Ann. For. Res. 65(1): 4720-4729, 2022
ISSN: 18448135, 20652445

ANNALS OF FOREST RESEARCH
https://www.e-afr.org/

CHEMICAL PARAMETERS OF COATED BEEF BURGER WITH EDIBLE OAT FILM DURING REFRIGERATED PRESERVING

Ali Ayad Hussein Al-Sabea[1,2,*], Amera K. Nasser[1] and Ali K. Al-Rikabi[3]
[1] Department of Animal Production, College of Agriculture, University of Basrah, Iraq.
[2] Department of Animal Production, College of Agriculture, Wasit University, Iraq.
[3] Department of Food Science, College of Agriculture, University of Basrah, Iraq.
[*]Corresponding author email: aliayaad@uowasit.edu.iq

Abstract
Beef burgers were coated with simple film, prepared from oats protein concentrate, and kept in refrigerated conditions at 4°C for ten days. The oxidation parameters of meat have been studied, such as peroxide value, the thiobarbituric acid value, the percentage of volatile fatty acids, and the volatile nitrogen value during the storage period. It was observed from the results that the encapsulation treatment was superior in reducing oxidative stress (POV, TBA, FFA, and TVN) during the different storage periods compared to the control (uncoated), which contributed to the prolongation of the storage period of the coated burgers under refrigeration conditions.
Keywords: Chemical parameters, coated meat burger, oat film, refrigerated preserving.

Introduction:

The use of coating techniques is an essential method in extending the shelf life of meat and other food products. However, most coatings processors include non-biodegradable synthetic materials such as plastic, nylon, and polyester (Assad et al., 2020), exacerbating the environmental damage caused by plastic waste containers' accumulation and failure to decompose. In addition to the toxic risks, it contains substances that, if transferred and interacted with the food, pose a danger to the consumer (Yang et al., 2019; Wang et al., 2021).

Consumer demand for safe and stable foods has increased due to awareness of food safety and the negative environmental impacts of non-biodegradable coatings (Bhagath & Manjula, 2019). Recent research has focused on developing coating materials made from natural polymers, such as proteins, polysaccharides, or fats, especially edible ones. These biodegradable polymers are an excellent alternative to traditional plastics. In addition, it works to prolong the storage period of the food while maintaining its quality elements as long as possible; by fortifying it or making chemical modifications, it preserves the physical and chemical properties of the coated food (Mahcene et al., 2021). Proteins are distinguished from other biological compounds by having a unique structure. It is made up of 20 different monomers, which allows for the possibility of binding with other molecules. It also has excellent mechanical and barrier properties for gases compared to fats and polysaccharides; therefore, it can be used to produce edible films (Bourtoom, 2009).

Coating techniques protect meat and its products from contamination factors. They act to shield the food and extend its shelf life. Edible films are natural biopolymers made of proteins, polysaccharides, or lipids. They can be used alone or cross-linking, which could be an attractive

substitute for non-biodegradable coating (Hamann et al., 2021). The objective of the current study is to identify the chemical characteristics of beef burgers that have been coated with edible oat film during refrigeration preservation.

Materials and Methods:

Prepare the Simple edible film

With a minor modification, the protein film-forming solution was made following the procedure used by Habibi Zarabadi et al., (2017). Added 5% oat protein concentrate as a ratio of weight to volume (protein: distilled water), then adjusted the pH solution to 10, using a 0.5 M solution of NaOH. Afterward, a water bath was used to heat the solution to 90 °C for 30 minutes. Then solution was cooled at a laboratory temperature of 24°C. At a concentration of 40% of the weight of the protein utilized, the plasticizer glycerol was added to the solution. Then, the film-forming solution was followed by an additional mixing process with a magnetic homogenizer for 10 minutes at a temperature of 24 °C. On a flat surface, pour 10 ml of the film-forming solution into plastic plates with a 9 cm diameter. The films were left to dry at 45°C for 6 hours in an air-drying oven.

