# Effect of Lentil (*Lens culinaris*) Coat Powder Addition on Lipid Oxidation and Quality Characteristics of Beef Burgers Stored at 4ºC

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**Abstract:** The effects of three concentrations (1, 2 and 3%) of lentil coat powder (LCP) on physicochemical properties, lipid stability and sensory characteristics of beef burgers were investigated after 0, 3, 6, 9 and 12 days of cold storage at 4 ± 1ºC. Burgers containing LCP had lower levels of moisture, protein, fat and pH, but they had higher levels of ash, carbohydrates, total phenolic compounds (TPC), antioxidant activity and water holding capacity (WHC) when compared with the control and BHT/BHA samples. Also, the addition of LCP retarded lipid oxidation by decreasing of TBARS values that improved the oxidative stability of burger samples. The efficiency of LCP to retard lipid oxidation was concentration-dependent. Moreover, LCP decreased *L**, *a** and *b** values of beef burgers. Lentil coat powder improved sensory characteristics during the cold storage, and the samples containing (1% and 2%) levels of LCP had the best quality.

***Keywords*:** Lentil coat powder, lipid oxidation, antioxidant activity, sensory properties, beef burger

## INTRODUCTION

Lipid oxidation is one of the important reasons of deterioration and reduced shelf life of meat and meat products (Devatkal *et al.,* 2010). Lipid oxidation may cause changes in meat quality characteristics such as color, odor, taste, texture and even nutritional value (Fernandez *et al.,* 1997). Synthetic antioxidants such as butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) have been successfully used by the food industry to minimize or prevent lipid oxidation in meat products (Devatkal *et al.,* 2010; Sáyago-Ayerdi *et al.,* 2009). However, reports of adverse health effects of these antioxidants have increased the refuse to use synthetic antioxidants in meat products (Dejong and Lanari, 2009). Nowadays, there is growing interest in finding natural antioxidants for use in foods because of their safety and consumer acceptability.

In recent years, more attention has been notably increased to use by-products from plant food processing for application in meat products. Waste materials from legumes, fruits and vegetables processing exhibit a practical and economic source of effective natural antioxidants that could replace synthetic antioxidants (Naveena *et al.,* 2008; Oomah *et al.,* 2011). Legume seed coats and cotyledons are excellent sources of polyphenolic compounds and natural antioxidants (Moïse *et al.,* 2005). Proanthocyanidins, flavones and flavonols from methanolic extracts of lentil seed coat were the major antioxidant contributors (Dueñas *et al.,* 2006). Many studies were published on the antioxidant activity and the effectiveness of lentil seed coat and lentil seed extracts in retarding lipid oxidation (Dueñas *et al.,* 2006; Kubicka and Troszyńska, 2003; Oomah *et al.,* 2011; Xu *et al.,* 2007).

The main objective of this study was to evaluate the effect of lentil coat powder (LCP) addition on the proximate composition, physico-chemical and sensory properties of beef burgers during 12 days of cold storage.

## MATERIALS AND METHODS

### Materials:

Fresh beef meat and back fat were purchased from a local retail market (Ismailia, Egypt). The meat was trimmed of visible fat and connective tissues, cut into small pieces and frozen until burgers processing. Spices (black pepper, nutmeg and clove) were obtained from a local market (Ismailia, Egypt). All spices were fresh ground directly before use and sieved through mesh 60 (0.25 mm). Lentil (*Lens culinaris*) coats were obtained as a gift from a local processing plant (Mufaddal Group, El-Obour, Egypt). 2-Thiobarbituric acid (TBA), butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA) and 2,2-diphenyl-1-picrylhydrazyl (DPPH) were obtained from Sigma-Aldrich Chemical Co. (St. Louis, MO, USA). Folin–Ciocalteau phenol reagent was obtained from Merck (Darmstadt, Germany). All other chemicals used were of analytical grade.

### Methods:

#### Preparation of lentil coat powder:

Clean lentil coats were dehydrated at 50ºC for 24 hr to facilitate the milling action by a grinder (Moulinex, LM2421, France). Then, the lentil coat powder (LCP) was sieved through mesh 60 (0.25 mm). The dried LCP was kept in a sealed polyethylene bags and stored at -18ºC until use.

#### Preparation of beef burgers:

Beef meat and back fat were minced twice using a meat mincer (SAP Meat Mincer TC22, Italy), through 8 mm plate followed by 4 mm plate. Beef mixture was produced by mixing 85% beef meat and 15% beef back fat in a classic meat mixer (Chef-KM353 Kenwood Ltd., Havant, UK), and then, the following additives were added and mixed (in g per 100 g quantities) with the meat mixture: (1.4) sodium chloride, (0.65) seasoning (black pepper, nutmeg and clove) and (0.015) sodium tripolyphosphate. After additives mixing,

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samples were assigned to one of the following five treatments: (1) control (beef burger mixture without LCP); (2) 0.2% BHA/BHT in a 1:1 ratio; (3) 1% LCP; (4) 2% LCP; (5) 3% LCP. Burgers of 50±1 g were formed using a burger former (Italmans, Italy). The formed burgers were placed on Styrofoam trays, wrapped with polyethylene film and kept in refrigerator at 4±1ºC for 12 days. The examined burgers were analyzed on 0, 3, 6, 9 and 12 days of cold storage.

