



THE INFLUENCE OF ALCOHOL AND AQUATIC EXTRACTS OF CAULIFLOWER AND CABBAGE ON THE IMPROVEMENT OF SOME CHEMICAL PROPERTIES OF BEEF BURGERS FROZEN STORAGE

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ABSTRACT

In this study, both of Cauliflower and Cabbage extract (alcohol and water) were used with a concentration of 1% as additives to the beef burger product. The results of the sensory assessment proved that there were no significant differences in qualities compared with the control sample, the study of the chemical and physical properties of the frozen beef burger stored from 0 to 60 days showed that the pH value of all samples did not reach 7, while the alcohol cauliflower sample recorded a lower value of 6.48 within 60 days of storage. The study showed an improvement in the character of carrying water in burger samples, samples of alcohol Cauliflower and cabbage recorded 17.8 and 18.80, respectively after 60 days of storage, while the control sample recorded 13.4. The results of the peroxide and thiobarbituric acid values showed stability. The cauliflower alcohol sample was less valuable among the samples, with a peroxide value of 2.62 after 60 days of storage, compared with 3.90 of control sample. The peroxide value and Thiobarbituric acid demonstrated stability. The thiobarbituric acid value of 0.55 compared with the control sample of 0.89, which is much lower than the value specified in the Iraqi standard of 0.9mg /kg.

Keywords: Beef Burger, fat, Antioxidant, aquatic extracts. Peroxide value.

* The research is taken from a master's thesis by the first researcher.

تأثير المستخلصات المائية والكحولية للقرنبيط والكرنب على تحسين بعض الخواص الكيميائية لبيركير اللحم البقري المخزن بالتجميد

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الخلاصة:

تم في هذه الدراسة استخدام مستخلصات اللبنة والقرنبيط بنوعيهما الكحولي والمائي وتركيز 1% كمضافات إلى منتج البيرغر البقري. أثبتت نتائج التقييم الحسي عدم وجود فروقات معنوية في الصفات مقارنة مع عينة السيطرة، كما أثبتت دراسة الخواص الكيميائية والفيزيائية للبيرغر البقري المخزن بالتجميد في الفترة من صفر إلى 60 يوماً أن قيمة pH لجميع العينات لم تصل إلى قيمة pH=7، بينما سجلت عينة القرنبيط الكحولي أقل قيمة 6.48 خلال 60 يوماً من التخزين. أثبتت الدراسة تحسن صفة قابلية حمل الماء في عينات البيرغر فسجلت عينات الكرنب والقرنبيط الكحولي 17.8 و 18.80 على التوالي بعد مدة تخزين 60 يوماً بينما سجلت عينة السيطرة 13.44. أظهرت نتائج قيمة رقم البيروكسيد وقيم حمض الثايوباربيتوريك استقراراً. وشهدت عينة القرنبيط الكحولي أقل قيمة بين العينات حيث سجلت قيمة البيروكسيد 2.62 بعد مدة تخزين 60 يوماً مقارنة بعينه السيطرة التي سجلت 3.90 وسجلت في قيمة حامض الثايوباربيتوريك 0.55 مقارنة مع عينة السيطرة حيث سجلت 0.89 وهي أقل بكثير من القيمة المحددة في المواصفة القياسية العراقية والتي تبلغ 0.9 ملغم/كغم.

الكلمات المفتاحية: البيرغر البقري، الدهن، مضادات الأكسدة، مستخلص مائي، قيمة البيروكسيد.

INTRODUCTION

The demand for nutritious products is on the rise, indicating a significant worldwide phenomenon. Consequently, there has been extensive research on compounds obtained from plants, such as extracts, to investigate their antioxidant properties. Antioxidants are substances that hinder the oxidation process in food by reducing it (Petcu *et al.*, 2023). The consumption of manufactured products has risen as a result of shifts in the dietary habits of the population, which have been accelerated by intense urbanization and industrialization. This has had an impact on the buying behavior of customers, especially when it comes to convenience foods, specifically; meat products like burgers are typically sold in a frozen state (Karre *et al.*, 2013). Processed meat products are prone to oxidative reactions that cause alterations in their sensory qualities. To preserve their quality, the food industry frequently employs synthetic antioxidants (Karre *et al.*, 2013). Nevertheless, many studies have indicated that these additives contribute to negative effects within the body. As a result of growing consumer apprehension regarding food safety and health, the food industry is striving to decrease their utilization in food products (Sambu *et al.*, 2022). Meat and processed meats are crucial for human health due to their role as the primary source of essential amino acids and numerous other nutrients. The beef burger holds significant significance among a broad range of consumers due to its nutritional value, affordability, diverse range of types and flavors, and convenience as a ready-to-eat food requiring minimal preparation (Geiker *et al.*, 2021). The meat industry and its products have garnered attention due to the susceptibility of meat to contamination, resulting in spoilage and chemical alterations that lead to a decline in quality (Anas *et al.*, 2019). Lipid oxidation is the most significant among the various chemical changes that contribute to quality deterioration. It leads to the development of unpleasant taste and aroma, reduces the time the product can be



stored, and negatively affects its sensory qualities (Domínguez *et al.*, 2019).

