JMBFS
Journal of Microbiology, Biotechnology and Food Sciences
International peer-reviewed scientific online journal
Published by Faculty of Biotechnology and Food Sciences

QUALITY OF RAW-COOKED MEAT PRODUCT AFTER APPLICATION GRAPE SEED EXTRACT

Marek Bobko[1], Miroslav Kročko[1], Peter Haščík[1], Andrea Mendelová[2], Alica Bobková[3], Juraj Čuboň[1], Jana Tkáčová[1], Luboš Harangozo[4]*

Address(es): doc. Ing. Marek Bobko, PhD.
[1]Slovak University of Agriculture in Nitra, Department of Animal Products Evaluation and Processing, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia.
[2]Slovak University of Agriculture in Nitra, Department of Plant Products Storage and Processing, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia.
[3]Slovak University of Agriculture in Nitra, Department of Food Hygiene and Safety, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia.
[4]Slovak University of Agriculture in Nitra, Department of Chemistry, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia.

*Corresponding author: marek.bobko@uniag.sk

doi: 10.15414/jmbfs.2018-19.8.3.867-870

ARTICLE INFO

Received 17. 7. 2018
Revised 19. 9. 2018
Accepted 20. 9. 2018
Published 1. 12. 2018

Regular article

OPEN ACCESS

ABSTRACT

The present study aimed to determine the effect of GSE application on quality (oxidative stability, color and sensory quality) of raw-cooked meat products stored 10 days at 4 °C. Antioxidant activity assessment of applied GSE of different grape varieties in Frankovka modrá (E2) grape varieties was observed higher antioxidant activity (91.2%) than that in Dunaj (E1) and Cabernet Sauvignon (E3) grape variety (85.3, resp. 85.8 %). At the end of storage (day 10), we observed higher oxidation stability in all experimental groups with grape seed extract supplements and therefore a lower MDA value compared to the control group without the addition of extracts. In control group was recorded the highest production of MDA (0.129 mg.kg^{-1}). From experimental groups with the addition of different grape seed extracts, we recorded the highest degree of oxidative stability in the experimental group with the addition of Frankovka modrá extract (0.115 mg.kg^{-1}). The highest degree of oxidative damage from all experimental groups was found in group with the addition of Dunaj extract (0.120 mg.kg^{-1}). The MDA content in the experimental group with the addition of Cabernet Sauvignon grape extract at the end of the refrigeration storage period was 0.118 mg.kg^{-1}. In the evaluation of the individual sensory quality indicators after grape seed extract we did not record statistically significant differences ($P > 0.05$) between individual groups, indicating that the sensory quality of raw-cooked meat products was not negatively affected by their addition. In the evaluation of the most important indicator of sensory quality (taste) we recorded better average ratings in all experimental groups with the addition of grape seed extract than in the control group. Based on the results of the oxidative stability and sensory quality of the raw-cooked meat product after 10 days of refrigerated storage at 4 °C, we can recommend using natural antioxidants in the production of the meat product in the form of grape seed extract Dunaj, Frankovka modrá and Cabernet Sauvignon to increase oxidative stability thereby increasing the shelf life and sensory quality of the raw-cooked meat product.