**Proximate analysis:**

Moisture, crude protein, fat, ash and crude fiber contents of the experimental burgers were determined according to AOAC (2005). For conversion of nitrogen into crude protein a factor 6.25 was used. Crude fiber was determined by digesting a known weight of fat-free sample in refluxing 1.25% sulfuric acid and 1.25% sodium hydroxide. Carbohydrates were calculated by difference.

**Determination of pH, water holding capacity and instrumental color:**

The pH was measured in 10 g burger sample using a pH meter (Jenway 3010; Jenway Ltd., Essex, UK). For water holding capacity (WHC) determination, the technique of Hamm press method (1986) was used. Objective measurement of color (CIE *L*, a**and *b**) was conducted on the surface of the raw burgers using a color reader CR-10 (Konica Minolta, Inc., Osaka, Japan).

**Determination of total phenolic compounds (TPC), antioxidant activity and thiobarbituric acid reactive substances (TBARS):**

One g of each burger sample (fifteen mg of LCP) were mixed with 25 ml of 50% ethanol, stirred at room temperature for 2 hr and filtered through Whatman No.1 filter paper (centrifuged at 3000 rpm for 20 min for burger sample). The total phenolic compounds (TPC) were determined in the ethanolic extract, according to the Folin–Ciocalteu method (Jaramillo-Flores *et al.,* 2003) by using a spectrophotometer (6505 UV/Vis, Jenway Ltd., Felsted, Dunmow, UK), and gallic acid was used to prepare the calibration curve. The antioxidant activity of LCP and burger samples was determined by the (DPPH) method (Lee *et al.,* 2003). For TBARS determination, the method of Tarladgis *et al.* (1960), as modified by Shahidi *et al.* (1987) was used. A portion of 10 g sample (5 ml) were reacted with 5 ml of TBA reagent and the absorbance of the resultant pink-colored chromogen was measured at 532 nm using the spectrophotometer (6505 UV/Vis, Jenway Ltd., Felsted, Dunmow, UK). TBARS values were calculated by multiplying the absorbance by the factor of 8.1 (mg malonaldehyde equivalents/kg of meat sample).

**Microstructure:**

Beef burger samples were fixed with 4% glutaraldehyde in 0.2 M sodium cacodylate buffer (pH 6) for 4 hr, then post-fixed with $OsO_4$ for 2 hr. Fixed tissues were rinsed and dehydrated through ethanol gradual serial dilutions from 10 to 100% for 10 min ended by 30 min in final concentration. The specimens were transferred on cupper slide and dehydrated using critical point dryer with liquid carbon dioxide, then coated with gold using Edwards S150A Sputter coater unit (BOC Edwards, UK). Finally, the specimens were examined and photographed using scanning electron microscope (Quanta Feg 250, FEI, USA).

**Sensory Evaluation:**

Beef burger samples were sensory evaluated as described by García *et al.* (2009).The samples were cooked on an electric grill (WA-BBQ 01, White Whale, China) at approximately 180 ºC for 2 min for each side. Cooked burger of each sample was served to the panelists. The test was carried out using non-structured 9 point scales (0 = dislike extremely and 9 = like extremely) in which the panelists evaluated different attributes: color, odor, taste, texture and overall acceptability.

**Statistical analysis:**

All treatments and analyses were carried out in triplicates. All data were expressed as means ± standard deviation (means ± SD). Data were subjected to analysis of variance (ANOVA) accompanied with Duncan test using SPSS software (version 16.0 for Windows, SPSS Inc., Chicago) to identify the significance ($p < 0.05$) among the treatments.

## RESULTS AND DISCUSSION

**Physico-chemical properties of raw powder:**

The physico-chemical properties of LCP are presented in Table (1). Moisture content of LCP was 5.95%, indicating low level of moisture. Also, LCP contained (2.88%). And it contained a moderate level of protein 9.05%, and 8.68% of fat. However, lentil coat powder had a high level of fiber (27.24%). Plants are important sources of dietary fiber, and consumption of dietary fiber may reduce the risk of some diseases such as gastrointestinal disorders, obesity, coronary heart diseases, diabetes and many cancers (Anderson *et al.,* 2009). Moreover, plant fibers in meat products are regarded as functional ingredients in two ways, by decreasing the caloric content and by increasing the complex carbohydrate content, which is low in meat products. Also, addition of plant dietary fibers as partial fat replacers into meat products may enhance the binding properties, textural characteristics and cooking yield of meat products (Borderías *et al.,* 2005). For carbohydrate content, the results showed that LCP had high carbohydrate content (73.44%). Regarding pH value, the results indicated that LCP had a relatively acidic pH value (6.14) value.

Moreover, LCP contained high level of total phenolic compounds (TPC) (111.41 mg/100 g) and exhibited high level of antioxidant activity (38.71%). The obtained results agree with those reported by Oomah *et al.* (2011) for phenolics and antioxidant activity of lentil coat. The color parameters of raw LCP are shown in Table (1). Lentil coat powder had a high lightness (*L**) value (60.38). On the other hand, LCP had low levels of redness (*a**) value (2.32) and yellowness (*b**) value (10.12).