Beef burger Preparation

Minced meat consisting of 80% lean and 15% fat, and a mixture of spices with salt and flour was mixed. To obtain an optimal homogeneity sample, mixing and mincing were done using a meat mincer. Circular beef burgers with a diameter of 7 cm, a weight of 50 ± 2 g, and a thickness of 7.5 mm were made. After that, the beef burgers were coated with edible oat film, while the control treatment was left uncoated.

Oxidative Index Tests

Peroxide Value

Using the method of Pearson et al., (1981), 3 grams of the oil extracted from the beef burger samples were obtained to estimate the PV of the stored beef burger samples for each refrigerator storage time. First, add 30 ml of a solution prepared from (60% glacial acetic acid and 40% chloroform). Then add 2 ml of saturated potassium iodide solution, which is kept in an opaque container, and leave for 15 minutes with constant stirring, next 30 ml of distilled water was added, then 1 ml of starch reagent solution was added. Finally, the mixture was titrated with sodium thiosulfate solution of 0.01 M with continuous shaking until the disappearance of the blue color. The PV value was calculated according to the following equation:

$$\textit{Peroxide Value}\ (\text{PV})\ \text{Meq/Kg of oil} = \frac{(\text{ml of } Na_2S_2O_3) \times 0.01 \times 1000}{(\text{Sample weight (gm)})}$$

Thiobarbituric acid (TBA) value Determination

Fat oxidation was determined by thiobarbituric (TBA) and measured as a malondialdehyde value, one of the products of the fat oxidation process for beef burger samples stored in refrigeration for each period of storage according to the method by Jouki et al., (2014), as reported by Zhang et al., (2021), and as follows: 5 gm of the sample was mashed with 20 ml of a solution (trichloroacetic acid at a concentration of 7.5% and dissolved in 2 M phosphoric acid) for two

minutes. Afterward, the mixture was transferred to a 50 ml volumetric flask. Then, complete the volume to the mark with distilled water and shake the mixture. Next, 25 ml of solution was withdrawn and centrifuged at (3000 rpm) for 15 min. The mixture was filtered with No. 102 filter paper. 5 ml of the obtained filtrate and 5 ml of 0.02 M TBA reagent solution were transferred into a test tube. However, a mixture of 5 ml of distilled water and 5 ml of 0.02 M TBA has used as a control (standard) solution. The mixture was incubated in a dark water bath for 30 minutes at a temperature of 90 °C and later left to cool at room temperature. A spectrophotometer measured absorbance at a wavelength of 532 nm. Finally, the TBA value was calculated according to the following equation:

Malonaldehyde concentration (mg/kg meat) = optical absorption at wavelength 532 nm ×7.8
7.8 represents the dilution factor

Free Fatty Acid ratio

Based on Pearson et al., (1981) approach, the free fatty acids (FFA) were calculated. 50 ml of 99% absolute ethanol alcohol, three grams of minced beef, and a few drops of phenolphthalein were mixed. The mixture was heated in a water bath until boiling. The combination was then titrated with 0.1 M KOH potassium hydroxide until the solution's color changed to light pink. The percentage of free fatty acids was estimated according to the following equation:

$$\boldsymbol{Free\ Fatty\ Acid\ ratio}(\%) = \frac{\mathbf{(A-B)\ titeration \times 0.1 \times 282 \times 100}}{\mathbf{Sample\ weight\ (gm) \times 1000}} \times \mathbf{100}$$

A: Potassium hydroxide (KOH) solution milliliter number, titration with the oil or fat sample.
B: Potassium hydroxide (KOH) solution milliliter number, titration with the plank sample.
282: Oleic acid molecular weight.

