12±0.1^{g}	26.73±1^{d}	0.490^{f}	7.1±0.23	0.02±0.0^{f}	27.47±2.1^{c}	0.502^{f}	4.8±0.1
Green gram	60	39.08±1.9^{a}	49.2±0.8^{a}	3.33±0.9^{a}	14.74±1.1^{a}	0.321^{a}	4.4±0.1	1.83±1^{a}	16.83±2.3^{a}	0.355^{a}	5.7±0.2	15.5±0.1^{a}	18.13±1.9^{a}	0.380^{a}	5.8±0.1
	120	42.18±1.4^{b}	52.3±1.7^{b}	3.23±1.1^{a}	19.69±2.7^{b}	0.401^{b}	4.5±0.2	1.41±1.1^{b}	21.89±1.4^{b}	0.430^{b}	6.4±0.1	12±0.6^{b}	22.79±2^{b}	0.446^{b}	6.1±0.4
	180	42.92±2^{c}	53.12±2.2^{c}	3.1±1.2^{b}	23.26±1.6^{c}	0.465^{c}	5.1±0.2	1.1±0.8^{c}	24.01±1.1^{c}	0.462^{c}	8.5±1	11±0.3^{c}	24.77±2.5^{c}	0.476^{c}	6.9±0.2
	240	42.85±1.1^{c}	53.05±2.1^{c}	2.79±0.11^{c}	23.68±2.^{d}	0.471^{d}	5.3±0.1	1.09±0.3^{d}	25.0±3.1^{d}	0.481^{d}	7.3±0.1	9±0.1^{d}	25.16±1.8^{c}	0.482^{d}	6.7±0.2
	300	42.96±1.9^{c}	53.16±2.1^{c}	2.34±0.0^{d}	24.08±1.3^{e}	0.474^{d}	6.1±0.2	0.87±0.5^{e}	25.69±1^{e}	0.491^{e}	6.1±0.2	7.1±0.2^{e}	26.08±2.2^{d}	0.497^{e}	6.1±0.2
	360	43.58±1.5^{d}	53.78±1.4^{d}	2.19±0.0^{e}	24.53±1.7^{f}	0.475^{d}	5.8±0.1	0.66±0.1^{f}	26.33±1.6^{f}	0.496^{f}	6.5±0.2	6.3±0.5^{f}	26.84±2.1^{d}	0.505^{f}	6.5±0.1
	420	44.54±1.2^{e}	54.74±2.6^{e}	2.05±0.1^{e}	24.99±2.4^{g}	0.474^{d}	5.7±0.2	0.51±0.6^{g}	26.9±1.1^{g}	0.496^{f}	6.9±0.2	3.1±0.02^{g}	27.18±3.5^{e}	0.499^{g}	6.4±0.3
	480	44.88±1.7^{e}	55.08±2.1^{e}	1.89±0.11f	25.45±2.1^{h}	0.478^{e}	5.6±0.3	0.43±0.1^{g}	27.5±1.2^{h}	0.503^{g}	6.6±0.3	3±0.1^{g}	27.76±3.1^{e}	0.507^{h}	5.8±0.2

Mean values in each column with the same superscript alphabets do not differ significantly (P > 0.05)

t test (P<0.05). The details of the other proximate constituents are shown in table.

It was essential to soak the splits to get desirable organoleptic properties after deep frying. For optimization of soaking time, chickpea splits were soaked in water in the ratio of 1:3 for 60 to 480min at room temperature (29±2ºC). Moisture content of chickpea splits was found to increase with increase in soaking time (Table 2). The moisture content of soaked chickpea splits was in the range of 50.27 to 54.21% Chickpea splits were fried at different temperature *viz* 150ºC, 170ºC and 190ºC to evaluate the effect of frying temperature on soaked splits. Soaking for 300 min and frying at 170ºC gave splits with the best sensory properties at 0.77% final moisture content, 25.50% oil content and 0.47 oil uptake ratio. Lesser soaking time 60-240min and lower temperature 150ºC gave inferior products after frying such as case hardening, color and flavor partially developed due to inadequate hydration. Higher temperature 190ºC products gets more brownish colored this is due to maillard reactions during frying.