**Table (1):** Physico-chemical properties of lentil coat powder

| | Parameter | Lentil coat powder (Mean ± S. D) |
|---|---|---|
| **Chemical composition** | **Moisture %** | 5.95±0.080 |
| | **Ash %** | 2.88±0.010 |
| | **Protein %** | 9.05±0.720 |
| | **Fat %** | 8.68±0.495 |
| | **Fiber %** | 27.24±0.10 |
| | **[a]Carbohydrates %** | 73.44±0.56 |
| **Antioxidant activity** | **TPC (mg/g dw)** | 111.4±0.517 |
| | **DPPH %** | 38.71±0.369 |
| **pH- value** | | 6.14±0.005 |
| **Color** | ***L*[b]*** | 60.38±0.084 |
| | ***a*[b]*** | 2.32±0.0450 |
| | ***b*[b]*** | 10.12±0.084 |

[a]Carbohydrates calculated by difference including fiber
TPC = total phenolic compounds
DPPH = antioxidant activity assayed by diphenyl picrylhydrazyl free radical
[b]*L*a**, and *b** refer to lightness, redness and yellowness, respectively

**Effect of LCP on chemical composition, pH and WHC of beef burgers:**

The results of chemical composition of raw beef burgers are listed in Table (2). The data showed that the control sample contained (62.17%) moisture, (15.81%) protein, (20.23%) fat, (1.09%) ash, and (0.75%) carbohydrate. Significant decreases ($p< 0.05$) were found in moisture contents of all burger treatments except BHT/BHA when compared to the control sample. Also, the decrease was proportional to the addition level of LCP, thus the higher percentage decrease was recorded in LCP3% (61.01%). The reduction of moisture contents could increase the shelf life of the burgers. Similar results were observed by El-Nashi *et al.* (2015) for beef sausage prepared with different levels of pomegranate powder. In contrast, significant increases ($p<0.05$) in moisture contents were found in beef burger formulated with hazelnut pellicle (Turhan *et al.,* 2005). On the other hand, no significant changes in the moisture contents were found in meat balls and chicken patties formulated with lentil flours (Naveena *et al.,* 2006; Serdaroğlu *et al.,* 2005).Regarding the protein contents, all treatments except BHT/BHA caused a significant decrease when compared to the control sample (15.81%). In addition, lowest level was recorded in LC3% (15.41%). Similar results were observed in chicken nuggets incorporated with soybean hulls and green banana flours by Kumar *et al.* (2013) and pomegranate seed powder by Kaur *et al.* (2015). However, Serdaroğlu *et al.* (2005) reported that lentil flour did not significantly affect the level of protein in meatballs. The decrease in the moisture and protein contents in the experimental burgers was attributed to the low levels of moisture and protein in LCP as shown in Table (1). LCP treatments caused a significant ($p < 0.05$)decrease in the fat content when compared to the control sample (20.23%). Similarly, Turhan *et al.* (2005) found a significant decrease of the fat content in beef burger fortified with hazelnut pellicle. On the contrary, Alakali *et al.* (2010) and El-Nashi *et al.* (2015) reported no significant changes in fat contents in beef patties and beef sausage when adding Bambara groundnut seed flour and pomegranate peels, respectively. Moreover, all LCP treatments caused a significant ($p < 0.05$) increase in ash and carbohydrates contents, while BHT/BHA treatment exhibited no effect. Also, the increase was proportional to the levels of LCP. Therefore, the highest levels of ash and carbohydrates were recorded in the addition level 3% of LCP (2.11% and 1.91%, respectively). These results were related to the chemical composition of LCP which contained high levels of ash and carbohydrates as shown in Table (1). Similar results were reported for ash content by Alakali *et al.* (2010) in beef patties and for carbohydrates in beef burger by Turhan *et al.* (2005).

pH and WHC values of the control sample were 5.93 and 65.80, respectively. The pH values of all treated burger samples were significantly ($p < 0.05$) lower compared to the control sample and this was may be due to the effect of LCP, because it had low pH value (Table 1). Also, the obtained results revealed that WHC of burger samples significantly ($p < 0.05$) increased with LCP addition. Moreover, the increase was proportional with the addition level of LCP, thus, the level of 3% had the highest WHC values. Similar results were observed in chicken cutlets incorporated with carrot powder (Kumar *et al.,* 2015).

**Effect of LCP on TPC, antioxidant activity and TBARS of beef burgers:**

Data presented in Table (3) show the changes in total phenolic content (TPC), antioxidant activity and TBARS of beef burger samples during cold storage. The results showed that, addition of LCP and BHA/BHT to beef burgers resulted in a significant ($p < 0.05$) increase of TPC contents in the burgers. The burgers formulated with LCP2% and LCP3% had the highest levels of TPC (119.69 and 145.33 mg/100 g, respectively), and this was attributed to the high content of TPC in LCP as shown in Table (1). Moreover, the levels of TPC were proportional with the levels of added LCP in the beef burgers. The present results are in good agreement with those reported for goat meat and chicken patties fortified with pomegranate rind powder, which increase the level of total phenolic compounds in these products (Devatkal *et al.,* 2010; Naveena *et al.,* 2008). A significant ($p < 0.05$) increase of antioxidant activity (DPPH) was observed in all treatments as compared to the control (28.21%) sample (Table 3). The burgers

formulated with LCP3% had the highest antioxidant activity (61.74%), while LCP1% had the lowest value (44.29%). A good relation between TPC and antioxidant activity has been reported, and diverse phenolic compounds with radical scavenging and chelating activities were found in peanut skin indicating their applicability to meat products (Munekata *et al.,* 2015). Thus, the high levels of antioxidant activity in LCP treatments were attributed to the high levels of TPC in LCP. Our results are similar to those reported by Devatkal and Naveena (2010) in ground goat meat. Moreover, Naveena *et al.* (2008) found a high antioxidant activity in cooked chicken patties with pomegranate rind powder. The TPC and antioxidant activity gradually decreased in all burger samples during the 12 days of storage. The decrease in TPC may be attributed to the decomposition of TPC during storage. Thus, because of the relation between the phenolic compounds and the antioxidant activity, the radical scavenging decreased. However, some treatments still had high levels of TPC and antioxidant activity after 12 days of storage, such as LCP2% and LCP3% (79.38 and 100.76 mg/100 g for TPC and 47.69 and 54.73% for antioxidant activity, respectively). The obtained results of TPC and antioxidant activity for LCP treatments indicated that LCP could be effectively used to retard lipid oxidation in meat products.

