

## ANTIOXIDANT PLANT EXTRACTS IN THE MEAT PROCESSING INDUSTRY

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The review highlights the role of antioxidants in minimizing oxidative changes that may adversely affect the quality of meat and meat products, cause changes in their testing and nutritional properties. This applies particularly to the use of natural antioxidants based on plant extracts, which can be a good alternative to traditional antioxidants, thanks to its high content of phenolic compounds. From the literature it can be concluded that extracts of broccoli, rosemary, mint, grape seed and green tea have a significant antioxidant effect in the meat products. Broccoli and grape seeds extracts have a pronounced antioxidant activity compared to synthetic antioxidants. Laminarin/fucoidan extracts have prooxidative effect on lipid peroxidation. Essential oils of *L. angustifolia* and *M. piperita* effectively inhibit *E. coli* O157:H7 and *S. aureus* in the chopped beef meat. The alcoholic extract of the dried leaves of oregano has the highest content of total phenols, however, does not exhibit antioxidant properties. The extracts of rosemary, orange, lemon, mint and curry have positive effect on the color of the meat products. When choosing natural antioxidants it is necessary to pay attention to their impact on testing and qualitative characteristics of these food products.

**Key words:** meat, meat products, natural antioxidants.

Lipid peroxidation and microbial contamination are the main factors that determine food quality loss and shelf life reduction. Therefore, delaying lipid peroxidation and preventing bacterial cross-contamination are highly relevant to food processors. The growth of microorganisms in meat products may cause spoilage or foodborne diseases. Lipid peroxidation can have negative effects on the quality of meat and meat products causing changes in sensory attributes (color, texture, odor, and flavor) and nutritional value. Synthetic antioxidants such as butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) have been widely used in meat to suppress or retard the development of warmed-over flavor. However, the use of synthetic antioxidants has come under more scrutiny due to their potential toxic effects. In response to recent demand for natural products and consumers' willingness to pay significant premiums for natural foods, the meat and poultry industry is actively seeking natural solutions to minimize

oxidative rancidity and increase products shelf life [1]. Due to their high content of phenolic compounds, fruits and other plant materials are a good source of natural antioxidants and provide an alternative to currently used conventional antioxidants [2].

Broccoli or broccoli extracts, being a rich source of various phenolic compounds could therefore be incorporated in meat products as a source of natural antioxidants to prolong quality and stability.

Banerjee et al. [3] evaluated antioxidant potential of broccoli powder extract (BPE) in goat meat nuggets at three different levels (1; 1,5 and 2%), compared with butylated hydroxyl toluene (100 ppm BHT) and control. Nuggets prepared with 1% BPE had pH values similar to those of control and BHT ones. However, higher amount of BPE significantly decreased the pH value of goat meat nuggets. This could be due to slightly lower pH (4.9) of broccoli powder extract than the normal pH of goat meat. The cooking yield was not significantly different in any of the

formulations tested. Total phenolics in BPE nuggets and BHT nuggets was significantly higher with respect to control nuggets. In BPE nuggets, phenolic content increase was correlated to the amount of BPE added and product containing 2% BPE had similar total phenolics to the BHT nuggets.

There were no significant differences in the redness, yellowness and hue values (Lightness/chroma/hue) among all products. Incorporation of BPE at 1.5 and 2.0% levels significantly decreased chroma value. Control, BHT and BPE1 nuggets had almost similar chroma values. But, yellowness and chroma values of products with BPE slightly decreased at higher levels. This could be attributed to the slightly grayish color of the broccoli powder extract. The organoleptic characteristics of all the products were almost similar and incorporation of broccoli powder extract did not make marked changes in any of the attributes.

Thiobarbituric acid reactive substance (TBARS) number of all the products increased significantly with the advancement of storage period. Among different goat meat nuggets, control had significantly higher TBARS number. Among BPE nuggets, TBARS number decreased with the higher levels of extract with significant effect at 2% level and its value was similar to the product with 100 ppm BHT.

Incorporation of broccoli powder extracts at 1.0 and 2.0% level which is equivalent to 0.1 and 0.2% broccoli powder significantly increases the phenolic contents in goat meat nuggets and can act as a source of natural antioxidants. Although instrumental color redness of products decreases at higher level of broccoli powder extract, upon sensory evaluation no difference was perceived as compared to control. Storage study of the products shows that broccoli powder extract significantly reduces the lipid peroxidation similar to the 100 ppm BHT thus improving the product quality and stability.