Green gram splits were also studied under these same experimental conditions. Increase in soaking time from 60 to 480 min absorption of water increased and moisture content was also increased from 49.26 to 55.08% in control condition. Green gram splits showed excellent sensory characteristics at 180 min soaking time. Splits fried at 170ºC frying temperature showed 1.1% final moisture content, 24.01% oil content and 0.46 as an oil uptake ratio. It shown higher oil uptake with increasing soaking time due to higher water absorption. It has been well established that oil absorption occurs as moisture is replaced from the food during frying (Suarez *et al*., 2008).

The difference in water absorption rate of chickpea and green gram splits was probably due to little correlation between size and density of splits because it is influenced by surface area. Somehow, fat, protein and carbohydrate content also affects on rate of water absorption (Hung *et al*., 1993; Abdel and Zakia, 1995). Therefore chickpea splits needs maximum soaking time as compared with green gram splits. The optimized temperature was 170ºC for both the splits because at higher temperature splits were not acceptable due to burnt flavour and dark color. Also temperatures above 175ºC assist the formation of toxic compounds, known to be potential carcinogenic substance for this reason, it would be advantageous to lower the frying temperature, maintain quality of the fried splits (Kita *et al*., 2007).

Data indicated in Table 3 and 4 shows the effect of incorporation of CMC at three different concentrations *viz* 0.5, 1 and 2%. Retention of moisture content was found to be increased with respect to increase in concentration of CMC. for Chickpea splits, 0.5% CMC solution with 5 min dipping showed reduction

Table 3. Effect of CMC coating on quality of Chickpea splits

CMC concentration (%)	Dipping time (Min)	Moisture content (%)	Oil content (%)	Oil uptake (UR)	Bulk density (kg/m^3)	Porosity	Crispiness (gm/sec)	Colour (ΔE)	overall acceptability
0.5	1	2.84±0.12^a	22.51±1.1^a	0.471±0.02^a	391±0.7^a	310±0.02^a	46023.42±15078^a	81.86±0.4^a	7.0±0.1
	3	1.83±0.07^b	16.34±1.1^b	0.335±0.01^b	504±0.3^b	252±0.01^b	38732.66±12256^b	78.79±0.3^b	8.0±2.0
	5	1.5±0.14^c	15.96±0.8^c	0.325±0.01^c	489±1.1^c	263±0.01^c	34074.39±11911^c	79.72±0.05^b	6.0±0.3
1.0	1	1.54±0.11^c	20.00±0.9^d	0.408±0.03^d	468±0.8^d	264±0.0^c	30183.58±10383^d	78.13±0.1^b	7.0±0.3
	3	2.23±0.11^e	19.52±1.1^e	0.404±0.02^e	491±0.6^e	244±0.03^d	29783.92±12481^e	79.92±0.3^b	7.5±0.9
	5	1.68±0.02.^{f}	20.94±1.2^f	0.428±0.04^f	464±0.3^d	256±0.01^f	20542.55±1137^f	79.13±0.2^b	5.0±0.6
2.0	1	2.01±0.08^g	22.18±1.1^a	0.456±0.01^g	389±0.7^e	264±0.02^g	33463.29±128.5^c	75.88±0.4^c	6.0±0.2
	3	1.46±0.03h^c	23.69±1.5^h	0.482±0.01^h	332±0.6^f	290±0.01^h	23560.57±10322^h	73.63±0.2^d	5.0±1.1
	5	1.22±0.03^i	24.29±1.2^i	0.492±0.06^i	369±0.4^g	229±0.0^i	21427.68±11436^i	71.59±0.6^e	3.0±0.1

Soaked chickpea splits moisture content is 50.66% at 300min soaking time.
Mean values in each column with the same superscript alphabets do not differ significantly (P > 0.05).

