

Research Article

Methylcellulose and hydroxypropyl methylcellulose-based coatings on partially defatted peanut to reduce frying oil uptake and enhance oxidative stability

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Abstract

Fried partially defatted peanut is a peanut product prepared through the following steps: mechanical pressing of the raw peanut to partially defat, reconstitution and frying. The product is expected to contain lower fat than the normal fried peanut and considered healthy food. However, this product has shorter shelf-life due to oxidation. The reaction is facilitated by the remaining oil content which gains higher during frying and also enhanced by the structural breakage of peanut due to pressing. They have been reported that coating on food using ether cellulose is able to reduce oil uptake, water loss and oil degradation during frying. This study aimed to evaluate the effectiveness of edible coatings formulated from methylcellulose (MC) and hydroxypropyl methylcellulose (HPMC) onto partially defatted peanuts in restricting oil absorption during frying and enhancing oxidative stability during storage. Coating was applied before frying using two different methods, by dipping and spraying. The fried products were analyzed for moisture content, oil content, hardness and colour properties. The oxidative stability was tested in term of peroxide value (PV) and thiobarbituric acid (TBA) in the samples during 14 days of storage. The results indicated that MC and HPMC coatings could give an effective barrier against oil absorption during frying. Coating with HPMC by spraying resulted in the product containing the lowest oil (35.25%), in comparison with the control or uncoated one (43.65%). Coatings did not significantly affect moisture content, hardness and colour appearance of the final product. Oxidative stability of the coated-partially defatted peanuts was significantly higher than the uncoated counterpart. Coating with HPMC by spraying showed the most effective restriction to oxidative reaction. Control underwent increase in PV and TBA values, i.e., 39.40 and 0.53 meq/kg, respectively. Meanwhile, coated peanut with HPMC by spraying resulted in increase in PV and TBA values, i.e., 5.92 and 0.19 meq/kg, respectively. Sensory evaluation of coated partially defatted peanuts should be further carried out to determine the acceptability.

Keywords: methylcellulose, coating, fried peanut, oil uptake, oxidation, Indonesia

Introduction

A snack food with high nutrition value is potential to be developed. Developing fried products from peanut containing high protein and fat seems to be prospective, because this kind of product has widely been consumed by people elsewhere. Fried peanut has unique flavour and taste. However, it has considerably high oil content and therefore product shelf-life and acceptability are limited. Considering these reasons, an innovative peanut product having lower lipid content is potential to be developed. One of those products is known as fried partially defatted peanut. In principle, the product is prepared through following steps: reducing the partial oil content of raw peanuts, reconstitution and frying. Reduction of the oil content is conducted by mechanical pressing. However, the fried partially defatted peanut undergoes a significant oil increase during frying process [1]. Another weakness of the product is its shorter shelf-life during storage due to rancidity. The product is complained by consumers after stored for two weeks at ambient condition. This unacceptable product is mainly caused by flavour and taste changes due to oxidation reaction. Beside higher oil content, the oxidation reaction is also facilitated by the ease exposure directly to oxygen due to structural damage caused by mechanical pressing. This also leads to the reaction between oil and other constituents, especially lipase, and extensive reaction between oil and oxygen [2], and finally resulting in rancidity.

Various polysaccharides and proteins based edible coating to reduce oil migration and oxidation have been applied on potatoes, onion rings, fried chicken, fried okara and peanuts [3; 4]. Edible film or coating is defined as edible thin material which is applied on food by casting, dipping, brushing or spraying. It functions as barrier to gas, water, solute migration and provides mechanical protection. Edible coating is usually applied in the form of liquid or solution to the food surface through dipping or spraying [5]. There have been reported that coating on food using ether cellulose can reduce oil uptake, water loss and fried oil degradation during frying [6]. The same hydrocolloid, mainly long chain polysaccharides have also been reported to be able to reduce oil absorption during deep fat frying [7; 8]. Some of the most useful hydrocolloids seem to be cellulose derivatives, such as methyl cellulose (MC), hydroxypropyl cellulose (HPC) and hydroxypropyl methyl cellulose (HPMC) [9]. These cellulosic derivatives are water soluble ethers with good film forming properties and the hydrophilicity increases in the order HPC<MC<HPMC<CMC [10]. Other studies showed that MC or HPMC reduced oil absorption and improved moisture retention in starchy and poultry products [3; 7; 11].