Kim et al. investigated the influences of chamnamul (*Pimpinella brachycarpa*) and fatsia (*Aralia elata*) extracts on lipid peroxidation and microbial criteria in raw beef patties stored at 4 °C for 12 days [4]. The addition of extracts and BHT resulted in concentration-dependent decreases in TBARS values and in the number of microorganisms in the beef patties and also improved meat color stability. The fatsia extract had more effective antioxidant and antimicrobial activities than the chamnamul. In another study authors investigated the effects of

butterbur (*Petasites japonicus*) and broccoli (*Brassica oleracea* L. var. *italica* Plenck) extracts on lipid peroxidation in ground beef patties stored at 4 °C for 12 days [5]. TBARS levels were significantly lower in the samples containing plant extracts or BHT than the non-treated control. In addition, the beef patties formulated with the selected plant extracts showed significantly better color stability than those without antioxidants.

*Lavandula angustifolia* (Lamiaceae) is well known as a powerful aromatic and medicinal herb. The plant is used in traditional and folk medicines. Recently it has also been employed in food manufacturing as natural flavoring agent [6].

*Mentha* sp. (Lamiaceae) has been also used in folk medicine. Furthermore, it is well-documented that the EOs (essential oils) or/and extracts from some *Mentha* species including *Mentha piperita* possess antimicrobial and antioxidant properties. The extracts obtained from *Mentha* species are nowadays extensively used in the manufacture of a wide range of food products.

Djenane et al. investigated antimicrobial activities of the EO of Algerian *L. angustifolia* and *M. piperita* against *E. coli* O157:H7 and *S. aureus* CECT 4459 *in vitro* and in minced meat and their antioxidant activity, as well as their ability to extend the shelf life of minced beef during abusive refrigerated storage [7]. According to authors, those EOs were very effective in inhibiting *E. coli* O157:H7 and *S. aureus* both *in vitro* and in minced meat. The initially recorded population of 3.6 log CFU/g of both pathogen strains increased to approximately 6.57 log CFU/g by the end of storage (days 9) in untreated samples. Indeed, a reduction of 0.60 and 1.76 log CFU/g was recorded for *E. coli* O157:H7 in 3 days of storage, respectively, by *Mentha* and *Lavandula* EOs. At day 9 the same effects were observed; a reduction to 2.03 and 1.5 log CFU/g, respectively for *M. piperita* and *L. angustifolia*.

Regarding *S. aureus*, after an initial decrease of total counts by 1.20 and 1.46 log CFU/g on day 3, respectively, in minced beef treated with *M. piperita* and *L. angustifolia* EOs, they decreased significantly and reached less than 2 log CFU/g by the end of the storage period for both EOs. Moreover, it has been found that *L. angustifolia* EO was most effective in inhibiting both Gram-positive and Gram-negative bacteria, while *M. piperita* exerted a higher inhibition only on the Gram-positive *S. aureus*.

They also exerted an antioxidant effect, which extended meat display life even at abuse temperature. Untreated samples showed the highest values of TBARS. They were well above 3.60 mg MDA/kg at day 9 of storage. Samples treated with EO had the lowest values; indeed, they did not reach 1.50 mg MDA/kg, even after 6 days of storage.

The obtained results showed that off-odor intensity increased throughout storage in all samples, though not at the same rate. Untreated samples were assessed by the panelists with scores above the rejection limit, whereas samples treated with each EOs were assessed with scores below the rejection limit. Therefore, the presence of EOs significantly extended minced beef fresh odor; in fact, beef with added EOs were scored 2.05 to 2.60, which may be considered as acceptable, at day 9 of storage.

Fernandez-Lopez et al. evaluated the antioxidant and antibacterial effect of rosemary, orange and lemon extracts, the ability of these natural extracts for inhibiting the growth of 11 foodborne bacterial contaminants and their ability to extend the storage shelf life of a cooked meat product [8].

The analysis of variance for the TBARS data indicates that the TBA values were significantly affected by both the storage period and the extract treatments. Initial (day 1) TBA values for all extract samples were significantly lower than those for the control. These results suggest that these antioxidants retarded lipid peroxidation during and immediately after cooking.