Table 4. Effect of CMC coating on quality of Green gram splits

CMC concentration (%)	Dipping time (Min)	Moisture content (%)	Oil content (%)	Oil uptake (UR)	Bulk density kg/m^3	Porosity	Crispiness (gm/sec)	Colour (ΔE)	overall acceptability
0.5	1	2.10±0.5^a	24.46±1.1^a	0.480±0.07^a	488±0.2^a	531±0.01^a	40930.47±1369^a	84.52±0.2^a	7.3±0.4
	3	3.48±0.14^b	20.13±1.3^b	0.406±0.01^b	413±0.1^b	521±0.03^b	37239.53±1147^b	80.58±0.4^b	8.2±0.7
	5	1.75±0.03^c	22.21±1^c	0.433±0.03^c	407±0.3^c	567±0.02^c	31796.17±1038^c	77.68±0.02^c	7.2±0.2
1.0	1	3.63±0.02^d	24.50±1.1^a	0.495±0.01^d	539±0.4^d	516±0.0^d	27507.59±929^d	78.34±0.3^c	7.5±0.9
	3	3.89±0.1^e	24.25±1.5^e	0.493±0.0^d	572±0.1^e	548±0.01^e	34899.45±1035^e	74.35±0.6^d	8.0±0.5
	5	3.76±0.1^f	24.87±1.3^f	0.504±0.0^e	568±0.5^f	577±0.04^f	38091.42±1240^f	74.99±0.03^d	6.0±0.5
2.0	1	1.92±0.0^g	23.15±1.3^g	0.452±0.02^f	449±0.2^g	388±0.01^g	29807.78±1008^g	73.04±0.4^d	6.5±0.2
	3	7.46±0.8^h	28.34±1.4^h	0.621±0.03^g	574±0.2^h	405±0.03^h	25462.07±1338^h	71.69±0.5^e	6.3±0.2
	5	16.99±0.7^i	29.66±1.1^i	0.821±0.01^h	826±0.3^i	484±0.03^i	38260.84±1163^i	69.48±0.2^e	3.0±0.01

Soaked green gram splits moisture content is 53.1% at 180min soaking time.
Mean values in each column with the same superscript alphabets do not differ significantly (P > 0.05)

in oil absorption by 37.41%, while oil content at 0.5% CMC in green splits for 3min showed reduction by 16.15%. Lower oil absorption was observed in coated as compared to uncoated splits but coating of higher concentration of hydrocolloid solution with maximum dipping time shows minimum oil reduction. Higher concentration (2%) of hydrocolloids solution had been less effective in reduction of oil content in fried splits. It was found to be reduced by 9.130-9.047% when dipped for 1 to 5 min. Green gram shows oil content reduction by 9.035-10%. A thin surface film of CMC may penetrate to a depth of several cellular layers. Oil absorption in the products was sufficiently reduced and it allows retention of high moisture loss, due to invisible thin film of these hydrocolloids. While a high concentration coating can result in rupture of the film from excessive pressure built up during frying (Debnath *et al*., 2011), this may be responsible for the increased oil content at higher levels of CMC concentration.

Table 5 and 6 shows the effect of incorporation of HPMC at three different concentrations. The retention of moisture content in fried chickpea and green gram splits were increased proportionally with increase in concentration of HPMC. Oil content was decreased from 19.74% and 20.23% in chickpea splits and green gram respectively for 1% HPMC concentration and at 3min dipping time. Higher concentrations of hydrocolloids and longer dipping time increased the oil content of splits gradually. At 2% level the reduction in oil uptake observed was 9.19-9.05% and 10.4-9.6% respectively for chickpea and green gram. The values for porosity, crispiness and color characteristics of fried splits were not significantly ($P<0.05$) different than control batches. These trends of results were in agreement with Bhat *et al*., 2001; Sanz *et al*., 2004. HPMC at higher concentrations form a thick coating, resulting in rupture of the film from excessive pressure built up during frying as CMC. This could be the reason for the increased oil content in splits containing higher concentrations of HPMC.

CMC and HPMC acted as barrier between fried products and frying medium. The coating treatment significantly ($p<0.05$) reduced the oil uptake and increased the water retention of the fried split samples when compared with uncoated splits (Table 2). Similar results were reported by various researchers applying cellulose derivatives and other gum coatings on different products (Pinthus *et al*., 1993; Bhat *et al*., 2001; Bravin *et al*., 2006). Organoleptic properties such as appearance, taste and overall acceptability of