Addition of LCP and BHT/BHA significantly ($p < 0.05$) reduced TBARS values compared to the control sample during storage of beef burgers. This effect depends on the addition level of LCP incorporated with the burgers. Hence, the highest level of LCP (3%) were most efficient in inhibiting the lipid oxidation (the lowest TBARS values). TBARS values increased rapidly with storage time in the control sample throughout the whole period of storage. On the other hand, the increase in TBARS values in treated samples was slight and remained lower than that of control sample (less than 0.7 mg malondialdehyde/kg sample). Similarly, the addition of pomegranate peel powder and grape antioxidant in beef sausage and breast chicken meat inhibited lipid oxidation during cold storage (El-Nashi *et al.,* 2015; Sáyago-Ayerdi *et al.,* 2009).

**Table (2):** Effect of LCP on chemical composition, pH and WHC values of beef burgers stored at 4ºC.

| Treatments | Physico-chemical properties | | | | | | |
|---|---|---|---|---|---|---|---|
| | Moisture % | Protein % | Fat % | Ash % | *Carbohydrates % | pH | WHC % |
| **LCP1%** | 61.67±0.11$^{c}$ | 15.67±0.01$^{b}$ | 19.74±0.03$^{b}$ | 1.38±0.01$^{c}$ | 1.54±0.08$^{a}$ | 5.90±0.01$^{b}$ | 75.21±0.45$^{c}$ |
| **LCP2%** | 61.54±0.02$^{b}$ | 15.58±0.01$^{c}$ | 19.59±0.08$^{c}$ | 1.61±0.04$^{b}$ | 1.67±0.15$^{a}$ | 5.89±0.01$^{b}$ | 78.91±0.38$^{b}$ |
| **LCP3%** | 61.01±0.42$^{b}$ | 15.41±0.01$^{d}$ | 19.56±0.02$^{c}$ | 2.11±0.01$^{a}$ | 1.91±0.42$^{a}$ | 5.87±0.00$^{c}$ | 79.99±0.29$^{a}$ |
| **BHT/BHA** | 62.13±0.12$^{a}$ | 15.80±0.02$^{a}$ | 20.19±0.02$^{a}$ | 1.09±0.01$^{d}$ | 0.61±0.16$^{b}$ | 5.90±0.01$^{b}$ | 65.43±0.61$^{d}$ |
| **Control** | 62.17±0.07$^{a}$ | 15.81±0.02$^{a}$ | 20.23±0.01$^{a}$ | 1.09±0.01$^{d}$ | 0.75±0.06$^{b}$ | 5.93±0.01$^{a}$ | 65.80±0.39$^{d}$ |

*Carbohydrates calculated by difference,
LCP = lentil coat powder (1, 2, and 3%); BHT/BHA= 0.2 g BHA/BHT (1:1)/kg meat
WHC= water holding capacity, data are presented as means ±S. D,
a,b, … there is no significant difference between any two means have the same superscript letter within the same column (P>0.05).

**Effect of LCP on color parameters of beef burgers:**

Color is a key factor which influences consumers when assessing the quality and palatability of meat and meat products. The color parameters ($L^*$, $a^*$ and $b^*$) of different formula of beef burgers are summarized in Table (4). For $L^*$ value, the control sample had the highest value ($p < 0.05$) compared to the other treatments. The addition of LCP to the burgers caused a darkening that resulted in lower $L^*$ values compared to the control sample. Also, $L^*$ values gradually decreased by rising the concentration of LCP up to 3% (39.98). The decrease of $L^*$ values in beef burger fortified with LCP was due to the dark color of LCP as shown in Table (1). The burgers containing BHT/BHA had a slight decrease in $L^*$ value (42.34) when compared to the control sample (43.32). Similar results were found by adding beet root powder, grape dietary fiber, kinnow and pomegranate rind powder to beef sausage, chicken burger and goat meat (Devatkal and Naveena, 2010; El-Gharably and Ashoush, 2011; Sáyago-Ayerdi *et al.,* 2009). Munekata *et al.* (2015) reported that variations in $L^*$ values seem to depend on phenolic concentrations. As regards to changes in $L^*$ values during storage (0 to 12 days), there was a gradual decreasing trend in all examined samples indicating more darkening (Table 4). In contrast, no significant effect of cold storage was reported on $L^*$ values in raw minced chicken breasts contained almond skin powder (Teets and Were, 2008).