At the end of storage time (day 12) all treatments resulted in significantly lower TBA values when compared to the control, which indicates that all the tested natural extracts added to meatballs showed antioxidant properties. The product samples with rosemary extracts showed the lowest TBA values at each time of storage. Only treatments with orange extracts and rosemary water miscible extracts maintained the initial TBA values during the 12 day storage period, and no differences were found between them. Samples treated with rosemary oil and water miscible extracts had slightly increased TBA values only during the first 6 days of storage and became stable after that period. The products with added lemon extracts reached higher TBA values than those with orange extracts by the end of storage.

In all samples, lightness increased with storage time, and the highest values of  $L^*$  (CIE) were obtained in control samples. This

increase could be related to the increase in metmyoglobin (MMb) formation.

These results suggests that the presence of antioxidant compounds in the natural extracts could retard metoximethyl butanol (MMb) formation in meatballs and so  $L^*$  values decreased. In all samples redness decreased as the storage time progressed, but red colour ( $a^*$ -values) of the control sample faded very rapidly. At the day 12 of storage  $a^*$ -values of the control samples were lower than day 1, and lower that of antioxidant treatments. In all samples yellowness values were not modified by storage time. Therefore, the differences in  $b^*$ -values observed between treatments incorporating citrus extracts and the others, can be attributed to the presence of pigments in the citrus extracts and not to the peroxidation processes.

In this work, the presence of coliforms, moulds and yeasts, and psychrotrophic microorganisms was not detected in any cooked meatball samples, regardless of storage time. Lactic acid bacteria (LAB) were detected at low levels in the control and samples with rosemary water and oil miscible extracts from day 1. After 12 days storage, the growth of LAB to levels of  $10^3$  log cfu/g was similar for control samples and treatments with rosemary extracts. These bacterial groups were not detected in samples from any treatment with citrus extracts during storage time. Despite the presence of lactic acid bacteria, there was no evidence of strong lactic fermentation in any product. The antibacterial activity obtained for rosemary extracts have not been manifested during the storage of cooked meatballs with added extracts. This could be explained by the dilution of the rosemary extracts necessary for its use in meat products.

Also, it is important to observe that citrus extracts appear to be more effective than the others to control LAB growth during the storage of meatballs. This is likely to be related with the lowered water activity within the product that would be the result of adding the citrus fruit preparations as a dry powder which contains fibre with high water absorption.

Lara et al. reported the effect of rosemary (*Rosmarinus officinalis*) and lemon balm (*Melissa officinalis*) extracts on the shelf life of cooked pork meat patties packaged in modified atmosphere (70%  $N_2$ +30%  $CO_2$ ) and stored under refrigeration and illumination conditions [9].

pH values were significantly lower in batches with natural antioxidants (rosemary and lemon balm) all throughout the storage

period, which could be attributed to the fact that the active compound in these extracts is an acid (carnosic acid, in the case of rosemary and rosmarinic acid in the case of lemon balm, with a pH of  $4.66 \pm 0.01$  and  $4.25 \pm 0.02$ , respectively). However, the lower pH values of rosemary and lemon balm batches did not affect sensory characteristics of evaluated patties.

Regarding the effect of the addition of antioxidants to pork patties  $a^*$ -values (CIE), significant differences can be observed after cooking and all throughout 6 days storage, the samples with added antioxidant showing a higher  $a^*$ -value in comparison to control (meat with no added antioxidant). The addition of rosemary extract allowed the obtaining of higher  $a^*$ -values in meat surface in comparison to control, BHT (20 mg BHT per 100 g meat) and lemon balm extracts samples. The lowest values of Hue were also presented by rosemary extract sample throughout the storage period.

Lipid peroxidation was significantly reduced in samples with added antioxidants compared to control, all throughout refrigerated storage. Rosemary extract was the most effective antioxidant followed by BHT and lemon balm extract. Control showed the highest hexanal concentration all throughout the storage period.