Coating on partially defatted peanut before frying is expected to reduce oil uptake during frying, because the coating material will control oil migration to the products. Coating is also expected to give protection to the peanuts surface from the direct contact with the air surrounding, therefore, it will reduce oil oxidation occurrence during storage of the product. The objectives of this study were to evaluate effectiveness of edible coatings formulated from MC and HPMC in restricting oil absorption during frying and maintaining oxidative stability during storage of fried partially defatted peanut.

Materials and Methods

Materials

MC (M7140-250G) and polyethylene glycol (PEG) with an average molecular weight 600 were obtained from Sigma Aldrich. HPMC (practical grade) was obtained from PT. Elo Karsa, Yogyakarta, Indonesia. Raw peanuts of Gajah variety were obtained from Balai Benih Palawija, Gunung Kidul, Yogyakarta, Indonesia.

Preparation of fried partially defatted peanuts

Fried partially defatted peanut was prepared in accordance with the method to produce "Kacang TePe", daily practiced in the Laboratory of Process Engineering, under Department of Food and Agricultural Product Technology, Faculty of Agricultural Technology, Gadjah Mada University. Simply, the process is undertaken through following steps; drying of unshelled peanuts, hydraulic pressing, de-skinning, reconstitution, and frying. First of all, the peanuts were dried in a cabinet dryer at 70-80°C for 24-30 h to bring the moisture content to 4%. In a warm condition, the dried peanuts were pressed by using a hydraulic press at 130 kg/cm² for about 7 min to lower oil content. To return their physical form, the peanuts were then reconstituted in warm water (80-100°C) containing desired spices for 10 min. Finally, the peanuts were then fried for 7-10 min using deep-fat frying method, as commonly practiced to prepare fried peanut products. Edible coating based on cellulosic material was applied on the partially defatted peanuts just before frying,

Preparation of edible coating solutions

To study the efficacy of edible coating, two types of ether cellulose namely MC and HPMC were tested for coating partially defatted peanut. The film forming solutions were prepared using the procedure as reported by [9], with a slight modification (Table 1).

Table 1. The formulation of edible coating solutions.

Coating Materials	Amount (g)	Water (ml)	Plasticizer (g)
MC	2.0	100	PEG: 0.20
HPMC	1.5	100	PEG: 0.15

This formulation was selected based on the best result obtained from the preliminary study in laboratory. Concentration of materials was chosen by considering the solution viscosity (450 cP). The coating ingredient was added incrementally to the water at room temperature and allowed to dissolve by mixing with a stirrer (Agitator, Boore Bosch) at 60 rpm. Then, PEG as a plasticizer was added and thoroughly mixed. To accomplish the dissolution, the mixture was heated to the temperature of 70–80°C until the solution became smooth, clear and pseudoplastic. The solution was covered with aluminium foil and left overnight at room temperature until the air bubbles disappeared.

Coating application on partially defatted peanuts

After preparing the solution according to the appropriate formulation and methods, whether for coating or dipping method, peanut samples were dipped into coating solution for about 15 s. The coated samples were taken out from the solution with a slotted spoon and then put on an aluminium foil. Samples were dried using a hair dryer at 30–40°C (Miyako) which provides a warm air. The samples were treated by dipping 3 times, referring to the best technique from the laboratory experiment. Coating of peanuts with spraying method was conducted using a pan coater (Erweka AR 400) and a set of sprayer (spray gun W-200, Anest

Iwata Corp.) and cup (PC-4 400 ml G 3/8, Anest Iwata Corp.). Sample was coated by placing them in the pan coater at 30 rpm and sprayed with a sprayer gun. Spraying was done for 30 s and then dried for 60 s. The procedure was repeated to ensure coating uniformity on sample surfaces. Ratio of peanuts weight:volume of solution used was 1:1.5 (based on the optimal result). The coated peanuts were then fried with a frying pan as the same method to produce partially defatted peanut product taken in our laboratory. The coated peanuts and control were analyzed of moisture content, oil content, hardness and colour parameter. Other parts of the samples were stored at ambient temperature for 14 days, and analyzed for peroxide and TBA value.