Table 5. Effect of HPMC coating on quality of Chickpea splits

HPMC concentration (%)	Dipping time (Min)	Final Moisture content (%)	Oil content (%)	Oil uptake (UR)	Bulk density (kg/m^3)	Porosity	Crispiness (gm/sec)	Colour *(ΔE)*	Overall acceptability
0.5	1	4.51± 1^{a}	23.60±0.3^{a}	0.470±0.01^{a}	405±1.4^{a}	457±0.01^{a}	49911.24±1532^{a}	80.47±0.2^{a}	8.0±0.5
	3	7.74±0.7^{b}	21.91±0.5^{b}	0.439±0.03^{b}	435±0.6^{b}	412±0.03^{b}	41274.09±1362^{b}	79.25±0.3^{a}	8.5±0.2
	5	13.23±0.9^{c}	21.11±0.2^{c}	0.428±0.01^{c}	460±0.7^{c}	312±0.02^{c}	36482.38±1203^{c}	78.86±0.2^{a}	6.5±0.3
1.0	1	2.249±0.5^{d}	22.14±1^{d}	0.439±0.02^{b}	390±0.1^{d}	365±0.0^{d}	33893.66±1422^{d}	77.79±0.4^{a}	7.0±0.4
	3	3.25±0.1^{e}	20.22±1.1^{e}	0.402±0.0^{d}	395±0.8^{d}	304±0.01^{e}	40673.49±1392^{e}	76.63±0.2^{b}	8.0±0.4
	5	1.84±0.01^{f}	22.50±0.6^{f}	0.446±0.01^{e}	353±0.5^{e}	422±0.04^{f}	40121.67±1105^{e}	75.58±0.7^{b}	4.0±0.1
2.0	1	2.766±0.7^{g}	21.49±0.8^{g}	0.449±0.04^{e}	392±0.4g^{f}	268±0.01^{g}	32685.73±1074^{g}	74.92±0.1^{b}	6.0±0.2
	3	3.95±0.1^{h}	21.96±0.9^{b}	0.437±0.01^{f}	401±0.8^{f}	325±0.03^{h}	29840.28±989^{h}	74.55±0.3^{b}	4.0±0.1
	5	1.48±0.002^{i}	23.35±0.9^{i}	0.462±0.02^{g}	348±0.1^{e}	343±0.03^{i}	22364.22±1147^{i}	72.05±0.2^{c}	3.0±0.0

Soaked chickpea splits moisture content is 50.66% at 300min soaking time.
Mean values in each column with the same superscript alphabets do not differ significantly (P > 0.05)

Table 6. Effect of HPMC coating on quality of Green gram splits

HPMC concentration (%)	Dipping time (Min)	Final Moisture content (%)	Oil content (%)	oil uptake (UR)	Bulk density (Kg/m^3)	Porosity	Crispiness (gm/sec)	Colour (ΔE)	Overall acceptability
0.5	1	1.30± 0.01^{a}	22.37±2.1^{a}	0.432±0.03^{a}	455±0.4^{a}	450±0.01^{a}	40629.11±1011a	86.11±0.4^{a}	6.5±0.5
	3	0.93±0.001^{b}	21.82±2^{b}	0.418±0.01^{b}	400±1.2^{b}	422±0.03^{b}	35017.87±1325^{b}	82.39±0.3^{b}	6.3±0.2
	5	0.42±0.002^{c}	20.85±1.8^{c}	0.396±0.0^{c}	389±1.5^{c}	401±0.02^{c}	34088.11±1150^{c}	79.15±0.2^{c}	3.0±0.01
1.0	1	0.72±0.1^{d}	22.04±1.2^{d}	0.421±0.01^{d}	417±0.9^{d}	459±0.0^{d}	33764.36±982d^{c}	78.34±0.3^{c}	8.0±0.4
	3	0.53±0.02^{e}	19.74±0.9^{e}	0.375±0.02^{e}	383±1.1^{c}	434±0.01^{e}	28750.76±102^{e}	75.47±0.2^{d}	8.5±0.6
	5	0.044±0.02^{f}	18.96±1^{f}	0.360±0.05^{f}	367±0.8^{e}	426±0.04^{f}	18131.11±1174^{f}	74.62±0.5^{d}	6.5±0.1
2.0	1	0.96±0.2^{g}	20.78±2.2^{g}	0.399±0.02^{g}	392±0.5^{f}	395±0.01^{g}	31149.44±1363^{g}	74.41±0.1^{d}	7.0±0.2
	3	0.11±1.2^{h}	23.76±3^{h}	0.457±0.03^{h}	437±0.3^{g}	390±0.03^{g}	26611.70±1002^{h}	72.57±0.2^{e}	8.0±0.2
	5	20.8±1.3^{i}	27.21±3.4^{i}	0.553±0.0^{i}	497±1.0^{h}	391±0.03^{g}	19057.95±849^{i}	70.33±0.4^{f}	4.0±0.01