**Table (3):** Effect of LCP on total phenolic compounds (mg/100 g), antioxidant activity (%) and TBARS (mg malonaldehyde/kg sample) of beef burgers stored at 4ºC.

| Treatments | | Storage time (days) | | | | |
|---|---|---|---|---|---|---|
| | | 0 | 3 | 6 | 9 | 12 |
| Total phenolic compound (TPC) | LCP1% | 88.85±0.255$^{d}$ | 76.94±0.440$^{d}$ | 73.28±0.610$^{d}$ | 69.00±0.610$^{d}$ | 62.59±0.470$^{d}$ |
| | LCP2% | 119.69±0.055$^{b}$ | 109.31±0.220$^{b}$ | 97.70±0.275$^{b}$ | 87.32±0.055$^{b}$ | 79.38±0.225$^{b}$ |
| | LCP3% | 145.33±0.615$^{a}$ | 126.40±0.055$^{a}$ | 116.94±0.140$^{a}$ | 105.34±0.030$^{a}$ | 100.76±0.275$^{a}$ |
| | BHT/BHA | 90.07±0.580$^{c}$ | 87.32±0.335$^{c}$ | 83.66±0.330$^{c}$ | 78.16±0.165$^{c}$ | 76.33±0.170$^{c}$ |
| | Control | 57.07±0.275$^{e}$ | 54.96±0.610$^{e}$ | 52.21±0.305$^{e}$ | 50.68±0.775$^{e}$ | 49.16±0.305$^{e}$ |
| Antioxidant activity (DPPH) | LCP1% | 44.29±0.280$^{d}$ | 42.68±0.240$^{d}$ | 39.47±0.535$^{d}$ | 37.47±0.960$^{d}$ | 35.56±0.730$^{d}$ |
| | LCP2% | 54.95±0.755$^{b}$ | 53.72±0.495$^{b}$ | 51.14±0.140$^{b}$ | 49.76±0.720$^{b}$ | 47.69±0.245$^{b}$ |
| | LCP3% | 61.74±0.882$^{a}$ | 58.13±0.805$^{a}$ | 57.15±0.380$^{a}$ | 55.36±0.420$^{a}$ | 54.73±0.365$^{a}$ |
| | BHT/BHA | 49.42±0.115$^{c}$ | 48.39±0.375$^{c}$ | 47.72±0.240$^{c}$ | 45.96±0.545$^{c}$ | 44.72±0.300$^{c}$ |
| | Control | 28.21±0.585$^{e}$ | 24.63±0.680$^{e}$ | 23.62±0.780$^{e}$ | 22.71±0.300$^{e}$ | 21.97±0.485$^{e}$ |
| Thiobarbituric acid reactive substances | LCP1% | 0.113±0.004$^{b}$ | 0.152±0.004$^{b}$ | 0.284±0.008$^{b}$ | 0.436±0.015$^{b}$ | 0.569±0.016$^{b}$ |
| | LCP2% | 0.109±0.001$^{bc}$ | 0.138±0.006$^{c}$ | 0.259±0.011$^{c}$ | 0.385±0.026$^{c}$ | 0.514±0.023$^{c}$ |
| | LCP3% | 0.094±0.001$^{d}$ | 0.120±0.004$^{d}$ | 0.225±0.006$^{d}$ | 0.317±0.012$^{d}$ | 0.442±0.013$^{e}$ |
| | BHT/BHA | 0.105±0.004$^{c}$ | 0.129±0.005$^{cd}$ | 0.238±0.005$^{d}$ | 0.343±0.009$^{d}$ | 0.478±0.018$^{d}$ |
| | Control | 0.137±0.004$^{a}$ | 0.234±0.008$^{a}$ | 0.406±0.008$^{a}$ | 0.706±0.012$^{a}$ | 0.987±0.012$^{a}$ |

LCP = lentil coat powder (1, 2, and 3%); BHT/BHA= 0.2 g BHA/BHT (1:1)/kg meat data are presented as means ±S. D,
a, b, … there is no significant difference between any two means have the same superscript letter within the same column (P>0.05).

Similar results were observed for *a** (redness) and *b** (yellowness) values of prepared burgers. Addition of LCP and BHT/BHA significantly ($p < 0.05$) decreased the *a** and *b** values when compared to the control sample (15.16 and 14.08, respectively), Table (4). Also, *a** and *b** values gradually decreased by rising LCP concentration up to 3%. These results are in good agreement with those reported for chicken patties and chicken hamburgers (Munekata *et al.,* 2015; Sáyago-Ayerdi *et al.,* 2009). In contrast, no significant effects had been reported for *a** values in raw minced chicken breasts and chicken patties when adding almond skin powder and peanut skin extract (Teets and Were, 2008; Munekata *et al.,* 2015). In addition, gradual decreases of *a** and *b** values were observed during the whole storage period for the control and the other treated samples. Similar results were reported by Devatkal and Naveena, (2010) who reported that *a**values of ground goat meat formulated with Kinnow rind powder and pomegranate rind powder significantly decreased during the storage period. However, Munekata *et al.* (2015) reported that *b** values of chicken patties fortified with peanut skin extract remained stable after 15 days of storage. Also, Teets and Were (2008) reported that no significant effect of storage time on *b** values for chicken breasts fortified with almond skin powder.

**Scanning electron microscopy:**

The microscopic structure for control beef burger showed smooth protein matrix with inclusion of pores and a lot of large fat globules which gave rough appearance over protein matrix, this protein network contains globular and fibrous proteins. Also, large holes and grooves with different sizes can be observed (Fig 1 A). On the other hand, burger sample incorporated with 2% LCP (Figure 1 B) appeared with denser, cohesive, homogenized texture, and lower amount of large oval fat globules. It is easy to distinguish LCP with slightly lighter appearance, giving a firm, and smooth texture.