Moreover, there are numerous harmful substances that can negatively impact one's health, such as compounds that pose risks to the circulatory system, cancer-causing agents, and factors that accelerate the aging process. These substances are often found in oxidized food, which can lead to rancidity (Dose *et al.*, 2016).

Cruciferous vegetables belong to the Brassicaceae (Cruciferae) family and encompass a variety of the vegetables included in the list are cauliflower, Horseradish, garden cress, wasabi, broccoli, radish, arugula, cabbage, Brussels sprouts, turnip, and watercress. These substances, namely Glucosinolates (GLS), carotenoids, terpenoids, phytosterols, flavonoids, and phenolic acids, are present in abundance in them (Favela-González *et al.*, 2020). Cruciferous vegetables are classified as functional foods due to their ability to enhance normal bodily functions and reduce the risk of cancer, cardiovascular disease, diabetes, and chronic inflammation when consumed. (Bachiega *et al.*, 2016) and (Gründemann & Huber, 2018).

Recent epidemiological research indicates that consuming a high number of cruciferous vegetables in one's diet can reduce the risk of contracting certain types of cancer. This finding supports the

Categorization of these vegetables as functional foods (Ağagündüz *et al.*, 2022). As a result, there has been an abundance of dietary supplements in the market that contain different extracts or compounds derived from cruciferous vegetables. The positive health effects of cruciferous vegetables primarily stem from GLS and the products resulting from their enzymatic hydrolysis (Connolly *et al.*, 2021); both polyphenols and triterpenes have positive effects on health. (Šamec *et al.*, 2016). The beneficial effects of cruciferous vegetables in fighting cancer, oxidants, inflammation, and cardiac disease can also be attributed to the combined activity of the phytochemicals mentioned above. There is a significant demand for products that are convenient and require minimal preparation. The product is formulated with organic components, including the incorporation of botanical extracts. Meat products have the potential to enhance and expand flavor attributes. The shelf life is determined by the antioxidant activities (Valisakkagari *et al.*, 2024). The aim of the present study was to improve the physicochemical properties of beef burgers using cauliflower and cabbage extracts.

MATERIALS AND METHODS

Sample of extraction powder

Cabbage and cauliflower plants were collected from a local market in the city of Baghdad. They were first cleaned of broken parts, then washed with sterile water and dried at a temperature of 40 °C for 24 hours using an oven, then they were ground using a grinder (Moulinex, type LM 207, 500 watts, France).

Aqueous extraction

In the study were weighed 25 grams of each of the plant powders used and placed in 500 ml of boiling distilled water. It was placed on a magnetic stirrer for 30 min and then filtered using a Buechner funnel and filter paper No1. After that, the filtrate underwent concentration using a rotary evaporator at a temperature of 40 °C. To get rid of the water. The



excess was then left to dry at room temperature 25°C and then placed in sterile bottles under refrigeration conditions until use (Zuecco *et al.*, 2022).

Alcoholic extraction

Weighed 100 grams of each powder, in 500 ml of 98% ethyl alcohol was added to it, and it was placed on a magnetic stirrer for 24 hours at room temperature of 25°C. It was filtered using filter paper No. 1 and the filtrate was concentrated in a rotary evaporator at a temperature of 40°C to get rid of the solvent. Then it was left at room temperature to complete evaporation until a viscous consistency was reached. It was placed in opaque, sterilized bottles under refrigeration conditions until use (Pham *et al.*, 2015).