Total Volatile Nitrogen estimation

The estimation of TVN in minced meat samples was based on the procedure described by Egan et al. (1981). The amount of total volatile nitrogen was calculated according to the following equation:

$$Total\ Volatile\ Nitrogen\ (\text{mg: 10 gm meat}) = \frac{\text{V(ml)} \times (\text{MO} + 300) \times 14}{500}$$

V: Milliliters number of hydrochloric acid 0.01 M.
MO: Moisture in the meat sample.
14: Molecular weight of nitrogen.

pH Value estimation

The pH values of the beef burger samples were computed based on the method by Zhang et al. (2021); transfer 5 g of the homogenized specimen to a glass tube, add 45 ml of distilled water and shake to obtain a homogeneous solution and leave for 5 minutes, followed by filtration of the mixture through a filter paper No. 102, use a digital pH meter, which has been pre-calibrated with buffer solutions at pH 4 and 7 at laboratory temperature 24°C.

Statistical analysis

The data were statistically analyzed using One-Way ANOVA with a complete randomized design (CRD). The statistical program (IBM SPSS Version 22) analyzed the data. Duncan's test was used to compare the averages at a probability level of ($p<0.05$) (Al-Rawi & Khalaf Allah, 2000).

Results and discussion:

Peroxide value (POV)

The results of the peroxide value test for the coated (OP) and non-coated (TC) beef burgers are shown in Table 1. On the first day of storage, the PV was (1.62 and 1.63) mEq/kg for the (TC and OP) treatments, respectively. It was noticed from the results that the simple film coating treatment was significantly ($P\leq0.05$) superior in keeping the peroxide values within acceptable limits. In contrast, the PV for uncoated treatment increased to a high rate of 5.91 mEq/kg on the seventh day of storage. The PV indicates that the initial oxidation of dietary fats, one of the spoilage factors in foods rich in unsaturated fatty acids, leads to strange flavors, which ultimately cause consumers to reject the product. It was noted from the results that the oat protein films contributed to the reduction of beef lipid oxidation more efficiently than the control treatment during refrigeration storage.

Table (1): Effect of treatments on the peroxide value of beef burgers during refrigeration storage at 4 °C.

Treatments	Storage periods (days)					
	1	3	5	7	9	10
TC	1.62 [a]	2.57 [a]	4.00 [a]	5.91 [a]		
OP	1.63 [a]	2.06 [b]	2.56 [b]	2.73 [b]	2.90 [a]	3.11 [a]

*Different letters within the same column demonstrate significant differences ($P\leq 0.05$) between the treatments.

(TC) uncoated. (OP) coated.

The results agreed with Al-Rmedh (2014), who indicated that the simple films of gelatin protein significantly reduced the peroxide values in both pieces of fish meat and chicken breast meat, which amounted to 1.24 and 3.56 mEq/kg after seven days when refrigerated, compared with the uncoated meats in the control treatment, where the peroxide values continued to rise to 2.97 and 10.49 mEq/kg, respectively. The strong gas-trapping capacity of protein films, which helped to limit oxidative factors in meat, is thought to be the cause. For chicken meat, lupine protein films supplemented with *Laurus nobilis* leaf extracts effectively reduce the peroxide value of coated chicken meat samples compared to uncoated meat after 15 days of refrigeration (Al-Sadi, 2020).

Alansari (2020) also showed that coating meat pies with starch films and supporting them with 6% rosemary oil lowered peroxide values to 5.20 mEq/kg in laminated models, compared with the uncoated control samples, which reached 22.33 mEq/kg on the tenth day of refrigeration. According to Alizadeh Behbahani et al., (2021), uncoated beef samples had a shelf life of fewer than five days, while models coated with *Lepidium perfoliatum* seed gum films enhanced with chicory oil had a shelf life of more than seven days within acceptable limits in the refrigerator.

According to Zhang et al. (2021), treatment of sodium alginate films supported with ginger oil considerably increased the shelf life of beef held in refrigerators at four degrees Celsius by more than nine days compared to the uncoated, in which the PV soared above the limits.

Thiobarbituric acid (TBA) value

Table 2 shows the effect of simple film coating treatments for oat protein on thiobarbituric values during beef refrigeration. First day of refrigeration, the TBA value was about 0.40 mg of malonaldehyde/kg of beef for all treatments. However, the control treatment reached 0.84, 0.98, and 1.52 mg of malonaldehyde/kg of meat, respectively, during 3, 5, and 7 days of storage. While the coated treatment maintained the TBA values within the acceptable ranges, it reached 1.25 mg of malonaldehyde/kg of meat in the OP treatment on the tenth day of storage.