**Table (4):** Effect of LCP on color parameters (*L*, a** and *b**) of beef burgers stored at 4ºC.

| Storage time (days) | Treatments | Color attributes | | |
|---|---|---|---|---|
| | | ***L**** | ***a**** | ***b**** |
| **0** | **LCP1%** | 43.08±0.873$^{a}$ | 13.76±0.261$^{c}$ | 13.84±0.986$^{a}$ |
| | **LCP2%** | 41.48±0.164$^{c}$ | 12.63±0.749$^{d}$ | 13.98±0.268$^{a}$ |
| | **LCP3%** | 39.98±0.512$^{d}$ | 11.88±0.522$^{d}$ | 14.28±0.683$^{a}$ |
| | **BHT/BHA** | 42.34±0.404$^{b}$ | 16.04±0.182$^{a}$ | 14.46±0.680$^{a}$ |
| | **Control** | 43.32±0.164$^{a}$ | 15.16±0.873$^{b}$ | 14.08±0.740$^{a}$ |
| **3** | **LCP1%** | 41.12±0.259$^{b}$ | 11.24±0.546$^{c}$ | 11.82±0.444$^{d}$ |
| | **LCP2%** | 40.02±0.342$^{c}$ | 10.66±0.279$^{d}$ | 12.34±0.792$^{bc}$ |
| | **LCP3%** | 39.16±0.114$^{d}$ | 9.66±0.230$^{e}$ | 12.98±0.268$^{b}$ |
| | **BHT/BHA** | 39.40±0.316$^{d}$ | 13.08±0.559$^{b}$ | 12.36±0.767$^{bc}$ |
| | **Control** | 43.32±0.164$^{a}$ | 15.16±0.873$^{a}$ | 14.08±0.740$^{a}$ |
| **6** | **LCP1%** | 40.24±0.550$^{b}$ | 10.04±0.477$^{b}$ | 11.56±0.270$^{c}$ |
| | **LCP2%** | 38.42±0.614$^{cd}$ | 9.40±0.158$^{c}$ | 11.96±0.404$^{bc}$ |
| | **LCP3%** | 38.00±0.678$^{d}$ | 8.30±0.696$^{d}$ | 12.32±0.396$^{ab}$ |
| | **BHT/BHA** | 38.78±0.618$^{c}$ | 12.10±0.394$^{a}$ | 11.68±0.363$^{bc}$ |
| | **Control** | 42.10±0.122$^{a}$ | 12.72±0.471$^{a}$ | 12.76±0.744$^{a}$ |
| **9** | **LCP1%** | 38.40±0.187$^{b}$ | 10.22±0.438$^{b}$ | 11.14±0.195$^{b}$ |
| | **LCP2%** | 37.02±0.164$^{c}$ | 8.68±0.239$^{c}$ | 11.44±0.114$^{b}$ |
| | **LCP3%** | 36.42±0.497$^{d}$ | 7.70±0.100$^{d}$ | 11.94±0.371$^{a}$ |
| | **BHT/BHA** | 38.38±0.356$^{b}$ | 10.52±0.192$^{b}$ | 11.18±0.228$^{b}$ |
| | **Control** | 41.62±0.311$^{a}$ | 11.38±0.277$^{a}$ | 12.20±0.200$^{a}$ |
| **12** | **LCP1%** | 36.92±0.455$^{c}$ | 10.00±0.141$^{a}$ | 10.72±0.507$^{cd}$ |
| | **LCP2%** | 36.30±0.548$^{d}$ | 8.24±0.167$^{c}$ | 10.94±0.261$^{bc}$ |
| | **LCP3%** | 35.44±0.503$^{e}$ | 7.48±0.084$^{d}$ | 11.30±0.316$^{bc}$ |
| | **BHT/BHA** | 37.74±0.167$^{b}$ | 9.94±0.279$^{a}$ | 10.44±0.207$^{d}$ |
| | **Control** | 40.28±0.476$^{a}$ | 8.58±0.303$^{b}$ | 11.70±0.255$^{a}$ |

LCP = lentil coat powder (1, 2, and 3%); BHT/BHA= 0.2 g BHA/BHT (1:1)/kg meat

a, b, … there is no significant difference between any two means have the same superscript letter within the same column (P>0.05).