Antioxidant Extract

in the study were weighed 0.04 gm DPPH was dissolved in 100 mL of methanol Note that the concentration of (DPPH) is (400ug/ ml) (Okunade, 2002). In order to prepare the standard solution of vitamin C, 0.5 grams of vitamin C were combined with 100 milliliters of a mixture containing methanol and distilled water. The standard solution had a concentration of 5000 parts per million (ppm). Using the dilution law, additional concentrations of vitamin C were prepared at 30, 60, 120, 250, and 500 ppm. The same concentrations were also prepared for the sample. The mixture was vigorously agitated and left to rest at room temperature for 30 min. Subsequently, the absorbance was quantified at a wavelength of 517 nm. by using spectrophotometer (UV-VIS BIOTech) (Stojković *et al.*, 2016). The IC₅₀ value of the sample, representing the concentration of the sample needed to inhibit 50% of the DPPH free radical, was determined using a logarithmic dose inhibition curve. Decreased absorbance of the reaction mixture indicated increased free radical activity (Marinova & Batchvarov, 2011). The percent DPPH scavenging effect was calculated by using following equation:

$$DPPH \text{ scavenging effect (\%)} = \frac{A_0 - A_1}{A_0} \times 100$$

Where: A₀ was the Absorbance of blank and A₁ was the absorbance in presence of test sample.

Reducing Antioxidant Potential Assay:

The method was used to evaluate the extracts' capacity to decrease ferric ions (Fe³⁺). 800 µl of extract was combined with 400 µl of phosphate buffer (0.2 M, pH=6.6) and 800 µl of a 1% potassium ferricyanide [K₃Fe (CN)₆]. The resulting mixture was then incubated at a temperature of 50 °C for duration of 20 min. A volume of approximately 800 micro liters, which corresponds to 10% of trichloroacetic acid (TCA), was introduced into the mixture. The mixture was then subjected to centrifugation for a duration of 10 min at a speed of 3000 rpm. Ultimately, 400 µl of the liquid remaining after centrifugation was combined with 400 µl of pure water and 80 µl of FeCl₃ (0.1%). The measurement of the absorbance was then taken at a wavelength of 700 nm. Elevated absorbance of the reaction mixture signifies heightened reducing power. The FRAP value was quantified in mmol Fe²⁺/g of sample using a standard curve of ferric chloride with the equation $Y = 1.7057x - 0.2211$ and a coefficient of determination (R²) of 0.9904.



Beef burger proration

The burgers were made with 84% beef and 14% lamb fat trimmings sourced from a local market in Baghdad. These ingredients had been stored for 1 week at a temperature of 18 ± 1 °C. Additionally, the burgers contained 2% salt and either a natural or synthetic antioxidant. The meat and fat were thawed at a temperature of 4 degrees Celsius for duration of 12 hours. They were then finely chopped into small pieces separately, with each batch being divided into three portions, resulting in a total of four identical samples. Following the process of mixing, a total of five treatments were prepared: In the absence of an antioxidant, the control group (CO); with 1% Alcoholic extraction of cauliflower, 1% of Alcoholic extraction Cabbage, 1 % of Aqueous extraction of cauliflower ,1 % of Aqueous extraction of Cabbage. The burgers, weighing 100 g each, were shaped using a manual mould with dimensions of 112 mm in diameter and 2 cm in height. The mould was lined with polyethylene film to prevent sticking. The specimens were enclosed in air-permeable polypropylene pouches and subjected to freezing in an ultra-low temperature freezer for duration of 40 min. They were promptly transferred to a vertical flex frost- free freezer set at a temperature of 18 ± 1 °C for a maximum storage period of 60 days. (Hajlaoui *et al.*, 2019).

Determination of Moisture:

The humidity percentage in the model was estimated by calculating the weight loss of the sample before drying. This was done using the exact weight of samples within a specified range (3 g). The samples were placed in a casing that had been pre-weighed, and then dried in an electric oven at a temperature of 105 m for duration of 16 hours. (A.O.A.C, 1995).

$$\text{Per cent humidity} = \frac{\text{weight of sample before drying} - \text{weight of sample after drying}}{\text{weight of sample before drying}} \times 100$$

Determination of fat content

The fat content was determined using the Sox let extraction method, specifically AOAC Official Method 960.39 (AOAC 2016) Alternatively, the fat content was determined either through the reduction in weight of the sample or by measuring the weight of the extracted fat (Min & Ellefson, 2010). The experiment was conducted in triplicates using the RAYPASX-6 MP Multi (Extraction) Mantles Sox let system manufactured by RAYPA in India.

Determination of protein content

The protein content was determined using the Kjeldahl Method, following the standard procedure outlined in AOAC Official Method 973.48 (AOAC 2016). This method utilizes a Fully automated kjeldahl analyzer (Gerhardt's, Germany) to accurately measure the protein content in burger samples. The experiment was conducted to assess the chromatic alteration of Tashiro's indicator. The protein was calculated based on equation:

$$\text{Nitrogen content, \% by wosight} = \frac{(t - b) \times 0.2 \times 14}{1000 \times \text{sample}} \times 100\%$$

Where t = volume of sample (mL), b = volume of blank (mL), 0.2 = normality of titrant, HCl (mol/l), 14 = atomic mass of nitrogen, W_{sample} = weight of sample taken (g).