TBA is one of the essential meat tests. As an indicator of fat oxidation, it develops and decomposes peroxides into aldehydes and ketones, causing unpleasant odors in meat during the refrigeration period. Furthermore, it was found that simple oat protein films, if treated with formaldehyde and enzyme, could reduce the fat oxidation speed in meat and extend its storage period with significant differences ($P \leq 0.05$) compared with the uncoated models.

Table (2): Effect of treatments on the Thiobarbituric acid of beef burgers during refrigeration storage at 4°C.

Treatments	Storage periods (days)					
	1	3	5	7	9	10
TC	0.40 [a]	0.84 [a]	0.98 [a]	1.52 [a]		
OP	0.40 [a]	0.48 [b]	0.55 [b]	0.68 [b]	1.00 [a]	1.25 [a]

*Different letters within the same column demonstrate significant differences ($P \leq 0.05$) between the treatments.

(TC) uncoated. (OP) coated.

Al-Sadi (2020) pointed out that simple lupine protein films supported with bay leaf extracts outperformed in reducing the value of thiobarbituric acid for coated chicken meat models compared with the control treatment without coating under refrigeration conditions for 15 days. That was consistent with our results. Yaghoubi et al., (2021) demonstrate that the coating of fresh chicken meat with chitosan films enriched with *Artemisia fragrans* oil contributed to significantly maintaining the values of TBA in coating transactions within acceptable limits, which amounted to 1.61 mg malonaldehyde/kg meat for coating treatments, compared with 2.10 mg malonaldehyde/kg meat in the uncoated control treatment on day 12 of refrigeration.

According to (Alizadeh Behbahani et al., 2021), using edible films made from *Lepidium perfoliatum* seed gum enriched with chicory oil effectively delayed beef fat oxidation for seven days under refrigeration conditions. The author suggested that adding chicory oil enhanced the films' ability to reduce the meat's exposure to light and reduce oxygen permeability, which could improve the used films' physical and barrier properties.

Free fatty acid (FFA) ratio

Free fatty acids in beef burgers stored for ten days under refrigeration conditions are shown in Table 3. On the first day, the (FFA) was 0.25 and 0.26% for TC and OP, respectively. It was

noticed that the percentage increased significantly (P≤0.05) in the uncoated treatment during 5 and 7 days of storage amounted to 0.87 and 1.26%, respectively. On the other hand, the coated treatment reached 0.78% on the seventh day. The coating treatment recorded 1.19% on the tenth day of refrigeration, with significant differences. At the same time, it did not exceed the limits of free fatty acids in meat and its products, which were determined by the Iraqi specification at 1.5% (Central Organization for Standardization and Quality Control, 1987) compared to the percentage reached by the uncoated treatment.

Table (3): Effect of treatments on the Free fatty acid (FFA) ratio of beef burgers during refrigeration storage at 4 °C.

Treatments	Storage periods (days)					
	1	3	5	7	9	10
TC	0.25 [a]	0.63 [a]	0.87 [a]	1.26 [a]		
OP	0.26 [a]	0.41 [c]	0.59 [b]	0.84 [b]	0.96 [a]	1.19 [a]

*Different letters within the same column demonstrate significant differences (P≤ 0.05) between the treatments.

(TC) uncoated. (OP) coated.

Al-Sadi (2020) indicated that simple lupine protein films supported with Laurus nobilis leaf extracts outperformed in keeping the free fatty acids within the permissible limits and did not exceed the standard limits, which is 2% in samples of coated chicken meat. Compared with the control treatment without encapsulation under refrigeration conditions for 15 days, the reason may be the presence of the active compounds in each of the protein isolates of lupine and Laurus nobilis leaf extracts, which inhibited the activity of lipolytic enzymes, which led to a decrease in the proportion of (FFA) produced.