**Table (5):** Effect of LCP on sensory properties of beef burgers stored at 4ºC.

| Storage time (days) | Treatments | Color | Odor | Taste | Texture | Overall acceptability |
|---|---|---|---|---|---|---|
| 0 | LCP1% | 9.83±0.408$^{a}$ | 9.83±0.408$^{a}$ | 10.00±0.00$^{a}$ | 9.67±0.516$^{a}$ | 9.83±0.303$^{a}$ |
| | LCP2% | 9.67±0.516$^{a}$ | 9.83±0.408$^{a}$ | 9.83±0.408$^{a}$ | 9.83±0.408$^{a}$ | 9.79±0.246$^{a}$ |
| | LCP3% | 9.50±0.548$^{a}$ | 9.67±0.516$^{a}$ | 9.67±0.516$^{a}$ | 10.00±0.00$^{a}$ | 9.71±0.292$^{a}$ |
| | BHT/BHA | 9.83±0.408$^{a}$ | 9.50±0.548$^{a}$ | 9.50±0.548$^{a}$ | 9.50±0.548$^{a}$ | 9.58±0.258$^{a}$ |
| | Control | 10.00±0.00$^{a}$ | 9.67±0.516$^{a}$ | 10.00±0.00$^{a}$ | 9.50±0.548$^{a}$ | 9.79±0.246$^{a}$ |
| 3 | LCP1% | 9.67±0.516$^{a}$ | 9.67±0.516$^{a}$ | 9.83±0.408$^{a}$ | 9.83 ±0.408$^{a}$ | 9.75±0.387$^{a}$ |
| | LCP2% | 9.50±0.548$^{a}$ | 9.67±0.516$^{a}$ | 9.67±0.516$^{a}$ | 9.67 ±0.516$^{a}$ | 9.63±0.379$^{a}$ |
| | LCP3% | 9.33±0.516$^{a}$ | 9.33±0.516$^{a}$ | 9.50±0.548$^{a}$ | 9.50 ±0.548$^{a}$ | 9.42±0.492$^{a}$ |
| | BHT/BHA | 9.67±0.516$^{a}$ | 9.33±0.516$^{a}$ | 9.33±0.516$^{a}$ | 9.33 ±0.516$^{a}$ | 9.42±0.408$^{a}$ |
| | Control | 9.83±0.408$^{a}$ | 9.50±0.548$^{a}$ | 9.83±0.408$^{a}$ | 9.33 ±0.516$^{a}$ | 9.63±0.379$^{a}$ |
| 6 | LCP1% | 9.17±0.408$^{ab}$ | 9.33±0.516$^{ab}$ | 9.33±0.516$^{a}$ | 9.83±0.408$^{a}$ | 9.42±0.342$^{a}$ |
| | LCP2% | 9.50±0.548$^{a}$ | 9.50±0.548$^{a}$ | 9.67±0.516$^{a}$ | 9.50±0.548$^{a}$ | 9.54±0.368$^{a}$ |
| | LCP3% | 9.17±0.408$^{ab}$ | 9.17±0.408$^{ab}$ | 9.50±0.548$^{a}$ | 9.33±0.516$^{a}$ | 9.29±0.292$^{a}$ |
| | BHT/BHA | 8.67±0.516$^{bc}$ | 8.67±0.516$^{b}$ | 8.67±0.516$^{b}$ | 8.67±0.516$^{b}$ | 8.67±0.258$^{b}$ |
| | Control | 8.17±0.408$^{c}$ | 9.00±0.632$^{ab}$ | 8.17±0.408$^{b}$ | 8.67±0.516$^{b}$ | 8.50±0.274$^{b}$ |
| 9 | LCP1% | 7.67±0.516$^{ab}$ | 7.50±0.548$^{ab}$ | 7.67±0.516$^{a}$ | 9.17±0.408$^{a}$ | 8.00±0.274$^{ab}$ |
| | LCP2% | 7.67±0.516$^{ab}$ | 7.67±0.516$^{ab}$ | 8.17±0.408$^{a}$ | 9.33±0.516$^{a}$ | 8.21±0.188$^{a}$ |
| | LCP3% | 7.17±0.408$^{bc}$ | 7.17±0.408$^{b}$ | 7.83±0.408$^{a}$ | 9.33±0.516$^{a}$ | 7.88±0.137$^{ab}$ |
| | BHT/BHA | 8.00±0.894$^{a}$ | 8.17±0.983$^{a}$ | 8.00±0.894$^{a}$ | 6.83±0.408$^{b}$ | 7.75±0.548$^{e}$ |
| | Control | 6.67±0.516$^{c}$ | 6.33±0.516$^{c}$ | 6.17±0.408$^{b}$ | 6.67±0.516$^{b}$ | 6.46±0.332$^{c}$ |
| 12 | LCP1% | 6.50±0.548$^{ab}$ | 6.50±0.548$^{ab}$ | 7.17±0.753$^{ab}$ | 6.67±0.516$^{b}$ | 6.71±0.102$^{b}$ |
| | LCP2% | 7.00±0.632$^{a}$ | 7.00±0.632$^{a}$ | 7.50±0.837$^{a}$ | 7.50±0.548$^{a}$ | 7.25±0.387$^{a}$ |
| | LCP3% | 6.00±0.632$^{b}$ | 6.33±0.516$^{b}$ | 6.67±0.516$^{b}$ | 6.67±0.516$^{b}$ | 6.42±0.129$^{c}$ |
| | BHT/BHA | 4.67±0.516$^{c}$ | 4.33±0.516$^{c}$ | 4.33±0.516$^{c}$ | 4.33±0.516$^{c}$ | 4.42±0.204$^{d}$ |
| | Control | 4.50±0.548$^{c}$ | 4.00±0.000$^{c}$ | 4.17±0.408$^{c}$ | 4.33±0.516$^{c}$ | 4.25±0.158$^{d}$ |

LCP = lentil coat powder (1, 2, and 3%); BHT/BHA= 0.2 g BHA/BHT (1:1)/kg meat
a, b, … there is no significant difference between any two means have the same superscript letter within the same column (P>0.05).