Water Holding Capacity (WHC)

The water-holding capacity of the meat products in question was assessed following heat treatment and throughout the designated storage periods using the methodology outlined by **Diniz & Martin (1997)** as described by **Yee & Amin (2020)**. To obtain a uniform mixture, combine 10 g of each sample with 20 milliliters of distilled water and mix thoroughly. Then, centrifuge the mixture for 20 min at a speed of 4000rpm. Filter the mixture using filter paper Whitman (No.1) and measure the volume of the filtered liquid using a graduated cylinder after 30 min. The water carrying capacity can be calculated using the following formula:

$$WHC \text{ (ml)} = \text{total water volume (ml)} - \text{The volume of water in the cylinder (ml)}$$

Determination of pH

The pH of the meat burger was measured after heat treatment by mixing 50 ml of distilled water with 10 g of each sample and thoroughly stirring for 5 min. The pH value was measured using a pH meter in accordance with the described method of **Malik et al. (2021)**.

Determination of Peroxide Value (PV)

The peroxide value was determined using the method described by **AOAC (2002)** as cited by **Ottaway et al. (2021)**. The procedure involved using 5 g of the sample and adding a mixture of 30 ml of glacial acetic acid and chloroform (in a ratio of 3:2, vole/v) along with 0.5 ml of saturated potassium iodide solution. The mixture was subjected to a 30min incubation period in the absence of light, followed by the addition of 20 ml of distilled water along with small amounts of 1% starch. Utilize 0.1 T of a solution containing (sodium thiosulfate) to perform a titration; with the objective of reaching the endpoint of the reaction by neutralized the free iodine.

$$\text{peroxide number} = \frac{V \times N \times 1000}{\text{Sample weight (g)}}$$

V = the volume of sodium thiosulfate required for a sample (ml). N = Sodium thiosulfate titer

Thiobarbitoric Acid (TBA)

The thiobarbitoric acid value was determined using the method described by Soltanizadeh and Ghiasi-Esfahani (2015). The measurement of absorbance was conducted at a specific wavelength of 532 nm, and the content of TBA was determined by applying the subsequent equation:

$$\text{TBA No. (mg malonaldehyde/kg fat)} = \frac{\text{Abs.} \times F \times 0.2}{W}$$

Where Abs = absorbance at 532 nm

W = weight of fat in volume of extract (g)

F = factor = 46.

Cooking Loss

The weight loss percentage was determined by assessing the cooked beef brisket samples after grilling and during storage periods, using the methodology outlined by Sánchez-Zapata *et al.* (2010) Given the following equation:



$$\text{Cooking loss (\%)} = \frac{\text{raw patty weight(g)} - \text{cooked patty weight (g)}}{\text{raw patty weight(g)}} \times 100$$

Measurement (Thaw loss):

The rate of post-soluble loss was estimated in accordance with the method presented by the **Mascheroni et al., 1981**. The ratio of loss was calculated on the basis of the following equation:

$$\text{Thaw loss \%} = \frac{\text{frozen sample weight} - \text{postsoluble sample weight}}{\text{frozen sample weight}} \times 100$$

STATISTICAL ANALYSIS

Statistical Analysis System-SAS (2018) was used in data analysis to study the impact of different transactions on the characteristics studied and a complete random design (CRD), and the moral differences between averages were compared with the lowest moral difference. (Least Significant Difference -LSD).

RESULT AND DISCUSSION

The effect of the treatment and time on the chemical components

Moisture: In the burger, humidity plays an important role in the critical quality of the product since the lower humidity refers to a lower juice in the product. The Table1 shows the contents of the moisture in burger during the storage period at zero time. After 60 days of storage at freezing point 18. The differences in humidity between the control sample and the alcohol and water extract samples of both Cauliflower and cabbage are as follows on the day of zero 63.25 and 64.23, 64.99 and 61.68, where there are no significant differences in humidity. However, after 60 days of storage, the humidity ratio in the eye of the burger was reduced to 56.0, while both the alcohol Cauliflower and cabbage samples were reduced to 61.18 and 62.11 respectively, and the log of the water extract Cauliflower and cabbage 62.58 and 62.64, respectively, noting that the water extract maintained the humidity ratio in the burger samples.