Analysis of moisture content

Moisture content was determined gravimetrically, by measuring weight loss of the fried products upon drying in an oven drying at 105°C until constant weight attained [12]. The result was expressed in the percentage of dry basis (db) of g water/g dry matter.

Analysis of oil content

Analysis of oil content was done using a Soxhlet method with *n*-hexane as solvent. Initially, sample was ground using a mortar. Two g of each ground sample was weighed on a filter paper and placed in a thimble. Oil was extracted with 2055 Foss Tecator Manual Ex. Unit for 1 h. Flask containing extracted oil was dried overnight in an oven drier at 65°C to evaporate remaining solvent. The oil left was calculated in term of percentage of dry basis.

Measurement of hardness

Peanut sample was tested for the hardness by measuring force recorded from the compression using Lloyd's Universal Testing Instrument (Zwick ZO.5). Half pieces of peanut sample was uniaxially pressed at a cross head speed of 20 mm/min. Hardness was determined from the maximal force (F_{\max}) recorded until the sample breakage in Newton (N) unit.

Measurement of colour parameters

Colour parameters were determined as L, a and b value using a Colorimeter (Minolta, CR-10 series, Japan). Parameter **L** represents lightness, **a** represents red-green, and **b** represents yellow-blue. Each sample was analyzed in triplicate.

Analysis of oxidative stability

The coated peanuts, accompanied by control (uncoated) were stored at ambient temperature for 14 days. The samples were analyzed of peroxide value (PV) and thiobarbituric acid (TBA) value after stored for 0, 1, 7 and 14 days. Initially, the oil content of partially defatted peanut being examined was extracted using *n*-hexane solvent. Lipid oxidation in the extracted oil was measured of the PV according to the procedure modified by Thiel and Hill [13] and TBA value according to the procedure reported by Ottolenghi [14].

Data and statistical analysis

Experimental design used in this study was Randomized Complete Design. The data obtained were analyzed using analysis of variants. If there was a significant effect would be processed with *Duncan's Multiple Range Test* at significance level of 5%. All calculation employed software *Statistical Package for Social Science* Version 15.0.

Results and Discussion

Moisture content, oil content and hardness

The moisture content, oil content and hardness of the coated peanuts and control can be seen in Table 2. The results indicated that edible coatings significantly ($p < 0.05$) affected moisture content of the products, in which the highest moisture content was related to the peanut coated with HPMC using dipping method. The role of edible coating was to retard polar agent (water) from product to frying medium. This caused entrapped water content in the product was higher. In addition, the hydrocolloid-based edible coatings could affect water holding capacity (WHC) of the product. In this case, WHC rising occurred through entrapping water in the product [8].

Table 2. Effect of edible coatings before frying on moisture content, oil content and hardness of fried-partially defatted peanuts.

Materials	Coating Method	Moisture Content (%)	Oil Content (%)	Hardness (N)
Control		2.34 ± 0.24^b	43.65 ± 0.32^c	18.85 ± 0.34^a
MC	Dipping	2.10 ± 0.02^b	37.48 ± 0.38^b	17.77 ± 0.81^a
	Spraying	2.45 ± 0.05^b	37.45 ± 0.18^b	19.21 ± 0.81^a
HPMC	Dipping	3.88 ± 0.11^c	37.16 ± 0.80^b	19.10 ± 3.48^a
	Spraying	1.87 ± 0.07^a	35.25 ± 0.19^a	17.96 ± 1.01^a

Means in the same column with different superscript letters are significantly different ($p < 0.05$).

Basically, the raw peanut used in this study contained oil 45.15% (db). After mechanical pressing, the oil decreased to 36.20% (db). It was getting increase again by frying process to 43.65% (db). The influence of MC and HPMC coating in decreasing oil content of fried partially defatted peanut is shown in Table 2. The result showed that edible coatings had a significant ($p < 0.05$) effect on the oil content of final product. It proved that MC and HPMC were effective in decreasing oil absorption during frying, and the highest effect was shown by coating with HPMC using spraying. Oil uptake during frying is a surface phenomenon. An increased hydrophobic character of the surface would result in an increase of oil uptake during frying. Meanwhile, the ability of ether cellulose (MC and HPMC) to reduce oil uptake in fried food has been attributed to its hydrophilic character [15]. It is known that hydrocolloid treatment may alter the WHC and consequently affect oil uptake [16]. The ability of coating to reduce oil uptake could be apart others due to the increase in WHC through entrapping moisture, and accordingly, preventing moisture replacement by oil [8].

