**Supplemental Table S1:** Details of meta-analysis.

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| --- | --- | --- | --- | --- |
| Author | Country | Year | Meat product | NPE source |
| Afshar et al.[1] | Iran | 2021 | Skinless and boneless chicken fillets | Nepeta pogonosperma |
| Al-Juhaimi et al. [2] | Saudi Arabia | 2020 | Beef burger | Acacia nilotica |
| Aksu & Turan [3] | Turkey | 2022 | Ground beef | Black carrots |
| Alexandre et al.[4] | Brazil | 2021 | Beef | Basil |
| Aslam et al.[5] | Pakistan | 2020 | Chicken Patties | Licorice |
| Aykln-Dinçer et al.[6] | Turkey | 2021 | Sausages | Beetroot |
| Bazhenova et al.[7] | Russia | 2020 | Meat paste | lingonberry |
| Cao et al.[8] | China | 2022 | Beef | Portulaca oleracea, Mignonette |
| Deepitha et al.[9] | India | 2021 | pangasius fillets | seaweed |
| Demir & Ağaoğlu[10] | Turkey | 2021 | Minced Meat | Artichoke |
| Fernández-López et al.[11] | Spain | 2020 | Bologna-Type Sausages | Black Quinoa |
| Fruet et al.[12] | USA | 2020 | Beef Patties | Quebracho Colorado Wood |
| Guo et al.[13] | China | 2021 | Beef | Watermelon |
| Gutiérrez-Pacheco et al.[14] | Mexico | 2021 | Pork sausages | Pomegranate |
| Hać-Szymańczuk et al.[15] | Poland | 2021 | Chicken meatballs | Rosemary |
| Hastaoğlu et al.[16] | Turkey | 2021 | Beef | Thyme, Rosemary, Red beet  |
| Hemmatkhah et al.[17] | Iran | 2020 | Beef Hamburger | Cumin |
| Jokanović et al.[18] | Serbia | 2020 | Precooked pork chops | Winter savory |
| Jonušaite et al.[19] | Lithuania | 2021 | Fish Burgers | Black elderberry |
| Jurčaga et al.[20] | Slovakia | 2021 | Frankfurter sausage | Blackcurrant,Kamchatka Honeysucklen |
| L. de O. Silva et al.[21] | Brazil | 2021 | Bluefish fillet | Pomegranates |
| Li et al. [22] | China | 2022 | Roast large yellow croaker | Blueberry, Acerola cherry, Grape  |
| Liang et al.[23] | China | 2022 | Beef patties | Sugarcane, Orange, Tomato |
| Macari et al.[24] | Moldova | 2021 | Sausages | Basil, Summer savory, Tarragon |
| Menegali et al.[25] | Brazil | 2020 | Chicken burger | Pink pepper |
| Montaño-Sánchez et al.[26] | Mexico | 2020 | Pork Chops | Green Tea |
| Nitteranon & Sayompark[27] | Thailand | 2021 | Cooked pork patties | Dimocarpus longan var. obtusus  |
| Nor Mazila Ramli et al.[28] | Malaysia | 2021 | Beef | pineapple,Jackfruit |
| P.Aliyari et al.[29] | Iran | 2020 | Beef sausage | Pomegranate , Pistachio |
| Rico et al.[30] | Spain | 2020 | Fish Burgers | Sea Fennel |
| Romero et al.[31] | Argentina | 2020 | Beef patties | Eugenia uniflora L. ,  Opuntia ficus-indica |
| Rubab et al.[32] | Korea | 2020 | Beef | Red Cabbage |
| Rubel et al.[33] | Bangladesh | 2020 | Mutton meatball | Olive  |
| Saleh et al.[34] | Egypt | 2020 | Chicken breast | Olive |
| Sharma et al.[35] | Thailand | 2020 | Raw chicken sausages | Moringa oleifera seed |
| Shukla et al.[36]  | India | 2020 | chicken patties | Syzygium aromaticum |
| Smit et al.[37] | Italy | 2020 | Italian salami | Honeybush |
| Šojić et al.[38] | Serbia | 2020 | Ground pork patties | Wild thyme |
| Stelmasiak et al.[39] | Poland | 2021 | smoked pork | Oregano, basil |
| Tamkutė et al.[40] | Lithuania | 2021 | Pork Burger and cooked ham | Chokeberries |
| Tomović et al.[41] | Serbia | 2020 | Dry Fermented Sausages | Juniperus communis L. |
| Tuffi et al.[42] | Brazil | 2021 | Beef meatballs | Grape |
| Villasante et al.[43] | Spain | 2020 | Beef Patties | Pecan Shell, Roselle Flower,Red Pepper |
| Wang et al.[44] | China | 2021 | Rabbit meat patties | purslane |
| Yerlikaya & Şen Arslan[45] | Turkey | 2021 | Chicken sausages | Sage, Lavender |
| Zhang et al.[46] | China | 2020 | Pork patties | Cauliflower |
| Zhou et al.[47] | China | 2021 | Western-style smoked sausage | Rosemary, Ginger |
| Zwolan et al.[48] | Poland | 2021 | chicken meatballs | Scutellaria baicalensis Georgi |

**References**

1. Afshar M, Fatemeh, Akram S, and Maryam A. 2021. Effect of Chitosan Coating Containing Nepeta Pogonosperma Extract on Shelf Life of Chicken Fillets during Chilled Storage. *Food Science & Nutrition* 9 (8):4517–4528. doi:10.1002/FSN3.2429.