Protein: Animal proteins are the only source of amino acids, and the human body cannot create them, so it takes them from animal meat, which is why it has such an important biological value. The table 1 shows that there are no moral differences in the protein ratio within zero days and after 60 days in the control sample and in the alcohol and water extract samples of Cauliflower and cabbage plants.

Fat: The table 1 shows a moderately satisfactory rise in fat content following a 60-day period of storage at a temperature of 18°C. This could be attributed to a decreased humidity ratio, resulting in an elevated fat ratio in relation to the total weight.



Table (1): The effect of Cauliflower and cabbage extracts on the chemical changes of the beef burger in the zero time, and after 60 days of storage.

Treatment	moisture		protein		fat		ash	
	zero	60	zero	60	zero	60	zero	60
control	63.25	56.10	21.19	22.24	13.37	14.18	1.14	2.11
cabbage Alcoholic	64.23	61.18	21.82	22.99	13.46	14.35	1.20	2.16
Cauliflower Alcoholic	64.2	62.11	22.15	23.43	13.55	14.29	1.21	2.13
cabbage Aqueous	64.99	62.58	21.63	22.64	13.40	14.23	1.17	1.98
Cauliflower Aqueous	64.71	62.46	22.02	23.27	13.49	13.78	1.19	1.89

Ash: The table 1 shows the differences in humidity between the control sample and the alcohol and water extract samples of both Cauliflower and cabbage. The ratios are as follows on zero day (1.14, 1.20, 1.21, 1.17 and 1.19), where there are no significant differences in ash, but after 60 days of storage, the ratio of ash in the control sample rose to 2.11 while the samples of the Cauliflower alcohol extract and cabbage decreased to 2.16 and 2.13 respectively and the log of the Cauliflower water extract and cabbage 1.98 and 1.89, respectively.

Evolution of Water Holding Capacity (WHC)

Figure 1 shows the effect of water and Alcoholic extracts, Cauliflower, and cabbage, with a 1% concentration on burger samples stored at 60 days temperature -18°C. It was found that there was no moral difference in zero days in the ratio of WHC but within 60 days it declined significantly and was slightly lower in the 200 samples of Cauliflower and cabbage. The results changed from 17.80, 19.80, 20.25, respectively, on zero day to 13.49, 15.77, 16.33 respectively, on 60 days &apex; storage, while the ratio in the alcohol extract sample was for both Cauliflower and cabbage (20.08, 21.25) on zero day of storage and the ratio changed to 17.80, 18.88, respectively, on 60 days . These results suggest that plant extracts of both alcohol and water have increased water retention capacity for burger samples, especially alcohol. These results are consistent with the findings of Soltanizadeh and Ghiasi-Esfahani, (2015), who stated that the samples processed from plant extracts are lower in value to WHC.

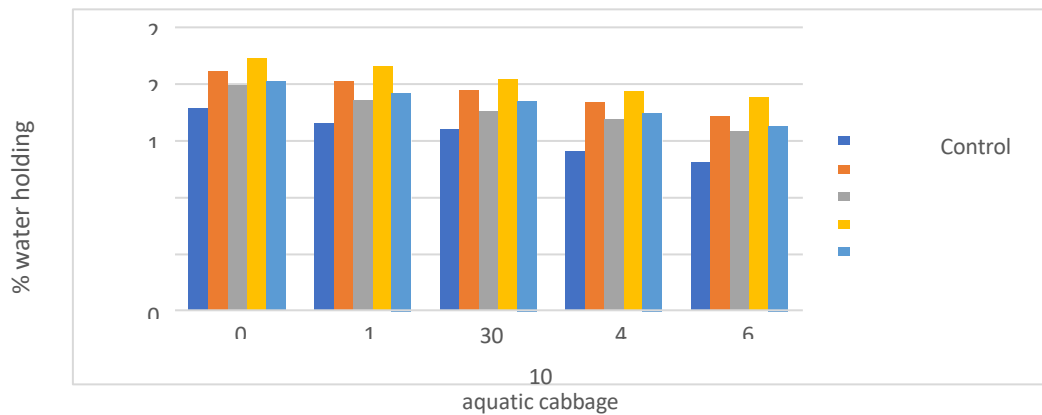


Figure (1): the effect of Cauliflower and cabbage extracts on the Water holding capacity of the Beef burger in the zero time and after 60 days of storage.

than non-treatment.

Evolution of PH:

Figure shows the pH values of the burger over a 60-day period of storage at a temperature of 18°C. The initial pH was 6.18 and there were no statistically significant differences in the pH values ($P < 0.05$) after 60 days, except for the control sample, which increased to 6.98.