Soaked green gram splits moisture content is 53.1% at 180 soaking time.
Mean values in each column with the same superscript alphabets do not differ significantly (P > 0.05).

fried splits were found to be unaffected ($p<0.05$) by the type of the hydrocolloid. However, HPMC had lower oil absorption than CMC. Thermal gelation and film-forming properties described for HPMC have also been used successfully to reduce oil absorption due to sufficient dehydration of the polymer occurs. Interactions between polymers create an oil barrier effect, when temperatures get higher and the gel point is reached Hydrophobic interactions among molecules with the methoxyl groups form an oil insoluble film with thermal reversible gelation properties that prevent the permeation of oil and water molecules during heating (Sanz *et al*., 2004).

Bulk density of the fried splits decreased and porosity increased with frying time. Data indicated in Table 3 about coating of chickpea splits with CMC showed bulk density in the range of 391- 489 kg/m^3 and porosity was 31.0-26.3 at 0.5% concentration. This porosity was higher and bulk density was lower than physical properties of 1% and 2% Table 6 shows the bulk density of fried green gram at the concentration of 1% HPMC, was varied from 417 to 367 kg/m^3 for 1-5min and porosity was 459-426. Porosity of the product formed during frying plays an important role in the oil uptake. When a crust begins to form at the surface of the sample, there is an excessive pressure build up and the product expands and puffs (Subramanian and Viswanathan, 2007). Porosity of the fried chickpea observed increased with decreased moisture content. Moreira *et al*., 1995 reported that similar trend of physical properties for fried products.

Color analysis of chickpea and green gram splits is an incredibly significant visual parameter according to consumer view point. It is one of the most important factors in the quality of deep fat fried products. Results from color evaluation showed that there was a variation in the lightness values among the fried snack as shown by L* value increased and b* value decreased with increase in frying time it indicate yellowish color decreased and comparatively samples developed red color during

Table 7. Regression equation between the oil content (x) in % and the uptake ratio U_R (Y)

Parameters		Hydrocolloid Concentration (%)	Regression equation	R^2
HPMC	Chickpea Splits	0.5	y=0.017x+0.065	0.996
		1.0	y=0.019x+0.010	1.000
		2.0	y=0.009x+0.230	0.561
	Green Gram	0.5	y=0.023x-0.097	0.999
		1.0	y=0.019x-0.013	1.000
		2.0	y=0.021x-0.038	0.999
CMC	Chickpea Splits	0.5	y=0.022x-0.028	0.999
		1.0	y=0.017x+0.053	0.967
		2.0	y=0.016x+0.083	0.999
	Green Gram	0.5	y=0.017x+0.058	0.982
		1.0	y=0.018x+0.040	0.959
		2.0	y=0.049x-0.716	0.862

frying. Total color difference (ΔE) was calculated by formula using L*, a,* b* values. Color characteristics of coated fried splits comparatively different than control splits (Huse *et al*., 2006). Higher amounts of hydrocolloids affect on color of splits. Browning color rate was affected primarily by the reducing sugars in splits some sugars that caramelize during frying and contribute to coating coloration. Moreover, at high viscous aqueous solution splits did not fry properly whereas it found to be moist and adhere with oil at surface.

Textural properties were significantly ($p<0.05$) affected by addition of hydrocolloids. Lower concentration of hydrocolloids increased the crispiness of the splits. Compression force was decreased with increasing concentration and it was linearly proportional to moisture content. Table 3 and 6 shows texture of the splits. Splits were dipped in 0.5% CMC solution was observed better crispiness with the force of 460234.2–340743.9 g/sec. for chickpea splits. HPMC 1% solution observed the crispiness in the sense of force that is from 337643.6-181311.1 g/sec for green gram splits. The maximum force is an indication of the peak resistance offered by splits during compression; an increase in moisture content increases maximum force it means product was not to be brittle or crisp. Crispiness values of all hydrocolloids coated were found to be significantly different from control fried snacks it may be explained by thermogelling property of HPMC and CMC which lead to an important role in providing crispy structure of product (Albert *et al*., 2010).