Keywords: oxidative stability, grape seed extract, malondialdehyd, sensory

INTRODUCTION

Meat is the muscle tissue of slaughter animals composed of water, proteins, lipids, minerals and a small proportion of carbohydrates. Meat and meat products are susceptible to quality deterioration due to their rich nutritional composition (**Devatkal *et al*., 2012**). The quality deterioration is due to chemical and microbial changes. The most common form of chemical deterioration is the oxidation of meat lipids. Lipid oxidation is a complex process and depends on chemical composition ofmeat, light and oxygen access and storage temperature (**Kanner, 1994**). The lipid oxidation is one of the major problems in meat industries. Meat products that are constituted of lipid and polyunsaturated fatty acids (PUFAs) tend to deteriorate due to lipid oxidation, leading to development of unpleasant flavours during processing and storage (**Mielink *et al*., 2006**).
Lipid oxidation can be reduced or inhibited by the use of antioxidants in meat and meat products and thus the product quality and shelf-life
can be improved. Antioxidants can prevent lipid peroxidation using the following mechanisms: preventing chain inhibition by scavenging initiating radicals, breaking chain reaction, decomposing peroxides, decreasing localized oxygen concentrations and binding chain initiating catalysts, such as metal ions (**Dorman *et al*. 2003, Baydar *et al*., 2007**).
Thus, application of suitable agents possessing both antioxidant and antimicrobial activities may be useful for maintaining sausage quality, extending shelf-life and preventing economic loss (**Yin and Cheng, 2003**). Consequently, several synthetic antioxidants have been added to sausage to prevent undesirable reactions to enhance its shelf-life (**Georgantelis *et al*., 2007**). However, the increasing concern over the negative consequences from using synthetic antioxidants has emphasized the value of natural antioxidants. So, interest in natural antioxidants and search on naturally occurring compounds with antioxidant and antimicrobial activities has increased dramatically (**Lorenzo et al., 2013**).
Agro-industries generate numerous waste materials that should be reduced/ eliminated to achieve a sustainable agriculture. In this sense, the possibility of using these residues as natural antioxidants in the food industry could represent a significant step towards maintaining an environment balance. For instance in wine and grape juice production, where residues account for approximately 30% of grape (*Vitis vinifera*) (**Rockenbach et al., 2008**).
According to the estimates provided by the Organisation Internationale de la Vignet et du Vin (OIV), annual process of grapes is estimated at around 66.5 million tonnes, with 38 million tonnes produced in Europe. At European level, the grape pomace production is about 8 million tonnes per year in total **(Burg *et al*., 2014)**.
A significant part of the grape pomace is comprised by grape seed which amounts to 38-52% on dry matter basis (**Maier, 2009**).
Among the beneficial effects of parts of a grape, grape seeds are believed to have a powerful antioxidant property due to its rich source of polyphenol compounds. The polyphenol compounds in grape seeds are in range of 60-70 %, only 10 % is in the fruit, and 28 - 35 % in the peels (**Garcia-Marino *et al*., 2006; Nawaz *et al*., 2006**).
It is likely that the demand for using natural antioxidants such as grape seed extract (GSE) has greatly increased in recent years. GSEs are substantially constituted with proanthocyanidins. They can react with free radicals and catalyzed metal ions necessary for the oxidation reaction then terminate chain reactions by removing radical intermediates, and inhibit other oxidation reactions by being oxidized themselves (**Shahidi and Wanasundara, 1992**; **Sanchez-**

Moreno *et al*., 1999). The phenolic substances in GSE ranges from 80% to 99%, the most important being resveratrol (trans-3,4′,5-trihydroxystilbene). Due to the strong antioxidant activity of resveratrol, it can inhibit peroxidation in a concentration-dependent manner. It does not scavenge hydroxyl radical nor does it react with H_2O_2, making it an inefficient catalyst of subsequent oxidation (**Murcia and Martinez-Tome, 2001)**.
In addition, GSE is rich in proanthocyanidins. The multiple mechanisms of their antioxidative activity are expressed in its ability of radical scavenging, metal chelation, and synergism with other antioxidants **(Lu and Foo, 1999)**.
Scientific studies have shown that grape seed extract is a more potent scavenger of reactive oxygen species and that it has greater antioxidant power than vitamin C and vitamin E (**Shi *et al*., 2003**). Also, Grape seed extract improves lipid stability by reduced the thiobarbituric acid reactive substances (TBARS) in meat products (**Sasse *et al*., 2009; Kulkarni *et al*., 2011; Perumalla *et al*., 2013**).
Based on the findings of many researches (**Tekeli *et al*., 2014**; **Iqbal *et al*., 2015**; **Lichovnikova *et al*., 2015**; **Tournour *et al*., 2016**; **Guerra-Rivas *et al*., 2016**; **Brenes *et al*., 2016**), application of grape pomace has been shown to a positive effect on animal products, such as improving the carcass parameters in chickens, oxidation stability and storage of meat products, egg production (**Kara and Kocaoglu-Guclu, 2012**; **Kara *et al*., 2016**), and in raw-cooked meat products **(Özvural and Vural, 2011; Özvural and Vural, 2013; Ryu *et al*., 2014)**.
The present study aimed to determine the effect of GSE application on quality (oxidative stability, color and sensory quality) of raw-cooked meat products stored 10 days at 4 °C.