Biswas et al. investigated the antioxidant activity of different solvent extracts of curry and mint leaf and their effect on color and oxidative stability of raw ground pork meat stored at  $4 \pm 1$  °C [10]. The  $L$ -value (lightness) decreased significantly in the control (meat without any extract) as compared to other samples during storage. In the T1 (contained 100 ppm of sodium nitrite) sample, the lightness, after an initial increase up to day 3, significantly decreased on day 6, indicating dark discolouration. Significant difference was also observed in lightness for T2 (ethanol extract of curry leaf) and T3 (hot water extract of mint leaf) treatments. T1 showed comparatively higher  $a$ -value but did not differ significantly from the other treatments. The  $a$ -value was found to increase in the control and the T1 treatment on day 6 and 9, respectively, while the  $b$ -value decreased linearly and significantly with increasing storage time. At the beginning of storage, the pH was not significantly different between control and the treatments. However, on the day 3, the pH was significantly higher in the control sample.

At day 0 of the shelf-life study, the TBARS values were significantly higher in

the control sample followed by T3, T2 and T1 treatments. Significant increases in the TBARS values during the storage period were observed in the control and T3. But in T2, a significant difference was observed only between day 0 and day 6 of storage. In contrast, the control showed a significant increase in the TBARS values between all storage intervals. In the T1 treatment, slight increases in the TBARS values were observed during the storage period. Treatment with curry leaf extract (T2) showed lower TBARS during any day of storage than the control, T1 and T3 treated samples. The control samples showed a significantly higher TBARS values as compared to all other samples. Among the two different extracts, the curry leaf extract was more effective in reducing malonaldehyde formation.

Hernandez-Hernandez et al. studied the rosemary (*R. officinalis* L.) and oregano (*Origanum vulgare* L.) extracts effect on color and peroxidation (as TBARS) of model raw pork batters stored at 4 °C and 20 °C [11]. The lowest TBARS values were observed in samples treated with rosemary extracts, although storage at 4 °C significantly reduced TBARS (1.831 and 0.452, 20 °C and 4 °C, respectively). A rapid increase in TBARS values was observed up to 48 h in samples stored at 20 °C, and up to 24 h in the control. Oregano extracts had prooxidant activity in batters stored at 20 °C, with mean TBARS values higher than the control. Special prooxidant effect was observed for fresh oregano extracts. Although ethanol dried oregano extracts had the highest total phenol concentration (0.2223 mg/ml), it did not act as an antioxidant.

In spite of having lower phenol concentration than ethanol dried oregano extracts, rosemary extracts are more efficient in reducing TBARS values. Therefore, antioxidant activity did not depend only on total phenol concentration, but also on their polarity and molecular structure.

Treatments with ethanol rosemary extracts gave the lowest  $L$ -values (the darkest samples, mean value = 69.46), it was significantly different to other treatments; this effect was more noticeable in samples stored at 20 °C. On average,  $L$ -values for all samples were significantly higher in those stored at 4 °C than at 20 °C ( $L = 74.61$  and  $67.28$ , respectively); no significant differences were observed in samples stored under refrigeration. A higher correlation (negative) was observed for  $L$ -versus TBARS values with respect to initial peroxidation conditions; as peroxidation



increased (as TBARS), lightness decreased (samples became darker).

Chroma (color intensity) showed a significant decreasing trend with time. Non-significant differences were observed among treatments, except for ethanol rosemary extracts. Chroma values were similar for all treatments throughout time, except for high initial peroxidation samples stored at 20 °C. Low values (more reddish samples) were observed for batters with added ethanol dried oregano extracts.

Sojic et al. examined the oxidative and microbial stability of cooked sausages, produced with the addition of 10 ppm (NO1) and 20 ppm (NO2) nutmeg (*Myristica fragrans*) EO [12]. The addition of nutmeg EO in concentrations up to 20 ppm did not affect lightness (CIE L<sup>\*</sup>-value) and yellowness (CIE b<sup>\*</sup>-value) of samples. On the other hand, certain differences in redness (CIE a<sup>\*</sup>-value) were registered between control and sausages with addition of nutmeg oil. At the beginning of storage, redness (CIE a<sup>\*</sup>-value) ranged from 8,02 (NO2) to 8,33 (NO1). At the beginning of the storage (1st day), TBARS values were within a very narrow range of 0.39 mg MDA/kg up to 0.41 mg MDA/kg. During storage, there was an increase in TBARS values in all three examined groups of sausages. After 60 days of storage, TBARS values in NO1 and NO2 sausages amounted to 1.21 mg MDA/kg and 0.95 mg MDA/kg, respectively, and were significantly lower, compared with this value in control (1.53 mg MDA/kg). The reducing lipid peroxidation in cooked sausages could be attributed to the presence of active phytochemicals in nutmeg essential oil [13, 14].