The results did not agree with Torusdag et al., (2020); gelatin films enriched with rosemary extract did not reduce the free fatty acid levels in meatballs stored for ten days under refrigeration conditions, which amounted to 1.66%, compared with 1.43% in the uncoated control treatment. Sharma et al., (2021) exhibited that sodium alginate films supplemented with medicinal Indian madder (Rubia cordifolia) extract might reduce the free fatty acid content in coated meat compared with the uncoated during refrigeration. This superiority is attributed to the effectiveness of the medicinal plant extract that supports the coating as a natural antioxidant.

pH value

The values of the treatments' pH during the different storage periods are presented in Table 4. On day one of storage, it was found that the pH value in the oat film treatment increased significantly as compared to the control treatment; however, on the fifth day, a high pH value was seen. This rise continued during the seventh day in the control treatment TC, which scored 6.39, with a significant decrease (P 0.05) for the oat film treatment, which scored 6.01. A high pH value may indicate the activity of critical enzymes in foods, an increase in microbial activities, or the addition of some substances to food that cause the pH value to rise. These causes lead to partial hydrolysis of protein materials, resulting in dipeptides and free amino acids.

Table (4): Effect of treatments on pH value of beef burgers during refrigeration storage at 4 °C.

Treatments	Storage periods (days)					
	1	3	5	7	9	10
TC	5.78 [c]	5.91 [b]	6.09 [a]	6.39 [a]		
OP	5.83 [b]	5.88 [b]	5.94 [b]	6.01 [c]	6.13 [b]	6.21 [a]

*Different letters within the same column demonstrate significant differences (P≤ 0.05) between the treatments.
(TC) uncoated. (OP) coated.

Yaghoubi et al., (2021) found that the pH values significantly increased in chicken meat samples in refrigeration storage for 12 days, and it was noted that the increase in the uncoated treatment reached 7.01, a high level compared with the treatment of meat wrapped with chitosan films, which scored 5.55. The cause may be ascribed to lactic acid bacteria production and the buildup of alkaline components made by psychrophilic bacteria. In addition to the autolysis activity of enzymes, it is the main reason for changing the pH during refrigeration. Keeping the pH within acceptable limits of the fresh meat in the encapsulated models may be due to the antibacterial properties of chitosan film. The results agreed with Soares et al., (2021), as it was noted that wrapping the meat burger with edible onion film kept the pH values significantly lower (P≤0.05) compared to the burgers without coating on 3, 6, and 9 days during the period of refrigeration.

On the other hand, Al-Abadi (2019) indicated that the pH value significantly increased in samples of steaks coated with simple cellulosic films and cellulosic films reinforced with thyme essential oil compared with the control treatment of uncoated steaks stored under refrigeration conditions for 14 days. According to Al-Sadi (2020), there were no significant differences in the pH value between the control treatment and the coating treatment of chicken meat burgers with lupine protein films supplemented with extracts of thyme essential oil. All treatments' pH values decreased from 6.3 on the first day of refrigeration to 5.5 and 5.8 for the uncoated and coated treatments, respectively. The coating and extract fortification method, which conserved the qualities of the coated meat, was credited as the cause.

Total Volatile Nitrogen (TVN) Value

Table 5 shows the superiority of the edible oat film treatment in maintaining the values of total volatile nitrogen for the beef burgers coated within acceptable limits with significant differences (P≤0.05) compared with the uncoated burgers, it was noted from the results that the values of TVN reached 4.69 and 4.66 mg/100 gm for the treatments (TC, OP) respectively on the first day of storage. The TVN values of the uncoated treatment increased significantly on the seventh day to 13.56 mg/100 gm of storage, while the TVN values of the coated treatment slightly increased to 7.58 mg/100 gm on the tenth day of storage.

The value of TVN is one of the most important indicators of the suitability of meat and its products, which mainly indicates the amounts of amines and ammonia liberated in foods, thus indicating the start of contamination factors in meat. Based on the values observed from the results, the coating treatment maintained the integrity of the beef burgers, significantly maintaining values

within the acceptable average compared with the uncoated treatment that was excluded on the seventh day due to microbial contamination factors.