The sensory quality is an important aspect in considering the overall acceptability of food product. Deep fat frying is widely used in industrial preparation of foods, because consumers prefer the taste, appearance and texture of fried food products (Bhat *et al*., 2001; Sanz *et al*., 2004). The fried pulses prepared by addition of CMC and HPMC in varied levels at various dipping time were subjected to sensory evaluation for different quality parameters like crispiness, taste, color, mouth feel and overall acceptability. The results on sensory quality of fried pulses with different hydrocolloids containing coating with CMC at 0.5% for 3min dipping time was found to be improved in quality with respect to overall acceptability. With increasing concentration of hydrocolloids oil content absorption increased, splits color was darken and crispiness was found to be decreased.

Table 7 shows regression equations between the oil content and oil uptake ratio. HPMC coated green gram shows good correlation at 1% that is R^2 was 1.00. At 2% concentration of CMC shows very poor correlation (R^2=0.561) and good correlation at 0.5 and 1% (R^2 =0.999) for chickpea splits. Green gram shows comparatively poor correlation at 2% (R^2=0.862). This data also revealed by the sensory score given in Table 4.

Conclusions

The results from this study indicated that edible coatings before frying for both the splits could be an effective barrier to oil absorption during deep-fat frying. Edible coatings based on CMC and HPMC reduced the oil content of fried splits. One percent HPMC for 3min dipping time and 0.5% CMC for 5min dipping time were better hydrocolloids studied with significantly low oil uptake. Chickpea and green gram splits showed reduction in oil absorption by 37.41%, 16.15% respectively. HPMC decreased the oil content to 19.74% and 20.23% in chickpea splits and green gram respectively. The oil reduction capability of the coatings was probably due to their abilities to form a thermal gel during frying. Oxidative stability of the coated splits was significantly higher than those of uncoated ones. HPMC coating was more suitable for green gram splits it shows better oil reduction than CMC coated splits. Chickpea splits coated with CMC hydrocolloid solutions found to be better oil reduction than HPMC coated splits. Thus, fried pulses with low fat and low calorie content with better acceptance can be prepared in order to meet the demand of low fatty foods of health conscious consumers.

Acknowledgements

Authors are grateful to University of Grants Commission for financial support for this project work.

References

Aguilera, J.M. and Hernandez, H.G. 2000. Oil absorption during frying of frozen parfried potatoes. Journal of Food Science 65(3): 476–479.

Akdeniz, N., Sahin, S. and Sumnu, G. 2005. Effects of different batter formulations on the quality of deep-fat-fried carrot slices. European Food Research and Technology 221 (1-2): 99–105.

Albert, A., Varela, P., Salvador, A. and Fiszman, S.M. 2010. Improvement of crunchiness of battered fish nuggets. European Food Research and Technology 228 (6): 923–930.

Altunakar, B., Sahin, S. and Sumnu, G. 2004. Functionality of batters containing different starch types for deep-fat frying of chicken nuggets. European Food Research and Technology 218 (4): 318–322.

Altunakar, B., Sahin, S. and Sumnu, G. 2006. Effects of hydrocolloids on apparent viscosity of batters and quality of chicken nuggets. Chemical Engineering Communication 193 (6): 675–682.

AOAC, Official methods of analysis, 16th ed. 1995. Washington: Association of Official Analytical Chemists.

Bhat, K.K. and Bhattacharya, S. 2001. Deep fat frying characteristics of chickpea flour suspensions. International Journal of Food Science and Technology 36 (5): 499–507.

Bravin, B., Peressini, D. and Sensidoni, A. 2006. Development and application of polysaccharide-lipid edible coating to extend shelf-life of dry bakery products. Journal of Food Engineering 76 (3): 280–290.

Chen, C.L., Li P.Y., Hu W.H., Lan M.H., Chen, M.J. and Chen, H.H. 2008. Using HPMC to improve crust crispness in microwave-reheated battered mackerel nuggets: Water barrier effect of HPMC. Food Hydrocolloids 22 (7): 1337–1344.

Debnath,S., Raghavaraob, K.S.M.S. and Lokesha, B.R. 2011. Hydrodynamic, thermo-analytical and molecular structural investigations of enzyme interesterified oil and its thermo-oxidative stability by thermogravimetric analysis. Journal of Food Engineering 105 (5): 671–679.

Dogan, S.F., Sahin, S. and Sumnu, G. 2005. Effects of batters containing different protein types on the quality of deep-fat fried chicken nuggets. European Food Research and Technology 220 (5-6): 502–508.