2. Al-Juhaimi, Fahad Y, Ibrahim A, Isam A, Kashif G, and Elfadil E. 2020. Potential of Acacia Nilotica Fruit Flesh Extract as an Anti-Oxidative and Anti-Microbial Agent in Beef Burger. *Journal of Food Processing and Preservation* 44 (7):e14504. doi:10.1111/JFPP.14504.
3. Aksu, Muhammet I, and Emre T. 2022. Properties of Black Carrot Extract and Its Efficacy for Improving the Storage Quality of Vacuum Packaged Fresh Meat Products. *Packaging Technology and Science* 35 (4):339–349. doi:10.1002/PTS.2631.
4. Alexandre S, Ana C, Camila M, Rodolpho M, Mariana G, Tatiane R, Ana G, Eduardo J, and Ivanor N. 2021. Use of Alginate Edible Coating and Basil (Ocimum Spp) Extracts on Beef Characteristics during Storage. *Journal of Food Science and Technology* 58 (10):3835–3843. doi:10.1007/S13197-020-04844-1/FIGURES/1.
5. Aslam M, Muhammad S, Khan A, Ali S, Amjad A, and Ahmed S. 2020. Lipids Oxidative Stability and Microbial Shelf Life Quality of Licorice (Glycyrrhiza Glabra L.) Extract Supplemented Chicken Patties. *Brazilian Journal of Poultry Science* 22 (3):1–10. doi:10.1590/1806-9061-2020-1316.
6. Aykln-Dinçer E, Keziban K, Emine C, and Mustafa E. 2021. The Use of Beetroot Extract and Extract Powder in Sausages as Natural Food Colorant. *International Journal of Food Engineering* 17 (1):75–82. doi:10.1515/IJFE-2019-0052/MACHINEREADABLECITATION/RIS.
7. Bazhenova B, Sesegma D, Yuliya Y, Alexander V, and Natalya D. 2020. Effects of Lingonberry Extract on the Antioxidant Capacity of Meat Paste. *Foods* and Raw Materials 8 (2):250–258. doi:10.21603/2308-4057-2020-2-250-258.
8. Cao Y, Rui H, Zonglin G, Ling H, Qunli Y, and Wei Z. 2022. Combined Effects of Superchilling and Natural Extracts on Beef Preservation Quality. *LWT* 153 (1):112520. doi:10.1016/J.LWT.2021.112520.
9. Deepitha R, Martin X, Porayil L, Binaya B, and Amjad Khansaheb B. 2021. Quality Improvement of Pangasius Fillets Using Aqueous Seaweed (Padina Tetrastromatica) Extract. *LWT* 137 (2):110418. doi:10.1016/J.*LWT*.2020.110418.
10. Demir T, and Sema A. 2021. Antioxidant, Antimicrobial and Metmyoglobin Reducing Activity of Artichoke (Cynara Scolymus) Powder Extract-Added Minced Meat during Frozen Storage. *Molecules* 26 (18):5494. doi:10.3390/MOLECULES26185494.
11. Fernández-López J, Raquel L, Alba R, Manuel V, Estrella S, Jaime B, Claudia M, and José A. 2020. Effects of Black Quinoa Wet-Milling Coproducts on the Quality Properties of Bologna-Type Sausages During Cold Storage. *Foods* 9 (3):274. doi:10.3390/FOODS9030274.