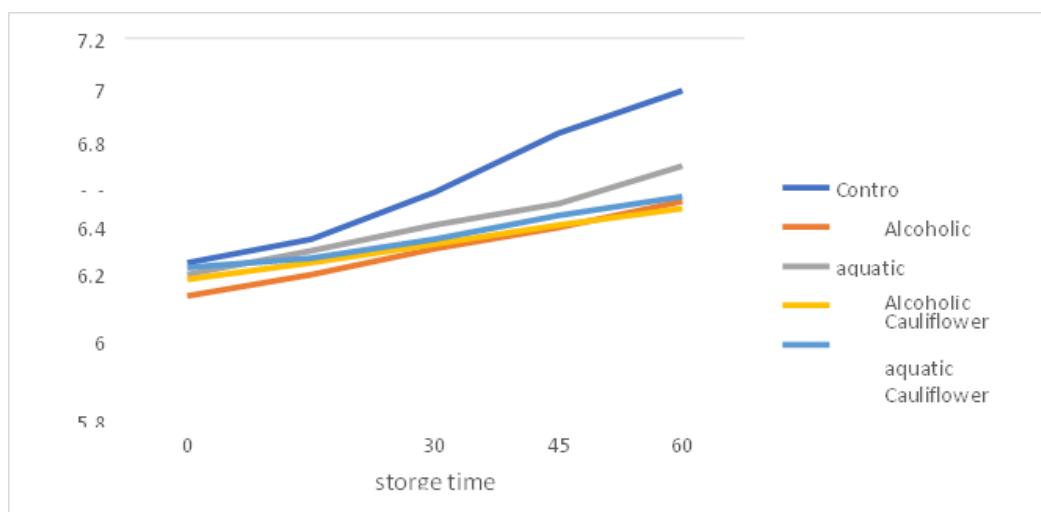


Figure (1): the effect of Cauliflower and cabbage extracts on the PH of the Beef burger in the zero time and after 60 days of storage.



Evolution of Peroxide value:

The table (2) shows the number of beef peroxide during the storage period from zero to 60 days and notes that there is a difference between the samples of alcohol and water extracts and the sample of control. The number of peroxides in the control sample rose to 3.90 in day 60, from 2.58 in zero times. The increase in the samples of the extracts, particularly in the alcohol Cauliflower extract, was slightly higher, from 2.62 in day 60, from 2.08 per day to 0.08 per day. As can be seen in the table, the samples of the alcohol and water extracts maintained the value of peroxide within the permitted limits of Iraq's standard specification. This study is in principle consistent with what was stated by Fasseas *et al.* (2008), which stated that the figure of peroxide decreased by adding plant extracts to the meat stored in the refrigeration.

Table (2): The effect of Cauliflower and cabbage extracts on the Thiobarbitoric acid and Peroxide value of the Beef burger in the 60 days of storage.

Treatment	Effect of treatment and time on pv					Effect of treatment and time on TBA				
storage (days)	0	15	30	45	60	0	15	30	45	60
Control	2.58	2.77	2.9	3.18	3.90	0.29	0.44	0.6	0.71	0.89
Alcoholic cabbage.	2.15	2.33	2.45	2.77	2.98	0.2	0.31	0.44	0.58	0.68
aquatic cabbage	2.33	2.45	2.62	2.82	3.11	0.25	0.37	0.49	0.61	0.72
Cauliflower Alcoholic	2.08	2.21	2.3	2.48	2.62	0.18	0.25	0.37	0.49	0.55
Cauliflower aquatic	2.17	2.35	2.5	2.81	2.98	0.23	0.33	0.47	0.53	0.74
LSD	0.505	0.523 *	0.574 *	0.611 *	0.607 *	0.127	0.163	0.209	0.178	0.215
	* (P≤0.05).					* (P≤0.05).				

The table shows the results of the estimation of Thiobarbitoric acid in the cow burger samples during the storage period. It is noted that the TBA value of all samples rose without exception during the storage period and different values were recorded by sample type. The samples added by alcohol and water extracts showed a decrease in the value of the increase compared to the sample of control during the storage period. The TBA sample increased from 0.29 day to 0.89 day in 60 days, while all remaining transactions showed a slight increase, maintaining a relatively low TBA value compared to the sample of control where the sample of the extract recorded alcohol Cauliflower for example, on the 60th day, due to the increase in TBA value of oxidation occurring in burger fat and the fracture of peroxides (Georgantelis *et al.*, 2007). These results are consistent with Clare Maria O'Sullivan *et al.* (2004) indication that adding plant extracts to sauce increases antioxidants and maintains the product during storage.