MATERIAL AND METHODS

The tested raw-cooked meat products were made from pork meat and additional raw materials purchased at a market and processed according to the recipe for the product type (Table 1). Four groups of meat products were evaluated. The groups were formed on the basis of various additions of GSE during the mixing in a bowl cutter, as follows:

- control group (C),
- experimental group 1 (E1): 10 ml of GSE Dunaj per 1 kg of meat mixture,
- experimental group 2 (E2): 10 ml of GSE Frankovka modra per 1 kg of meat mixture
- experimental group 3 (E3): 10 ml of GSE Cabernet Sauvignon per 1 kg of meat mixture

The GSE-treated meat product was smoked and heat-treated (temperature in a product core reached 70 °C and persisted for 10 min). After the heat-treatment, the product was cooled to 4 °C. Meat samples were stored at 4±1 °C during the experimental period (10 days).

Preparation of grape seed extract

Extraction of grape seeds was carried according to **Shirahigue et al. (2010)**. The homogenized grape seeds (20 g) were mixed with 100 ml of 80% ethanol in a laboratory shaker in the dark and at room temperature for 24 hours. Subsequently, the liquid phase was separated from the solid phase by filtration and added into volumetric flask. The 80% ethanol was then added until a total volume of 100 ml. After that, the liquid fraction was evaporated in the vacuum rotary evaporator at 65 °C. The dry residue was weighed and redissolved in 50 ml of distilled water. The extract was then applied into raw-cooked meat product in an amount of 10 ml per 1 kg of raw material.

Table 1 Composition of meat product (g).

Component	Amount
Pork meat	1000.0
Water	200.0
Curing salt	18.0
Garlic (*Allium sativum*)	0.5
Red pepper (*Capsicum annuum*)	2.0
Black pepper (*Pipper nigrum*)	3.0
Mace (*Myristica fragrans)*	1.0
Polyphosphate	7.0

Assessment of antioxidant activity (AOA) with DPPH radical

The DPPH (2,2-diphenyl-1-picrylhydrazyl) inhibition in GSE according to method of **Brand-Williams et al. (1995)**. The DPPH radical is used to quantify the ability of antioxidants to quench the DPPH radical. The dark purple colour of DPPH will be lost when it is reduced to its nonradical form stable organic nitrogen centred free radical with a dark purple colour which when reduced to its nonradical form by antioxidants becomes colourless. When the DPPH radical is scavenged, the colour of the reaction mixture changes from purple to yellow and decrease of the DPPH radical is measured spectrophotometrically. On the determination of AOA was used which in ethanol solution is in colourless radical form. Its reduction is manifested by the change of colour of solution and is measured spectrophotometrically. Gallate was used as standard and the amount of AOA sample expressed as gallate equivalent was calculated.

Determination of the oxidative stability

During four storage times (day 1, 4, 8, and 12), oxidative stability of meat product samples was determined according to **Marcinčák et al. (2010)**. The method is based on the rupture of lipid bilayer by free radical to form malondialdehyde (MDA) as a secondary product. Two molecules of thiobarbituric acid react with one molecule of MDA to form pink coloured product showing maximum absorbance at 532 nm called TBARS. The absorbance was measured using UV spectrophotometer (Jenway UV-VIS Spectrophotometer). The results were calculated as malondialdehyde (MDA) quantity per 1 g of sample.

Sensory evaluation

Sensory quality of raw-cooked meat products (n = 9) after cooking (80 °C, 5 min) was assessed by five-member panel on the 4th day after processing. Sensory characteristics of meat products including surface appearance and colour, appearance and colour in cross-section, texture, aroma, and taste on a five-point hedonic scale (5 = very good, 1 = very bad).

RESULTS AND DISCUSSION

Antioxidant activity assessment of applied grape seed extracts of different grape varieties is shown in Table 2. In Frankovka modrá grape varieties applied in E2 group was observed higher antioxidant activity (91.2%) than that in Dunaj (E1) and Cabernet Sauvignon (E3) grape variety (85.3, resp. 85.8 %). Similarly, **Bajčan et al. (2015)**, and **Špakovská et al. (2012)** found AA in the range of 69 – 90.9 % in red wine grape varieties. In addition, similar AA values (61.4 – 87.1%) found **El-Beshbishy et al. (2009)** in red grape seed extracts.

Table 2 Antioxidant activity (AA) of grape seed extracts of different grape varieties (%)(mean ±*S.D.*).