12. Fruet A, Francine M, Mozart A, José L, and Amilton S. 2020. Effects of the Incorporation of Tannin Extract from Quebracho Colorado Wood on Color Parameters, Lipid Oxidation, and Sensory Attributes of Beef Patties. *Foods* 9 (5):667. doi:10.3390/FOODS9050667.
13. Guo Z, Xiangzhen G, Weizheng L, Lihua Y, Ling H, and Qun l. 2021. Active-Intelligent Film Based on Pectin from Watermelon Peel Containing Beetroot Extract to Monitor the Freshness of Packaged Chilled Beef. *Food Hydrocolloids* 119 (10):106751. doi:10.1016/J.FOODHYD.2021.106751.
14. Gutiérrez-Pacheco S, Juan P, Germán C, Humberto G, Fernando A, José B, and Martín V. 2021. Effects of Pomegranate Juice and Pomegranate Peel Powders on Quality Properties and Antioxidant Activity of Pork Sausage. *Journal of Food Processing and Preservation* 45 (9):e15755. doi:10.1111/JFPP.15755.
15. Hać-Szymańczuk E, Aneta C, Marta C, Kamil P, and Katarzyna T. 2021. Addition of Different Rosemary Preparations (Rosmarinus Officinalis L.) to Chicken Meatballs Improves Their Quality Profile. *International Journal of Food Science and Technology* 56 (12):6236–6245. doi:10.1111/IJFS.15310.
16. Hastaoğlu E, Halil V, and Özlem P. 2021. Effects of Thymol and Rosemary Essential Oils and Red Beet Extract on Low-Nitrite and Carmine-Free Beef Mortadella. *Journal of Food Processing and Preservation* 45 (10):e15855. doi:10.1111/jfpp.15855.
17. Hemmatkhah F, Fariba Z, and Hadi A. 2020. Encapsulated Cumin Seed Essential Oil-Loaded Active Papers: Characterization and Evaluation of the Effect on Quality Attributes of Beef Hamburger. *Food and Bioprocess Technology* 13 (3):533–547. doi:10.1007/S11947-020-02418-9/FIGURES/6.
18. Jokanović M, Maja I, Snežana Š, Vladimir T, Branimir P, Branislav Š, Zoran Z, Tatjana P, and Predrag I. 2020. Essential Oil and Supercritical Extracts of Winter Savory (Satureja Montana L.) as Antioxidants in Precooked Pork Chops during Chilled Storage. *LWT* 134 (12):110260. doi:10.1016/J.LWT.2020.110260.
19. Jonušaite K, Petras R, Gines B, Amaury T, Gema N, Antonio L, and Fulgencio M. 2021. Antioxidant and Antimicrobial Effect of Plant Essential Oils and Sambucus Nigra Extract in Salmon Burgers. *Foods* 10 (4):776. doi:10.3390/FOODS10040776.
20. Jurčaga L, Marek B, Adriana K, Alica B, Alžbeta D, Peter H, L’Ubomír B, Andrea M, Ondřej B, Miroslav K, et al. 2021. Blackcurrant (Ribes Nigrum L.) and Kamchatka Honeysuckle (Lonicera Caerulea Var. Kamtschatica) Extract Effects on Technological Properties, Sensory Quality, and Lipid Oxidation of Raw-Cooked Meat Product (Frankfurters). *Foods*10 (12):2957. doi:10.3390/FOODS10122957.
21. Silva L, Rafael G, Maria L, Carlos A, and Alexandre G. 2021. Pomegranate (Punica Granatum) Peel Fractions Obtained by Supercritical CO2 Increase Oxidative and Colour Stability of Bluefish (Pomatomus Saltatrix) Patties Treated by UV-C Irradiation. *Food Chemistry* 362 (11):130159. doi:10.1016/J.FOODCHEM.2021.130159.
22. Li M, Songyi L, Ruichun W, Duo G, Zhijie B, Dong C, Yue T, Na S, and Simin Z. 2022. Inhibitory Effect and Mechanism of Various Fruit Extracts on the Formation of Heterocyclic Aromatic Amines and Flavor Changes in Roast Large Yellow Croaker (Pseudosciaena Crocea). *Food Control* 131 (1):108410. doi:10.1016/J.FOODCONT.2021.108410.
23. Liang Z, Vivi V, Jiehe H, Pangzhen Z, and Zhongxiang F. 2022. Combined Effects of Plant Food Processing By-Products and High Oxygen Modified Atmosphere Packaging on the Storage Stability of Beef Patties. *Food Control* 133 (3):108586. doi:10.1016/J.FOODCONT.2021.108586.