MC and HPMC formed a protective layer due to the thermal gelation above 60°C. The methyl group in MC or HPMC molecules underwent intermolecular association with adjacent molecules at temperature above the incipient gelation temperature (IGT). The IGT is the temperature at which intermolecular association begins to occur very rapidly. Above the IGT, viscosity increases dramatically with the increase of temperature to the point where the solution gels. The IGT of MC and HPMC is in the range 50 – 90°C. This gel layer might have controlled the transfer of moisture and oil between the product and frying medium [7]. Coatings also reduced the depth of oil penetration into the product and it slowed migration of polar agent (water) from the product to the oil [4].

Table 2 shows that the hardness of peanuts defined by measuring F_{max} is almost the same. The hardness between coated and uncoated peanuts was not significantly ($p > 0.05$) different. The hardness ranged from 17-19 Newton. It informed that there is no considerable effect of

coating treatment on the hardness in comparison with the control. Therefore, it is expected no to influence textural properties in terms of mouthfeel aspect of the fried partially defatted peanut.

Colour properties of peanuts

In terms of appearance, there is no distinct difference among the samples, between coated and uncoated peanuts and among coated peanut themselves. The product appearance could be seen in Figure 1. For quantification, colour properties of peanuts were measured by using a colorimeter, and the colour was brought into values of **L**, **a** and **b** according to Hunter Lab system. The colour properties of coated and uncoated peanuts can be seen in Table 3. In term of **L** value (lightness), it showed that there was no significant ($p>0.05$) difference between control and coated peanuts. The **a** value observation showed that the peanut coated with MC by dipping method resulted in highest score, while others were not different from the control. It means that the appearance was a bit green. The similar result was shown on the **b** value measurement, in which the peanut coated with MC by dipping showed the highest score. It indicated that the sample was a bit yellow. Overall, the appearance and colour of the peanuts were almost the same, no remarkable differences due to coating treatment.