At the beginning of the storage, the total number of aerobic mesophilic bacteria was the lowest in NO2 sausages (20.0 cfu/g) and the highest in the control (25.0 cfu/g). During the storage, in all three groups of sausages, there was an increase in the total number of aerobic mesophilic bacteria. After 45 and 60 days of storage, the total number of aerobic mesophilic bacteria in NO1 (93.3 cfu/g, 137.0 cfu/g) and NO2 sausages (28.3 cfu/g and 78.3 cfu/g) was significantly lower, compared to those values in sausages of the control (155.0 cfu/g; 185.0 cfu/g).

During 30 days of storage, sensory evaluated aroma did not differ significantly between the examined groups of sausages. After 45 days of storage, in all three examined groups of sausages, there was a decline in sensory quality of aroma. After 60 days of

storage, sensory evaluated aroma for NO2 sausages (4.39) was significantly higher, compared to NO1 sausages (3.93) and the control (3.25).

Jongberg et al. reported the antioxidative mechanisms of phenolic-rich extracts from green tea and rosemary added to Bologna type sausages prepared from oxidatively stressed pork [15]. Lipid peroxidation as determined by the formation of secondary lipid peroxidation products, TBARS, was found to be significantly inhibited in the sausages added green tea extract and close to significant for the rosemary extract. As compared to the control the TBARS values were reduced by ~80% or 73% in sausages added green tea extract or rosemary, respectively. According to authors, the observed effects may be related not only to the phenolic profile of the two extracts, but also to the different concentration of active compounds (total phenols content) in the sausages, which were 500 ppm and 400 ppm for green tea and rosemary extract, respectively.

Accordingly, the result of the sensory evaluation showed that the taste of the Bologna type sausages added rosemary extract deviated significantly by two descriptors compared to the control and the sausages added green tea extract. Bologna type sausages added rosemary extract were found bitterer than the two others in both weeks of evaluation. With regard to smell, the Bologna type sausages added rosemary extract was found to be more acidic than the other two sausages in both weeks of evaluation. Again this observation may be a result of increased levels of phenolic acids in rosemary extract compared to green tea extract [16]. The color of the Bologna type sausages was affected by addition of the plant extracts, as both samples with plant extracts showed more intense gray color and less pink color especially after four weeks storage. Both plant extracts inhibited off-flavors derived from lipid peroxidation and were found to affect the texture of the Bologna-type sausages. Further, addition of rosemary extract was found to impair the flavor, while addition of green tea extract maintained a more neutral taste of the sausages.

Reddy et al. evaluated the antioxidant and antimicrobial efficacy of grape seed extract (GSE) compared to butylated hydroxyl anisole in both aerobic and vacuum packed precooked restructured mutton slices (RMS) under refrigerated storage (4 ± 1 °C) [17]. GSE showed lower TBARS values compared to controls and BHA. The storage period significantly increased the TBARS values,

from 0.19 (0 day) to 0.49 (14 days) in aerobic packaging and 0.19 (0 day) to 0.84 (28 days) in vacuum packaging of RMS. Vacuum packaged RMS had significantly lower TBARS values than aerobic packed RMS. The RMS treated with GSE had significantly lower free fatty acid content (%) than BHA.

Addition of GSE significantly influenced the total psychrophilic counts of aerobic and vacuum packaged RMS during 14 and 28 days of refrigerated storage respectively. In vacuum packaged RMS, incorporation of GSE reduced the overall mean values of total psychrophilic counts from 3.51 to 3.23 log cfu/g.

GSE significantly improved the color scores compared to control and BHA during refrigerated storage of both aerobic and vacuum packaged RMS. The RMS treated with GSE showed significantly higher flavor scores than control and BHA. GSE acts as an excellent natural antioxidant compared to the synthetic antioxidant BHA. Addition of GSE at 0.1% enhanced the shelf life of RMS, to at least 28 days under refrigerated.