24. Macari A, Rodica S, Ildiko L, Maria L, Ocsana O, Greta B, Aliona G, Dan C, and Daniela C. 2021. Antimicrobial Effects of Basil, Summer Savory and Tarragon Lyophilized Extracts in Cold Storage Sausages. *Molecules* 26 (21):6678. doi:10.3390/MOLECULES26216678.
25. Menegali B, Miriam M, Erick S, Iliani P, Julia P, Priscilla S, Natan D, and Carmen J. 2020. Pink Pepper Extract as a Natural Antioxidant in Chicken Burger: Effects on Oxidative Stability and Dynamic Sensory Profile Using Temporal Dominance of Sensations. *LWT* 121 (3):108986. doi:10.1016/J.LWT.2019.108986.
26. Montaño-Sánchez E, Brisa D, Rey D, Nelson H, Armida S, María J, and Gastón R. 2020. Effects of Chitosan Coating with Green Tea Aqueous Extract on Lipid Oxidation and Microbial Growth in Pork Chops during Chilled Storage. *Foods* 9 (6):766. doi:10.3390/FOODS9060766.
27. Nitteranon V, and Sayompark D. 2021. Effect of Dimocarpus Longan Var. Obtusus Seed Aqueous Extract on Lipid Oxidation and Microbiological Properties of Cooked Pork Patties during Refrigerated Storage. *International Food Research Journal* 28(5). doi:10.47836/ifrj.28.5.11.
28. Nor M, Aizi, Hazrulrizawati A, Farah H, Normaiza Z, Prakash B, Nor H, Universiti T, Malaysia C, Malaysia P, and Lebuhraya T. 2021. Physicochemical Properties and Tenderness Analysis of Bovine Meat Using Proteolytic Enzymes Extracted from Pineapple (Ananas Comosus) and Jackfruit (Artocarpus Heterophyllus) by-Products. *Journal of Food Processing and Preservation* 45 (11):e15939. doi:10.1111/JFPP.15939.
29. Aliyari P, Bakhshi K, Barzegar M, and Ahmadi G. 2020. Production of Functional Sausage Using Pomegranate Peel and Pistachio Green Hull Extracts as Natural Preservatives. *Journal of Agricultural Science and Technology* 2020, 22(1): 159-172.
30. Rico D, Irene A, Oscar M, Elvira L, and Ana B. 2020. Use of Sea Fennel as a Natural Ingredient of Edible Films for Extending the Shelf Life of Fresh Fish Burgers. *Molecules* 25 (22):5260. doi:10.3390/MOLECULES25225260.
31. Romero M, Ricardo A, Carina L, Mirtha M, Ana M, and María A. 2021. Effects of Freeze-Dried Pulp of Eugenia Uniflora L. and Opuntia Ficus- Indica Fruits on Quality Attributes of Beef Patties Enriched with n-3 Fatty Acids. *Journal of Food Science and Technology* 58 (5):1918–1926. doi:10.1007/S13197-020-04703-Z.
32. Rubab M, Ramachandran C, Kandasamy S, Kaliyan B, Shuai W, Jong R, Daesang Y, Myeong H, and Deog H. 2020. Bioactive Potential of 2-Methoxy-4-Vinylphenol and Benzofuran from Brassica Oleracea L. Var. Capitate f, Rubra (Red Cabbage) on Oxidative and Microbiological Stability of Beef Meat. *Foods* 9 (5):568. doi:10.3390/FOODS9050568.
33. Rubel S, Yu Z, Murshed H, Ariful I, Dalia S, Rahman S, and Jun W. 2021. Addition of Olive (Olea Europaea) Leaf Extract as a Source of Natural Antioxidant in Mutton Meatball Stored at Refrigeration Temperature. *Journal of Food Science and Technology* 58 (10):4002–4010. doi:10.1007/S13197-020-04863-Y/TABLES/3.
34. Saleh E, Alaa E, Eman E, Sarah A, Helal F, Philippe J, Ramadan Y, Gaber E, and Eman A. 2020. Effects of Olive Leaf Extracts as Natural Preservative on Retailed Poultry Meat Quality. *Foods* 9 (8):1017. doi:10.3390/FOODS9081017.
35. Sharma P, Jetsada W, and Wannaporn K. 2020. Antimicrobial and Antioxidant Activities of Defatted Moringa Oleifera Seed Meal Extract Obtained by Ultrasound-Assisted Extraction and Application as a Natural Antimicrobial Coating for Raw Chicken Sausages. *International Journal of Food Microbiology* 332 (11):108770. doi:10.1016/J.IJFOODMICRO.2020.108770.