CONCLUSION

The addition of cabbage extracts and cabbage water alcohol showed that it was able to maintain the cow burger stored by freezing chemical changes and oxidation for up to 60 days. The results showed that the best extract was the alcohol Cauliflower extract at a concentration of 1% compared to other samples as well as control. The extracts contributed to improving the quality of the samples.



REFERENCES

1. Ağagündüz, D., Şahin, T. Ö., Yılmaz, B., Ekenci, K. D., Duyar Özer, Ş., & Capasso, R. (2022). Cruciferous Vegetables and Their Bioactive Metabolites: from Prevention to Novel Therapies of Colorectal Cancer. *Evidence-Based Complementary and Alternative Medicine*, 1–20.
2. Anas, M., Ahmad, S., & Malik, A. (2019). Microbial Escalation in Meat and Meat Products and Its Consequences. *Health and Safety Aspects of Food Processing Technologies*, 29–49.
3. AOAC (2000) Official Methods of Analysis. 17th Edition, The Association of Official Analytical Chemists, Gaithersburg, MD, USA. Methods 925.10, 65.17, 974.24, 992.16. - References - Scientific Research Publishing. (2000). Retrieved from www.scirp.org website: <https://www.scirp.org/reference/ReferencesPapers?ReferenceID=1687699>
4. Bachiega, P., Jolelem Mastrodi Salgado, Ernesto, Lúcia, A., Schwarz, K., Tiago Tezotto, & Maressa Caldeira Morzelle. (2016). Antioxidant and maturation stages of broccoli (Brassica oleracea Italica) biofortified with selenium. *Food Chemistry*, 190, 771–776.
5. Clare Maria O'Sullivan, Anna-Marie Lynch, Patrick Brendan Lynch, Denis Joseph Buckley, & Joseph Patrick Kerry. (2004). Assessment of the Antioxidant Potential of Food Ingredients in Fresh, Previously Frozen and Cooked Chicken Patties. *International Journal of Poultry Science*, 3(5), 337–344.
6. Connolly, E. L., Sim, M., Travica, N., Marx, W., Beasy, G., Lynch, G. S., ... Blekkenhorst, L. C. (2021). Glucosinolates From Cruciferous Vegetables and Their Potential Role in Chronic Disease: Investigating the Preclinical and Clinical Evidence. *Frontiers in Pharmacology*, 12(3).1-12
7. Diniz, F. M., & Martin, A. M. (1997). Effects of the Extent of Enzymatic Hydrolysis on Functional Properties of Shark Protein Hydrolysate. *LWT - Food Science and Technology*, 30(3), 266–272.
8. Domínguez, R., Pateiro, M., Gagaoua, M., Barba, F. J., Zhang, W., & Lorenzo, J. M. (2019). A Comprehensive Review on Lipid Oxidation in Meat and Meat Products. *Antioxidants*, 8(10), 1-31.
9. Dose, J., Matsugo, S., Yokokawa, H., Koshida, Y., Okazaki, S., Seidel, U., Esatbeyoglu, T. (2016). Free Radical Scavenging and Cellular Antioxidant Properties of Astaxanthin. *International Journal of Molecular Sciences*, 17(1), 1-14.
10. Fasseas, M. K., Mountzouris, K. C., Tarantilis, P. A., Polissiou, M., & Zervas, G. (2008). Antioxidant activity in meat treated with oregano and sage essential oils. *Food Chemistry*, 106(3), 1188–1194.
11. foodchem Favela-González, K. M., Hernández-Almanza, A. Y., & De la Fuente-Salcido, N. M. (2020). The value of bioactive compounds of cruciferous vegetables (Brassica) as antimicrobials and antioxidants: A review. *Journal of Food Biochemistry*, 44(10).
12. Geiker, N. R. W., Bertram, H. C., Mejbörn, H., Dragsted, L. O., Kristensen, L., Carrascal, J. R., ... Astrup, A. (2021). Meat and Human Health—Current Knowledge and Research Gaps. *Foods*, 10(7), 338–342.