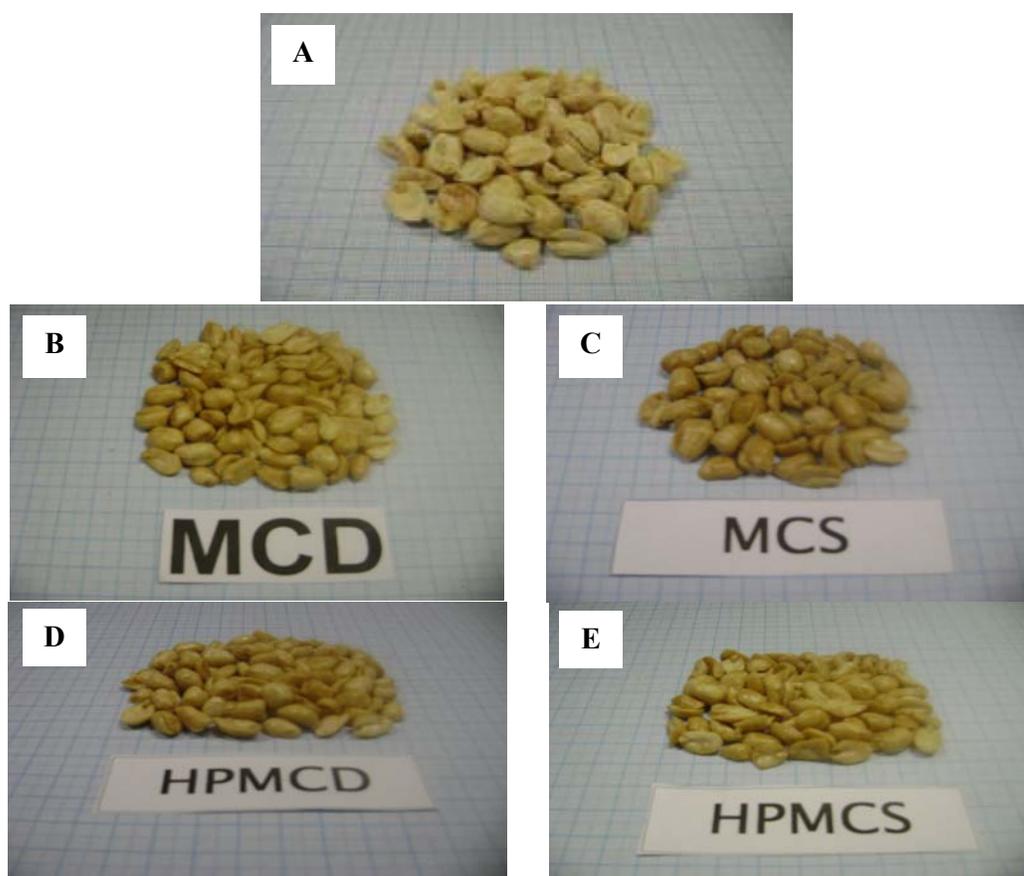


Figure 1. Fried partially defatted peanuts; (A) Control, (B) Coated with MC by dipping method, (C) Coated with MC by spraying method, (D) Coated with HPMC by dipping method, and (E) Coated with HPMC by spraying method.

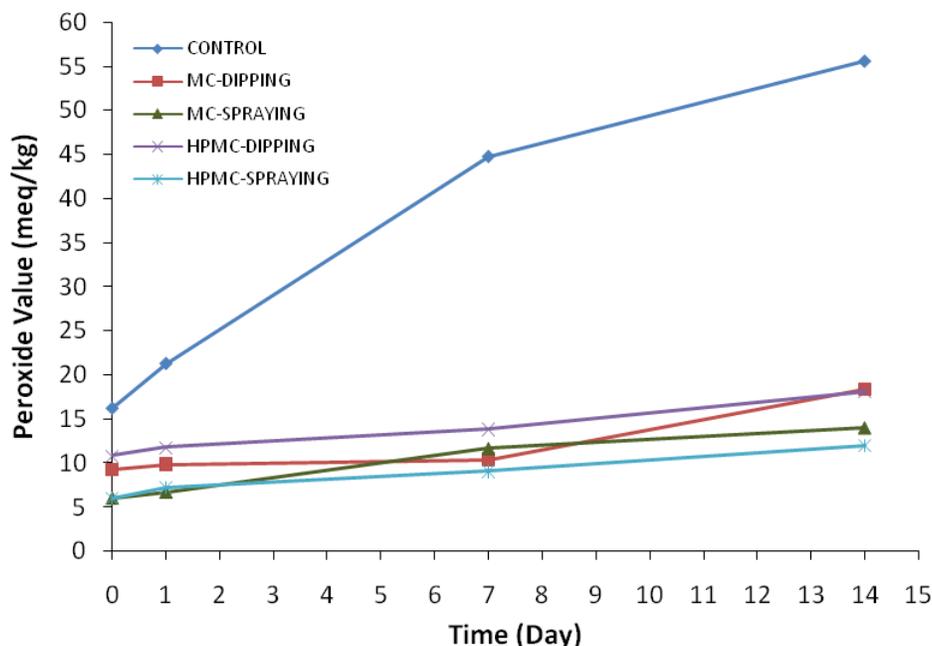
Table 3. Effect of edible coating before frying on colour properties (L, a and b value) of fried-partially defatted peanuts.

Materials	Coating Method	Colour Parameter		
		L	a	b
Control		62.30 ± 1.64 ^a	9.00±0.10 ^a	27.83±0.29 ^b
MC	Dipping	60.27 ± 1.29 ^a	16.23±0.64 ^c	35.90±0.26 ^d
	Spraying	60.47 ± 0.15 ^a	10.87±1.05 ^b	24.33±1.19 ^a
HPMC	Dipping	60.90 ± 0.70 ^a	10.83±0.32 ^b	30.07±0.15 ^c
	Spraying	60.57 ± 0.67 ^a	11.90±1.30 ^b	32.30±2.56 ^c

Means in the same column with different superscript letters are significantly different (p<0.05).