36. Shukla V, Sanjod K, Ravindra J, Ravi K, and Rohit K. 2020. Effects of Chitosan Coating Enriched with Syzygium Aromaticum Essential Oil on Quality and Shelf-Life of Chicken Patties. *Journal of Food Processing and Preservation* 44 (11):e14870. doi:10.1111/JFPP.14870.
37. Smit P, Marco C, Antonella D, Stefania B, Louwrens C, and Enrico N. 2020. Effects of Honeybush (Cyclopia Subternata) Extract on Physico-Chemical, Oxidative and Sensory Traits of Typical Italian Salami. *Food Science & Nutrition* 8 (5):2299–2306. doi:10.1002/FSN3.1509.
38. Šojić B, Vladimir T, Sunčica K, Danijela B, Predrag P, Živan M, Saša Đ, Marija J, Maja I, Snežana Š, et al. 2020. Supercritical Extracts of Wild Thyme (Thymus Serpyllum L.) by-Product as Natural Antioxidants in Ground Pork Patties. *LWT* 130 (8):109661. doi:10.1016/J.LWT.2020.109661.
39. Stelmasiak A, Damaziak K, and Wierzbicka A. 2021. The Impact of Low Salt Level and Addition of Selected Herb Extracts on the Quality of Smoked Pork. *Animal Science Papers and Reports* 39:47-60.
40. Tamkutė L, Rūta V, Beatriz M, Isabel J, Jordi R, and Petras R. 2021. Effects of Chokeberry Extract Isolated with Pressurized Ethanol from Defatted Pomace on Oxidative Stability, Quality and Sensory Characteristics of Pork Meat Products. *LWT* 150 (10):111943. doi:10.1016/J.LWT.2021.111943.
41. Tomović V, Branislav Š, Jovo S, Sunčica K, Branimir P, Marija J, Vesna D, Nenad P, Aleksandra M, and Dragan V. 2020. New Formulation towards Healthier Meat Products: Juniperus Communis L. Essential Oil as Alternative for Sodium Nitrite in Dry Fermented Sausages. *Foods* 9 (8):1066. doi:10.3390/FOODS9081066.
42. Tuffi L, Daniel A, Jéssica C, Paulo C, and Carlos E. 2021. Grape Residue Flour as an Antioxidant and Fiber Source in Beef Meatballs. *British Food Journal* 123 (8):2831–2843. doi:10.1108/BFJ-12-2020-1152/FULL/PDF.
43. Villasante J, Manel O, Ares B, Isidoro M, and María P. 2020. The Effects of Pecan Shell, Roselle Flower and Red Pepper on the Quality of Beef Patties during Chilled Storage. *Foods* 9 (11):1692. doi:10.3390/FOODS9111692.
44. Wang Z, Zhifei H, Dong Z, Xiaosi C, and Hongjun L. 2021. Effects of Purslane Extract on the Quality Indices of Rabbit Meat Patties under Chilled Storage. *Journal of Food Processing and Preservation* 45 (9): e15644. doi:10.1111/JFPP.15644.
45. Yerlikaya S, and Hülya Ş. 2021. Antioxidant and Chemical Effects of Propolis, Sage (Salvia Officinalis L.), and Lavender (Lavandula Angustifolia Mill) Ethanolic Extracts on Chicken Sausages. *Journal of Food Processing and Preservation* 45 (6):e15551. doi:10.1111/JFPP.15551.
46. Zhang H, Ying L, Xinling L, and Huaibin K. 2020. Antioxidant Extract from Cauliflower Leaves Effectively Improve the Stability of Pork Patties during Refrigerated Storage. *Journal of Food Processing and Preservation* 44 (7):e14510. doi:10.1111/JFPP.14510.
47. Zhou Y, Zonghao L, Yan C, Hui F, and Shujie W. 2021. Effects of Rosemary and Ginger on the Storage Quality of Western-Style Smoked Sausage. *Journal of Food Processing and Preservation* 45 (7): 15634. doi:10.1111/JFPP.15634.
48. Zwolan A., Pietrzak D., Adamczak L., Chmiel M., Florowski T., Kalisz S., Hać-Szyma E., Bryś J., Oszmiański, J. 2022. Characteristics of water and ethanolic extracts of Scutellaria baicalensis root and their effect on color, lipid oxidation, and microbiological quality of chicken meatballs during refrigerated storage. *Journal of Food Processing and Preservation*, 46(1), e16192.doi:10.1111/jfpp.16192