Haciseferogullaria, H., Gezer, I., Bahtiyarca, Y. and Menges, H.O. 2003. Determination of some chemical & physical properties of sakiz faba bean (*Vicia faba* L. *Var*. major). Journal of Food Engineering 60 (4): 475–479.

Holikar, M.V., Annapure, U.S., Singhal, R.S. and Kulkarni, P.R. 2005. Pectin and calcium chloride treatment for low-fat fried green gram splits. Journal of the Science of Food and Agriculture 85(10): 1677–1680.

Hung, T.V., Liu, L.H., Black, R.G. and Trewhella, M.A. 1993. Water absorption in chickpea (*C. arietinum*) and field pea (*P. sativum*) cultivars using the peleg model. Journal of Food science 58(4): 848-852.

Huse, H.L., Hung, Y.C. and Mcwatters, K.H. 2006. physical and sensory characteristics of fried cowpea (*Vigna unguiculata* L. *Walp*) paste formulated with soy flour and edible coatings. Journal Food Quality 29(4): 419–430.

Israel, S.S. and Pinthus, E.J. 1995. Oil uptake during deep fat frying factors and mechanism. Food Technology 49 (4): 142-145, 152.

Kader, A. and Zakia, M. 1995. Study of some factors affecting water absorption by faba beans during soaking. Food chemistry 53(3): 235-238.

Kim, B.K., Lee, J.S., Lee, C.H. and Park, D.J. 2008. Preparation of low-fat uptake frying batter composite by dry particle coating of microparticulated soybean hull. LWT–Food Science Technology 41 (1):34–41.

Kita, A., Lisinska, G. and Golubowska, G. 2005. The effects of oils and frying temperature on the texture and fat content on potato crisps. Food chemistry 102 (1):1-5.

Mellema, M. 2003. Mechanism and reduction of fat uptake in deep fat fried foods. Trends Food Science Technology 14 (9): 364–373.

Moreira, R.G., Palau, J., Sweat, V. and Sun, X. 1995. Thermal and physical properties of tortilla chips as a function of frying time. Journal Food Process Preservation 19 (3): 175-189.

Nimkar, P.M. and Chattopadhyay, P.K. 2001. Some physical properties of green gram. Journal of Agriculture Engineering Research 80 (2):183-189.

Pinthus, E.L., Weinberg, P. and Saguy, I.S. 1993. Criterion for oil uptake during deep-fat frying Journal of Food Science 58 (1): 204–205, 222.

Primo-Martín, C., Sanz, T., Steringa, D.W., Salvador, A., Fiszman, S.M. and Vliet,T.V. 2010. Performance of cellulose derivatives in deep-fried battered snacks: oil barrier and crispy properties. Food Hydrocolloids 24 (8): 702–708.

Priya, R., Singhal, R.S. and Kulkarni, P.R. 1996. Carboxymethylcellulose and hydroxypropylmethylcellulose as additives in reduction of oil content in batter based deep-fat fried boondis. Carbohydrate Polymers 29 (4): 333–335.

Sanz, T., Salvador, A. and Fiszman, S.M. 2004. Effect of concentration and temperature on properties of methylcellulose-added batters Application to battered, fried seafood. Food Hydrocolloids 18 (1): 127–131.

Singthong, J. and Thongkaew, C. 2009. Using hydrocolloids to decrease oil absorption in banana chips. LWT - Food Science and Technology 42 (7): 1199–1203.

Suarez, R.B., Campanone, L.A, Garcıa, M.A. and Zaritzky, N.E. 2008. Comparison of the deep frying process in coated and uncoated dough systems. Journal of Food Engineering 84 (3): 383–393.

Subramanian, S. and Viswanathan, R. 2007. Bulk density and friction coefficients of selected minor millet grains and flours. Journal of Food Engineering 81 (1): 118-126.

Tavera-Quiroz, J.M., Urriza, M., Pinottia, A. and Bertolaa,

N. 2011. Plasticized methylcellulose coating for reducing oil uptake in potato chips. Journal of Food Science and Agriculture 92 (7): 1346-1353.

Varela, P. and Fiszman, S.M. 2011. Hydrocolloids in fried foods. A review. Food Hydrocolloids 25 (8): 1801–1812.