Grape variety	AA
Dunaj	85.3 ±0.7
Frankovka mudra	91.2 ±0.7
Cabernet Sauvignon	85.8 ±0.8

Table 3 Values of thiobarbituric number during the storage expressed as MDA ($mg.kg^{-1}$) (mean ±*S.D.*)

Storage time	Group C	E1	E2	E3
Day 1	0.103 ±0.003	0.092 ±0.005	0.102 ±0.002	0.093 ±0.002
Day 4	0.113 ±0.002	0.106 ±0.001	0.107 ±0.005	0.104 ±0.002
Day 7	0.121 ±0.002	0.116 ±0.001	0.117 ±0.005	0.113 ±0.006
Day 10	0.129 ±0.006	0.120 ±0.006	0.115 ±0.005	0.118 ±0.009

Note: MDA – malondialdehyde; C – control group; E1, E2, E3 – experimental groups.

Oxidation of meat lipids is a complex process and its dynamics depend on numerous factors including chemical composition of meat, light and oxygen access, and storage temperature. The manufacturing processes of meat products cause degradation of the muscle membrane system and have a strong impact on the oxidation of intracellular fat, primarily phospholipids (**Karakaya et al., 2011**). Thermal treatment makes oxidative processes faster, what significantly changes the value of thiobarbituric acid. The level of oxidative damage of lipids in the manufacture and storage of frankfurters is presented in Table 3.

Table 4 Sensory evaluation of raw-cooked meat products (mean ±*S.D.*)

Sensory characteristic	Group C	E1	E2	E3
Surface appearance and colour	4.65 ±0.47	4.75 ±0.28	5.00 ±0.00	4.70 ±0.35
Appearance and colour in cross-section	4.77 ±0.26	4.72 ±0.32	4.75 ±0.50	4.75 ±0.28
Texture	4.87 ±0.25	4.82 ±0.23	4.85 ±0.19	4.95 ±0.10
Aroma	4.82 ±0.23	4.57 ±0.29	4.82 ±0.17	4.77 ±0.33
Taste	4.25 ±0.50	4.45 ±0.49	4.42 ±0.50	4.60 ±0.39

Note: C – control group; E1, E2, E3 – experimental groups.

As regards determination of oxidative stability of raw-cooked meat products (stored at 4 °C) on day 1, the highest MDA content was found in control group (0.102 mg.kg^{-1}) compared to experimental groups E1 and E3 (0.092 and 0.093 mg.kg^{-1}, respectively). At the end of storage (day 10), we observed higher oxidation stability in all experimental groups with grape seed extract supplements and therefore a lower MDA value compared to the control group without the addition of extracts. In control group was recorded the highest production of MDA (0.129 mg.kg^{-1}). From experimental groups with the addition of different grape seed extracts, we recorded the highest degree of oxidative stability in the experimental group with the addition of Frankovka modrá extract (0.115 mg.kg^{-1}). The highest degree of oxidative damage from all experimental groups was found in group with the addition of Dunaj extract (0.120 mg.kg^{-1}). The MDA content in the experimental group with the addition of Cabernet Sauvignon grape extract at the end of the refrigeration storage period was 0.118 mg.kg^{-1}. Our results indicate a higher degree of oxidative stability after application of natural antioxidants and are consistent with the findings of **Mielnik et al. (2006), Özvural and Vural (2010), Özvural and Vural (2013)** and **Ryu et al. (2014)**, who also noted an increase in the oxidative stability of raw-cooked meat products after application of natural antioxidants.

The mean value of sensory characteristics of raw-cooked meat products (surface appearance and colour, appearance and colour in cross-section, texture, aroma, and taste) after addition of GSE are presented in Table 4. In the evaluation of the individual sensory quality indicators after grape seed extract we did not record statistically significant differences ($P > 0.05$) between individual groups, indicating that the sensory quality of raw-cooked meat products was not negatively affected by their addition. In the evaluation of the most important indicator of sensory quality (taste) we recorded better average ratings in all experimental groups with the addition of grape seed extract than in the control group. Similar results were found in study of **Brannan (2009)** who investigated grape seed in ground chicken, as well as **Kulkarni et al. (2011)** who investigated grape seed in beef sausages, with no significant effects on sensory quality.

CONCLUSION

Based on the results of the oxidative stability and sensory quality of the raw-cooked meat product after 10 days of refrigerated storage at 4 °C, we can recommend using natural antioxidants in the production of the meat product in the form of grape seed extract Dunaj, Frankovka modrá and Cabernet Sauvignon to increase oxidative stability thereby increasing the shelf life and sensory quality of the raw-cooked meat product.

Acknowledgments: This work was supported by grants VEGA No. 1/0591/18 and APVV-17-0508.