Soy sauce or soya sauce is a widely used condiment and has been utilized for marinade and seasoning in a variety of meat-based cuisines in East Asia, such as China, Japan, Korea, and Thailand [18]. Soy sauce is a fermented food derived from soybean or wheat. Soy sauce contains salt (approximately 15–20%), water (approximately 50–70%), peptides, isoflavones, free sugar, and organic acids derived from the soybeans during fermentation [19]. Soy sauce contains several antioxidants such as melanoidins (formed during fermentation), phenolic compounds and free amino acids.

Kim et al. evaluated the antioxidant effects of soy sauce on lipid peroxidation and color stability of raw beef patties [20]. Raw beef patties were formulated with four solutions such as NaCl (sodium chloride solution), NaCl/SS (1:1 ratio of sodium chloride and soy sauce solution), SS (soy sauce solution), or SS/A (soy sauce solution combined with 0.05% ascorbic acid) in the same salt concentration. Addition of soy sauce resulted in the decreased pH, lightness, and increased yellowness. Treatment NaCl had the highest pH value (5.97), and the pH values of the other treatments decreased with adding the soy sauce at the initial storage time due to the low pH of soy sauce. The pH values of the all treatments decreased with storage time.

Lightness (CIE  $L^*$ -value) decreased with the addition of soy sauce, and the treatment NaCl had the highest lightness

when compared with the other treatments. As the storage period increased, the lightness of all treatments increased. During the initial storage time, no differences in redness (CIE  $a^*$ -value) were observed among all treatments, however, the redness of all samples decreased with increasing storage periods. After 3 days, the treatment NaCl had the lowest redness compared to the other treatments. A difference in yellowness (CIE  $b^*$ -value) between the treatment NaCl and the treatments containing the soy sauce was observed, but there were no significant difference among NaCl/SS, SS, and SS/A treatments on day 0. These results were partially attributed to the browning color of the soy sauce. Yellowness increased during storage. Treatment NaCl had the highest yellowness value at the end of storage.

On day 0, the treatment NaCl had a higher TBA value than the other treatments; however, there were no differences between other treatments. The increase in TBA concentration depended upon the storage time. After 7 days of storage, the TBA values were different between the NaCl/SS, SS, and SS/A treatments. Treatment SS/A had the lowest TBA value on the final day of storage. The soy sauce limits the formation of secondary products such as malondialdehyde on raw beef meat when compared to the addition of the sodium chloride. Combined with ascorbic acid, soy sauce would be more effective in inhibiting lipid peroxidation.

The use of seaweed (macroalgae) or seaweed extracts as food additives is growing in popularity due to the vast range of functional properties they impart in food products. Seaweeds contain high proportions of polysaccharides such as laminarin and fucoidan, proteins, minerals, and vitamins and have low lipid content [21]. Seaweed polysaccharides are a potential source of soluble and insoluble dietary fibre. Pigments present in seaweed can influence meat product color depending on the seaweed/extract type and concentration added [22].

Moroney and O'Grady found that addition of a seaweed (*Laminaria digitata*) extract containing polysaccharides (soluble dietary fibres) did not enhance quality parameters of the fresh minced pork patties [23]. The laminarin/fucoidan (L/F) extract exerted a prooxidant effect on lipid peroxidation over time attributed to the prooxidant components (sodium, copper and iron) present in the extract. Decreased lipid peroxidation observed in cooked pork patties containing the L/F extract (0.5%) provided evidence that heating

can enhance the antioxidant capacity of seaweed extracts in muscle foods and improve quality parameters possibly do to the formation of brown melanoidins (Maillard reaction products) with antioxidant functionality. The L/F extract at a level of 0.01% can be incorporated without adversely affecting the color, lipid peroxidation, texture or sensorial acceptance of pork patties. Further research is necessary to examine the effects of more refined or purified laminarin and fucoidan extracts in meat products.