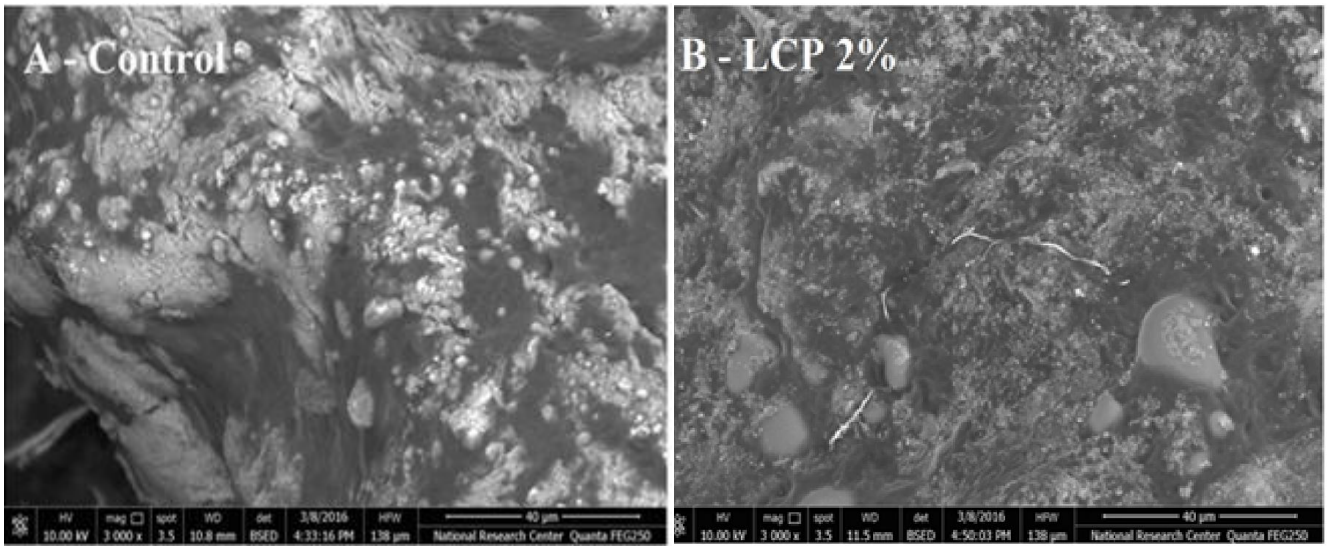


**Fig. (1):** Scanning electron micrographs of beef burger (3000x) 10.00 KV
A= Control, B= LCP2%

**Effect of LCP on sensory properties of beef burgers:**

The effect of different addition levels of LCP on the sensory properties of beef burgers are presented in Table (5). In general, no significant ($p > 0.05$) differences were observed at zero time for all examined sensory properties (color, odor, taste, texture and overall acceptability) among the control sample and the other treatments. During the cold storage, the scores of all sensory properties gradually decreased as the time extended in all burger treatments. With the progress of cold storage, the sensory scores of all LCP treated burgers were deteriorated. Less rates of sensory properties deterioration were found in burger samples treated with LCP1% and LCP2% when compared to the other treatments. The dietary fiber in LCP may improve the texture of burgers by its water holding capacity and fat binding properties. The obtained results are in good agreement with those of O'Keefe and Wang (2006), Nag *et al.* (1998) and Sharma *et al.* (1988).

## CONCLUSION

Physicochemical properties of beef burgers were influenced by the addition of lentil coat powder (LCP). Moisture, protein, fat and pH levels decreased, whereas the levels of ash, carbohydrates, total phenolic compounds, antioxidant activity (DPPH) and water holding capacity (WHC) increased. Also, the addition of LCP significantly retarded the lipid oxidation during 12 days of cold storage, and increased the lipid stability of the burgers. Moreover, LCP decreased $L^*$, $a^*$ and $b^*$ values for beef burgers. Sensory evaluation demonstrated significant differences among the control and the remaining treatments, and the burgers containing low levels of LCP (1 and 2%) had the best quality.

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# تأثير إضافة مسحوق قشور العدس على أكسدة الدهن وخصائص الجودة لبرجر اللحم البقرى المخزن على ٤°م

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تم دراسة تأثير ثلاثة تركيزات (١، ٢، ٣%) من مسحوق قشور العدس على الخصائص الطبيعية الكيميائية، ثبات الدهن والخصائص الحسية لبرجر اللحم البقرى بعد ٠، ٣، ٦، ٩، ١٢ يوم من التخزين المبرد على ٤ ± ١°م. احتوت عينات برجر اللحم المدعمة بمسحوق قشور العدس على مستويات أقل من الرطوبة، البروتين، الدهن والـ pH، بينما احتوت نفس العينات على مستويات أعلى من الرماد، الكربوهيدرات، المركبات الفينولية الكلية، النشاط المضاد للأكسدة والقدرة على الاحتفاظ بالماء (WHC) بالمقارنة بالعينات الكنترول والمحتوية على الـ BHT/BHA. كما أوضحت النتائج أن إضافة مسحوق قشور العدس يؤخر من أكسدة الدهن وبالتالي يخفض من قيم الـ TBARS ويحسن من الثبات التأكسدى لعينات برجر اللحم ولوحظ أن قدرة هذه القشور على تأخير أكسدة الدهن تعتمد على التركيز المضاف منها. علاوة على ذلك، فقد أدى إضافة مسحوق قشور العدس إلى خفض قيم اللون $L^*$, $a^*$, $b^*$ لعينات برجر اللحم المختبرة. حسّن مسحوق قشور العدس من الخصائص الحسية لبرجر اللحم خلال التخزين المبرد حتى ٩ أيام من التخزين، وظهر أن العينات المحتوية على مستويات (١، ٢%) من مسحوق قشور العدس هي الأفضل جودة.