Oxidative stability of stored peanuts

Peanut has a high content of unsaturated fatty acids and therefore, it is very susceptible to lipid oxidation resulting in a formation of off-flavour during storage [17]. Oxidative deterioration has often been quantified in terms of PV or/and TBA value. The change in PV and TBA value of coated and uncoated peanut during storage are presented in Figure 2 and Figure 3, respectively. Both graphs show that the oxidation reaction occurred in the peanuts, and increased during storage. Figure 2 illustrates that the rate of peroxide value increase in the peanuts coated with either MC or HPMC, by dipping or spraying, was lower than the control. HPMC showed a lower increase in PV than using MC, and the lowest oxidation rate was shown by HPMC-coated partially defatted peanuts with spraying. PV measures the content of hydroperoxides and is often used as an indicator for primary products of lipid oxidation [18].

**Figure 2.** Effect of coating on peroxide value of fried partially defatted peanuts during storage.

The TBA test is based on the formation of coloured products when TBA is reacted with malonaldehyde or other TBA reactive substances which are presumed to be produced from oxidized lipids or fats [19]. It has been demonstrated that fatty acids with three or more unsaturated bonds are mainly capable of undergoing cyclization that results in formation of

malonaldehyde and the intensity of the reaction increases along with unsaturation degree. Malonaldehyde condenses with two molecules of TBA to form a chromagen having maximum absorbance at 532 nm. Based on the data illustrated in Figure 3, it can be seen that the increase of TBA value in the peanuts coated with MC or HPMC were lower than uncoated one. The effect of coating to restrict the increase of TBA was markedly shown after 7 days of storage. HPMC-based coating resulted in a lower increase of TBA value in comparison with MC-coated peanuts. Edible coating is a barrier to the gas, moisture and solute. The presence of a layer on the product surface is able to limit moisture and oxygen uptake to the product, so oxidation rate could be consequently suppressed [20; 21].

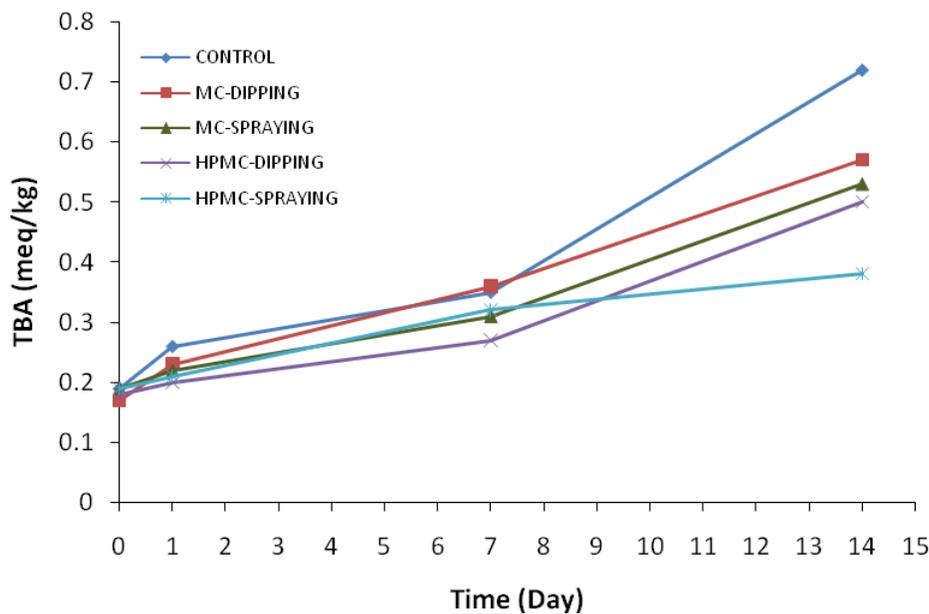


Figure 3. Effect of coating on TBA value of fried partially defatted peanuts during storage.

Conclusions

The results from this study indicated that edible coatings before frying on partially defatted peanuts could be an effective barrier to oil absorption during deep-fat frying. Edible coatings based on MC and HPMC reduced the oil content of fried partially defatted peanuts. Edible coating based on HPMC by spraying was effective in reducing oil content of the product up to 19.24% (db). 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-partially defatted peanuts was significantly higher than those of uncoated ones. Due to some changes in the peanut products caused by coating application, the sensory evaluation is necessary for further study to determine consumer acceptability.

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