Hwang et al. evaluated raw and deep fried chicken nuggets containing various levels of ganghwayakssuk (*Artemisia princeps* Pamp.) ethanol extract (GE) in combination with ascorbic acid (Aa) effect on shelf life during refrigerated storage (4 °C) [24]. As the storage period progressed, the TBARS values are increased significantly in control and all the treated raw samples. However, when the antioxidant mixture (GE and Aa) was added, the treated samples resisted lipid peroxidation and displayed much lower TBARS values than the control on all days. The TBARS values of

the deep fried chicken nugget samples, except for those of GE 0.2 and Aa + GE 0.1, increased at the beginning of storage and then began to decrease at day 12. Among the antioxidant combinations, Aa + GE 0.1 (0.05% ascorbic acid + 0.1% ganghwayakssuk ethanolic extract) was the most effective in inhibiting lipid peroxidation of raw and deep fried chicken nuggets. Samples treated with GE 0.2 and Aa + GE 0.1 exhibited significantly lower counts during the whole period of storage.

The lightness and redness values of the raw and deep fried chicken nuggets decreased with increasing GE level, whereas the yellowness values increased significantly with increasing GE content. The pH and color values of all samples were significantly affected by adding GE.

Thus, it can be concluded that rosemary, mint, green tea, broccoli extracts and soy sauce are perspective to use in meat products processing. These extracts can be direction for following scientific investigation in meat products shelf life improving sphere.

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## АНТИОКСИДАНТНІ РОСЛИННІ ЕКСТРАКТИ У М'ЯСОПЕРЕРОБНІЙ ПРОМИСЛОВСТІ

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В огляді наголошується на важливості використання антиоксидантів для мінімізації окисних змін, що можуть негативно впливати на якість м'яса та м'ясних продуктів, спричинювати зміни в їхніх сенсорних і харчових властивостях. Передусім це стосується натуральних антиоксидантів на основі рослинних екстрактів, які можуть становити альтернативу традиційним антиоксидантам завдяки високому вмісту фенольних сполук. Дані літератури свідчать, що у м'ясних продуктах екстракти броколі, розмарину, м'яти, виноградних кісточок та зеленого чаю спричиняють значний антиоксидантний вплив. Екстракти броколі та виноградних кісточок мають більш виражені антиоксидантні властивості порівняно із синтетичними антиоксидантами. Екстракт ламінарину/фукоїдану справляє проокисну дію на пероксидацію ліпідів. Ефірні олії *L. angustifolia* і *M. piperita* ефективно пригнічують *E. coli* O157:H7 і *S. aureus* у січеному яловичому м'ясі. Спиртовий екстракт із висушеного листа орегано містить найбільшу кількість загальних фенолів, однак не виявляє антиоксидантних властивостей. Екстракти розмарину, апельсину, лимону, каррі та м'яти позитивно впливають на колір м'ясопродукту. Вибираючи натуральні антиоксиданти, слід брати до уваги вплив їх на сенсорні та якісні показники харчової продукції.

**Ключові слова:** м'ясо, м'ясні продукти, натуральні антиоксиданти.

## АНТИОКСИДАНТНЫЕ РАСТИТЕЛЬНЫЕ ЭКСТРАКТЫ В МЯСОПЕРЕРАБАТЫВАЮЩЕЙ ПРОМЫШЛЕННОСТИ

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В обзоре подчеркивается роль антиоксидантов для минимизации окислительных изменений, которые могут негативно влиять на качество мяса и мясных продуктов, стать причиной изменений их сенсорных и пищевых свойств. Прежде всего это касается натуральных антиоксидантов на основе растительных экстрактов, которые могут быть альтернативой традиционным антиоксидантам благодаря высокому содержанию фенольных соединений. Данные литературы свидетельствуют, что в мясных продуктах экстракты брокколи, розмарина, мяты, виноградных косточек и зеленого чая оказывают значительный антиоксидантный эффект. Экстракты брокколи и виноградных косточек имеют более выраженные антиоксидантные свойства по сравнению с синтетическими антиоксидантами. Экстракт ламинарина/фукоидана оказывает проокислительное действие на пероксидацию липидов. Эфирные масла *L. angustifolia* и *M. piperita* эффективно подавляют *E. coli* O157:H7 и *S. aureus* в рубленом говяжьем мясе. Спиртовой экстракт из высушенных листьев орегано имеет наибольшее содержание общих фенолов, однако не проявляет антиоксидантных свойств. Экстракты розмарина, апельсина, лимона, карри и мяты позитивно влияют на цвет мясопродукта. При выборе натуральных антиоксидантов необходимо принимать во внимание их влияние на сенсорные и качественные показатели пищевой продукции.

**Ключевые слова:** мясо, мясные продукты, натуральные антиоксиданты.