REFERENCES

BAJČAN, D., ŠIMANSKÝ, V., TÓTH, T., ÁRVAY, J. 2015. Colour, Phenolic content and antioxidant activity of the Slovak Alibernet red wine samples. *Journal of Microbiology, Biotechnology and Food Sciences*, 4(3), 5-8. https://doi.org/10.15414/jmbfs.2015.4.special3.5-8

BAYDAR, N. G., ÖZKAN, G, YASAR, S. 2007. Evaluation of the antiradical and antioxidant potential of grape extracts. *Food Control*, 18(9), 1131-1136. https://doi.org/10.1016/j.foodcont.2006.06.011

BRANNAN, R. G. 2009. Effect of grape seed extract on descriptive sensory analysis of ground chicken during refrigerated storage. *Meat Science*, 81(4), 589-595. https://doi.org/10.1016/j.meatsci.2008.10.014

BRAND-WILLIAMS, W., CUVELIER, M. E., BERSET, C. 1995. Use of a free radical method to evaluate antioxidant activity. *LWT - Food Science and Technology*, 28(1), 25-30. http://dx.doi.org/10.1016/S0023-6438(95)80008-5

BRENES, A., VIVEROS, A., CHAMORRO, S., ARIJA, I. 2016. Use of polyphenol-rich grape by-products in monogastric nutrition. A review. *Animal Feed Science and Technology*, 211, 1-17. https://doi.org/10.1016/j.anifeedsci.2015.09.016

BURG, P., DĚDINA, M., HEJTMANKOVA, A. HEJTMANKOVA, K., JELINEK, A., LACHMAN, J., LIPAVSKY, J., MAŠAN, V., PIVEC, V., SKALA, O., STŘALKOVA, R., TABORSKY, J., ZEMANEK, P. 2014. The study of biologically active compounds in grapevine seeds and annual shoots and possibilities obtaining oil from the seeds. Brno : Mendelova univerzita v Brně, 2014, 1st ed., 93 p. ISBN 978-80-7509-165-9.

DEVATKAL, S. K., THORAT, P., MANJUNATHA, M. 2012. Effect of vacuum packaging and pomegranate peel extract on quality aspects of round goat meat and nuggets. *Journal of Food Science and Technology*, 51(10), 2685-2691. http://dx.doi.org/10.1007/s13197-012-0753-5

DORMAN, H. J. D., PELTOKETO, A., HILTUNEN, R., TIKKANEN, M. J. 2003. Characterisation of the antioxidant properties of deodourised aqueous extracts from selected Lamiaceae herbs. *Food Chemistry*, 83, 255–262. https://doi.org/10.1016/s0308-8146(03)00088-8

GARCIA-MARINO, M., RIVAS-GONZALO, J. C., IBÁÑEZ, E., GARCIA-MORENO, C. 2006. Recovery of catechins and proanthocyanidins from winery by-products using subcritical water extraction. *Analytica Chimica Acta*, 563(1-2), 44-50. https://doi.org/10.1016/j.aca.2005.10.054

GEORGANTELIS, D., AMBROSIADIS, I., KATIKOU, P., BLEKAS, G., GEORGAKIS, S. A. 2007. Effect of rosemary extract, chitosan and α-tocopherol on microbiological parameters and lipid oxidation of fresh pork sausages stored at 4°C. *Meat Science*, 76(1), 172–181. https://doi.org/10.1016/j.meatsci.2006.10.026

GUERRA-RIVAS, C., VIEIRA, C., RUBIO, B., MARTÍNEZ, B., GALLARDO, B., MANTECÓN, A. R., LAVÍN, P., MANSO, T. 2016. Effects of grape pomace in growing lamb diets compared with vitamin E and grape seed extract on meat shelf life. *Meat Science*, 116, 221-229. https://doi.org/10.1016/j.meatsci.2016.02.022

EL-BESHBISHY, H. A., MOHAMADIN, A. M., ABDEL-NAIM, A. B. 2009. *In Vitro* Evaluation of the Antioxidant Activities of Grape Seed (*Vitis vinifera*) Extract, Blackseed (*Nigella sativa*) Extract and Curcumin. *Journal of Taibah University Medical Sciences*, 4(1), 23-35. https://doi.org/10.1016/s1658-3612(09)70090-3