Table (5): The effect of treatments on the TVN Value of beef burgers refrigerated at 4 °C.

Treatments	Storage periods (days)					
	1	3	5	7	9	10
TC	4.69 [a]	6.95 [a]	9.79 [a]	13.56 [a]		
OP	4.66 [a]	5.88 [c]	5.94 [c]	6.93 [c]	7.15 [b]	7.58 [b]

*Different letters within the same column demonstrate significant differences (P≤ 0.05) between the treatments.

(TC) uncoated. (OP) coated.

Yaghoubi et al., (2021) indicated that coating fresh chicken meat with chitosan films enriched with Artemisia fragrans oil contributed significantly to maintaining the TVN values of coating treatments, which increased from 8.7 mg/100 gm on day one of storage to 25.3 mg/100 gm on day 12 of storage, compared with the increase in the uncoated control, which increased from 17.9 mg/100 gm on day one of storage to 182.3 mg/100 gm on day 12 of storage. The author claims that the initial microbial load and the alkaline components produced by psychrophilic bacteria might be the reasons. The enzymes' autolysis activity will increase the pH value during refrigeration. Active compounds in oil added with chitosan film contributed to TVN values remaining at an acceptable level.

Using corn protein films with ginger extracts contributed to maintaining the TVN value of the bovine meat stored in refrigerated conditions at four °C for 20 days, within acceptable levels. In comparison, the non-coated control exceeded the permissible limits at the end of the storage time (Sayadi et al., 2021).

Conclusion:

The aforementioned findings support the idea that coating beef burgers with edible oat film could increase the meat's and other foods' shelf lives. Also, using oat film has an advantage in stabilizing chemical constituents such as (PV, TBA, FFA, and TVN) values, therefore reducing lipid oxidation.

Acknowledgments:

The author would like to thank the College of Agriculture, University of Basrah, for providing facilities.

References

Al-Abadi, Safaa, A.L.S. (2019). Preparation of cellulose edible film incorporated with thyme oil, characterization and using in steaks. M.Sc. thesis, College of Agriculture, University of Basrah, Iraq.

Alansari, Batool, M. (2020). Development of Antioxidant Activity of Potato Starch Edible Films Incorporating with Rosemary *Rosmarinus officinalis* L. Oil and Using it in Packaging Beef Patties. *Basrah Journal of Agricultural Sciences*, 33(2), 67-79.

Alizadeh Behbahani, B.; Falah, F.; Vasiee, A. & Tabatabaee Yazdi, F. (2021). Control of microbial growth and lipid oxidation in beef using a *Lepidium perfoliatum* seed mucilage edible coating incorporated with chicory essential oil. *Food science and nutrition*, 9(5), 2458-2467.

Al-Rawi, K.M. & Khalaf Allah, A.M. (2000). Design and download agricultural experiments. The second edition, Dar Al-Kutub for Printing and Publishing, University of Mosul. pp,56.

Al-Rmedh, Yagoob, S.S. (2014). Preparation of edible film from gelatin extracted from animal by-product and study its effect quality characteristics of food. M.Sc. thesis, College of Agriculture, University of Basrah, Iraq.

Al-Sadi, Mohammed, Q.R. (2020). Preparation of edible modified films from lupine proteins isolate and using in coating chicken meat tablets. PhD thesis, College of Agricultural Engineering, University of Baghdad, Iraq.

Assad, I.; Bhat, S.U.; Gani, A. & Shah, A. (2020). Protein based packaging of plant origin: Fabrication, properties, recent advances and future perspectives. *International Journal of Biological Macromolecules*, 164, 707-716.

Bhagath, Y. B. & Manjula, K. (2019). Influence of composite edible coating systems on preservation of fresh meat cuts and products: a brief review on their trends and applications. *International Food Research Journal*, 26(2): 377-392.