13. Georgantelis, D., Blekas, G., Katikou, P., Ambrosiadis, I., & Fletouris, D. J. (2007). Effect of rosemary extract, chitosan and α -tocopherol on lipid oxidation and colour stability during frozen storage of beef burgers. *Meat Science*, 75(2), 256–264.
14. Gründemann, C., & Huber, R. (2018). Chemoprevention with isothiocyanates – From bench to bedside. *Cancer Letters*, 414(1), 26–33.
15. Hajlaoui, H., Arraouadi, S., Mighri, H., Chaaibia, M., Gharsallah, N., Ros, G., ... Kadri, and A. (2019). Phytochemical Constituents and Antioxidant Activity of *Oudneya Africana* L. Leaves Extracts: Evaluation Effects on Fatty Acids and Proteins Oxidation of Beef Burger during Refrigerated Storage. *Antioxidants*, 8(10), 2-19.
16. Juntachote, T., Berghofer, E., Siebenhandl, S., & Bauer, F. (2006). The antioxidative properties of Holy basil and Galangal in cooked ground pork. *Meat Science*, 72(3), 446–456.
17. Karre, L., Lopez, K., & Getty, K. J. K. (2013). Natural antioxidants in meat and poultry products. *Meat Science*, 94(2), 220–227.
18. Malik, I. A., Elgasim, E. A., Adiamo, O. Q., Ali, A. A., & Mohamed Ahmed, I. A. (2021). Effect of frozen storage on the biochemical composition of five commercial freshwater fish species from River Nile, Sudan. *Food Science & Nutrition*, 9(7), 3758–3767.
19. Marinova, G., & Batchvarov, V. (2011). Evaluation of the Methods for Determination of the Free Radical Scavenging Activity by DPPH. *Bulgarian Journal of Agricultural Science*, 17(1), 11–24.
20. Min, D. B. 1, & Ellefson, W. C. (2010). Fat Analysis. Food Science Texts Series, 1, 117–132.
21. Okunade, A. L. (2002). *Ageratum conyzoides* L. (Asteraceae). *Fitoterapia*, 73(1), 1–16.
22. Ottaway, J. M., Carter, J. C., Adams, K. L., Camancho, J., Lavine, B., & Booksh, K. (2021). EXPRESS: Comparison of Spectroscopic Techniques for Determining the Peroxide Value of 19 Classes of Naturally Aged, Plant-Based Edible Oils. *Applied Spectroscopy*, 75(7),
23. Petcu, C. D., Tăpăloagă, D., Mihai, O. D., Gheorghe-Irimia, R.-A., Negoită, C., Georgescu, I. M., ... Ghimpețeanu, O. M. (2023). Harnessing Natural Antioxidants for Enhancing Food Shelf Life: Exploring Sources and Applications in the Food Industry. *Foods*, 12(17), 3176.
24. Pham, H., Nguyen, V., Vuong, Q., Bowyer, M., & Scarlett, C. (2015). Effect of Extraction Solvents and Drying Methods on the Physicochemical and Antioxidant Properties of *Helicteres hirsuta* Lour. Leaves. *Technologies*, 3(4), 285–301.
25. Sambu, S., Hemaram, U., Murugan, R., & Alsofi, A. A. (2022). Toxicological and Teratogenic Effect of Various Food Additives: An Updated Review. *BioMed Research International*, (1), 1-11.
26. Šamec, D., Pavlović, I., & Salopek-Sondi, B. (2016). White cabbage (*Brassica oleracea* var. capitata f. alba): botanical, phytochemical and pharmacological overview. *Phytochemistry Reviews*, 16(1), 117–135.
27. Sánchez-Zapata, E., Muñoz, C. M., Fuentes, E., Fernández-López, J., Sendra, E., Sayas, E., ... Pérez-Alvarez, J. A. (2010). Effect of tiger nut fibre on quality characteristics of



- pork burger. *Meat Science*, 85(1), 70–76.
28. Stojković, G., Dimitrieska-Stojković, E., Soklevska, M., & Velez, R. (2016). Optimization, Validation and Application of UV-Vis Spectrophotometric-Colorimetric Methods for Determination of Trimethoprim in Different Medicinal Products. *Macedonian Veterinary Review*, 39(1), 65–76.
29. Valisakkagari, H., Chaturvedi, C., & Rupasinghe, H. P. V. (2024). Green Extraction of Phytochemicals from Fresh Vegetable Waste and Their Potential Application as Cosmeceuticals for Skin Health. *Processes*, 12(4), 1-22.
30. Yee, Y. J., & Amin, A. M. (2020). Physicochemical Properties Of Undulated Surf Clam (*Paphia Undulata*) Hydrolysate As Affected By Degree Of Hydrolysis. *Universiti Malaysia Terengganu Journal of Undergraduate Research*, 2(3), 15– 26.
31. Zuecco, G., Amin, A., Frentress, J., Engel, M., Marchina, C., Anfodillo, T., ... Penna, D. (2022). comparative pressure chamber vs. cryogenic vacuum distillation. *Hydrology and Earth System Sciences*, 26(13), 3673–3689.