IQBAL, Z., KAMRAN, Z., SULTAN, J. I., ALI, A., AHMAD, S., SHAHZAD, M. I., AHSAM, U., ASHRAF, S., SOHAIL, M. U. 2015. Replacement effect of vitamin E with grape polyphenols on antioxidant status, immune, and organs histopathological responses in broilers from 1- to 35-d age. *The Journal of Applied Poultry Research*, 24(2), 127-134. https://doi.org/10.3382/japr/pfv009

KANNER, J. 1994. Oxidative processes in meat and meat products: Quality implications. *Meat Science*, 36, 169–174. https://doi.org/10.1016/0309-1740(94)90040-X

KARA, K., KOCAOĞLU GÜÇLÜ, B., BAYTOK, E., ŞENTÜRK, M. 2015. Effects of grape pomace supplementation to laying hen diet on performance, egg quality, egg lipid peroxidation and some biochemical parameters. *Journal of Applied Animal Research*, 44(1), 303-310. https://doi.org/10.1080/09712119.2015.1031785

KARA, K., KOCAOGLU-GUCLU, B. 2012. The Effects of Different Molting Methods and Supplementation of Grape Pomace to the Diet of Molted Hens on Postmolt Performance, Egg Quality and Peroxidation of Egg Lipids. *Journal of Faculty of Veterinary Medicine, Erciyes University*, 9, 183-196.

KULKARNI, S., DESANTOS, F. A., KATTAMURI, S., ROSSI, S. J., BREWER, M. S. 2011. Effect of grape seed extract on oxidative, color and sensory stability of a pre-cooked, frozen, re-heated beef sausage model system. *Meat Science*, 88(1), 139-144. https://doi.org/10.1016/j.meatsci.2010.12.014

LICHOVNIKOVA, M., KALHOTKA, L., ADAM, V., KLEJDUS, B., ANDERLE, V. 2015. The effects of red grape pomace inclusion in grower diet on amino acid digestibility, intestinal microflora, and sera and liver antioxidant activity in broilers. *Turkish Journal of Veterinary and Animal Sciences*, 39, 406-412. https://doi.org/10.3906/vet-1403-64

LORENZO, J. M., GONZÁLEZ-RODRÍGUEZ, R. M., SÁNCHEZ, M., AMADO, I. R., FRANCO, D. 2013. Effects of natural (grape seed and chestnut extract) and synthetic antioxidants (buthylatedhydroxytoluene, BHT) on the physical, chemical, microbiological and sensory characteristics of dry cured sausage "chorizo." *Food Research International*, 54(1), 611–620. https://doi.org/10.1016/j.foodres.2013.07.064

LU, Y., FOO, Y. L. 1999. The polyphenol constituents of grape pomace. *Food Chemistry*, 65(1), 1-8. https://doi.org/10.1016/s0308-8146(98)00245-3

MAIER, T., SCHIEBER, A., KAMMERER, D. R., CARLE, R. 2009. Residues of grape (*Vitis vinifera* L.) seed oil production as valuable source of phenolic antioxidants. *Food Chemistry*, 112(3), 551-559. https://doi.org/10.1016/j.foodchem.2008.06.005

MARCINČÁK, S., POPELKA, P., ŠIMKOVÁ, J., MARCINČÁKOVÁ, D., MARTONOVÁ, M. 2010.Oxidative stability of chilled chicken meat after feeding of selected plants. *Potravinarstvo*, 4(3), 46-49. http://dx.doi.org/10.5219/

MIELINK, M. B, OLSEN, E., VOGT, G., ADELINE, D., SKREDE, G. 2006. Grape seed extract as antioxidant in cook, cold store turkey meat. *LWT - Food Science and Technology*, 39(3), 191-198. https://doi.org/10.1016/j.lwt.2005.02.003

MURCIA, M. A., MARTÍNEZ-TOME, M. 2001. Antioxidant activity of resveratrol compared with common food additives. *Journal of Food Protection*, 64(3), 379-384. https://doi.org/10.4315/0362-028x-64.3.379

NAWAZ, H., SHI, J., MITTAL, G. S., KAKUDA, Y. 2006. Extraction of polyphenols from grape seeds and concentration by ultrafiltration. *Separation and Purification Technology*, 48(2), 176-181. https://doi.org/10.1016/j.seppur.2005.07.006

ÖZVURAL, E. B., VURAL, H. 2011. Grape seed flour is a viable ingredient to improve the nutritional profile and reduce lipid oxidation of frankfurters. *Meat Science*, 88(1), 179-183. https://doi.org/10.1016/j.meatsci.2010.12.022