Bourtoom, T. (2009). Edible protein films: properties enhancement. *International Food Research Journal*, 16(1), 1-9.

Central Organization for Standardization and Quality Control (1987). Standard Specification for beef and buffalo, fresh and chilled and frozen No. (1185/2). Republic of Iraq.

Egan, H.; Kirk, H.S. & Sawyer, R. (1981). Pearson's Analysis of Foods. Churchill Living Stone Publishers, London, 596.

Habibi Zarabadi, M.; Kadivar, M. & Keramat, J. (2018). Production and evaluation the properties of laminated oat protein film and electrospun nylon. *Journal of Food Processing and Preservation*, 42(2), e13513.

Hamann, D.; Puton, B.M.S.; Colet, R.; Steffens, J.; Ceni, G.C.; Cansian, R.L. & Backes, G.T. (2021). Active edible films for application in meat products. *Research, Society and Development*, 10(7), 1-15.

Jouki, M.; Yazdi, F.T.; Mortazavi, S.A.; Koocheki, A. & Khazaei, N. (2014). Effect of quince seed mucilage edible films incorporated with oregano or thyme essential oil on shelf life extension of refrigerated rainbow trout fillets. *International journal of food microbiology*, 174, 88-97.

Mahcene, Z., Hasnı, S., Goudjil, M.B. & Khelil, A. (2021). Food edible coating systems: A review. *European Food Science and Engineering*, 2 (1), 26-33.

Pearson, D.; Egan, H.; Kirk, R.S. & Sawyer, R. (1981). Chemical analysis of food. Longman Scientific and Technical New York.

Sayadi, M.; Mojaddar Langroodi, A. & Jafarpour, D. (2021). Impact of zein coating impregnated with ginger extract and Pimpinella anisum essential oil on the shelf life of bovine meat packaged in modified atmosphere. *Journal of Food Measurement and Characterization*, 15(6), pp5231-5244.

Sharma, R.; Bhat, Z.F.; Kumar, A.; Kumar, S.; Bhatti, M.A. & Jayawardena, R. (2021). *Rubia cordifolia* based novel edible film for improved lipid oxidative and microbial stability of meat products. *Journal of Food Processing and Preservation*, 45(7), e15654.

Soares, K. S.; Souza, M.P.; Silva-Filho, E.C.; Barud, H.S.; Ribeiro, C.A.; Santos, D.D.; Rocha-Souza, K.N.; De Moura, J.F.; Oliveira, R.L. & Bezerra, L.R. (2021). Effect of Edible Onion (Allium cepa L.) Film on Quality, Sensory Properties and Shelf Life of Beef Burger Patties. *Molecules*, 26(23), 7202.

Torusdag, G.B.; Gumus, S. & Boran, G. (2021). Effect of gelatin-based active coatings formulated with rosemary extract on quality of cold stored meatballs. *Food Science and Technology*, 42.

Wang, X.; Xu, M.; Yang, A.; Wang, Y.; Hou, S.; Zheng, N.; D.; Liang, X.; Hua, X. & Dong, D. (2021). Health risks of population exposure to phthalic acid esters through the use of plastic containers for takeaway food in China. *Science of The Total Environment*, 785, 147347.

Yaghoubi, M.; Ayaseh, A.; Alirezalu, K.; Nemati, Z.; Pateiro, M. & Lorenzo, J.M. (2021). Effect of chitosan coating incorporated with Artemisia fragrant essential oil on fresh chicken meat during refrigerated storage. *Polymers*, 13(5), 716.

Yang, J.; Song, W.; Wang, X.; Li, Y.; Sun, J.; Gong, W. & Sun, C. (2019). Migration of phthalates from plastic packages to convenience foods and its cumulative health risk assessments. *Food Additives and Contaminants*: Part B, 12(3), 151-158.

Zhang, B.; Liu, Y.; Wang, H.; Liu, W.; Cheong, K. L. & Teng, B. (2021). Effect of sodium alginate-agar coating containing ginger essential oil on the shelf life and quality of beef. *Food Control*, 130, 108216.