ÖZVURAL, E. B., VURAL, H. 2013. Which is the best grape seed additive for frankfurters: extract, oil or flour? *Journal of the Science of Food and Agriculture*, 94(4), 792-797. https://doi.org/10.1002/jsfa.6442

PERUMALLA, A. V. S., HETTIARACHCHY, N. S., OVER, K., RICKE, S. C., SLAVIK, M. F., GBUR, E., ACOSTA, S. 2012. Effect of partial replacement of potassium lactate and sodium diacetate by natural green tea and grape seed extracts and postpackaging thermal treatment on the growth ofListeria monocytogenesin hotdog model system. *International Journal of Food Science & Technology*, 48(5), 918–926. https://doi.org/10.1111/ijfs.12042

ROCKENBACH, I. I., SILVA, G. L. DA, RODRIGUES, E., KUSKOSKI, E. M., FETT, R. 2008. Influência do solvente no conteúdo total de polifenóis, antocianinas e atividade antioxidante de extratos de bagaço de uva (Vitis vinifera) variedades Tannat e Ancelota. *Ciência e Tecnologia de Alimentos*, 28, 238–244. https://doi.org/10.1590/s0101-20612008000500036.

RYU, K. S., SHIM, K. S., SHIN, D. 2014. Effect of Grape Pomace Powder Addition on TBARS and Color of Cooked Pork Sausages during Storage. *Korean Journal for Food Science of Animal Resources*, 34(2), 200-206. https://doi.org/10.5851/kosfa.2014.34.2.200

SANCHEZ-MORENO, C., LARRAURI, J. A., SAURA-CALIXTO, F. 1999. Free radical scavenging capacity and inhibition of lipid oxidation of lipid oxidation of wine, grape juices and related polyphenolic constituents. *Food Research International*, 32(6), 407-412. https://doi.org/10.1016/s0963-9969(99)00097-6

SASSE, A., COLINDRES, P., BREWER, M. S. 2009. Effect of Natural and Synthetic Antioxidants on the Oxidative Stability of Cooked, Frozen Pork Patties. *Journal of Food Science*, 74(1), S30–S35. https://doi.org/10.1111/j.1750-3841.2008.00979.x

SHAHIDI, F., WANASUNDARA, P. K. 1992. Phenolic antioxidants. *Critical Reviews in Food Science and Nutrition*, 32(1), 67-103. https://doi.org/10.1080/10408399209527581.

SHI, J., YU, J., POHORLY, J. E., KAKUDA, Y. 2003. Polyphenolics in Grape Seeds—Biochemistry and Functionality. Journal of Medicinal Food, 6(4), 291–299. https://doi.org/10.1089/109662003772519831

SHIRAHIGUE, L. D., PLATA-OVIEDO, M., DE ALENCAR, S. M., D'ARCE, M. A. B. R., DE SOUZA VIEIRA, T. M. F., OLDONI, T. L. C., CONTRERAS-CASTILLO, C. J. 2010. Wine industry residue as antioxidant in cooked chicken meat. *International Journal of Food Science and Technology*, 45(5), 863-870. https://doi.org/10.1111/j.1365-2621.2010.02201.x

ŠPAKOVSKÁ, E., MARCINČÁK, S., BAČA, M., TUREK, P. 2012. Polyphenolic content and antioxidative activity of wines from Sobrance region. *Potravinarstvo*, 6(3), 32-35. https://doi.org/10.5219/204

TEKELI, A., RUSTU KUTLU, H., CELIK, L. 2014. Dietary Inclusion of Grape Seed Oil in Functional Broiler Meat Production. *Bulgarian Journal of Agricultural Science*, vol. 20, no. 4, p. 924-932.

Tournour, H. H., Segundo, M. A., Magalhães, L. M., Costa, A. S. G., Cunha, L. M. 2016. Effect of Touriga nacional Grape Extract on Characteristics of Mechanically Deboned Chicken Meat Kept under Frozen Storage. *Journal of Food Process Engineering*, 40(3), e12434. https://doi.org/10.1111/jfpe.12434

YIN, M., CHENG, W. 2003. Antioxidant and antimicrobial effects of four garlic-derived organosulfur compounds in ground beef. *Meat Science*, 63(1), 23–28. https://doi.org/10.1016/s0309-1740(02)00047-5