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Quality changes of Vacuum Packed meat and meat products: A review

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Abstract

Vacuum packaging is recent innovations that have been gaining importance as preservation techniques to improve the shelf life of meat and poultry. In Vacuum Packaging, air is completely removed however, color is regained when meat is removed from Vacuum packets and exposed to air. Microbial profiles of Vacuum Packaging of meat do not differ significantly. Vacuum packaging offers several unique advantages for retaining the desirable market quality of meat and meat products. The safety of vacuum meat is still a concern under temperature abuse conditions but it can be improved by coupling with hurdle technology and proper preservation systems. Vacuum packaging is a significant area of advancement to further improve the safety of meat and poultry products. This contribution critically reviews the existing knowledge on Vacuum Packaging of meat and poultry in order to broaden our understanding of the subject and to suggest further areas of research to effectively use these technologies for marketing safe meat and poultry products.

Key words: meat and meat products, vacuum packaging, microbial and sensory quality

I. Introduction

Vacuum packaging is accomplished by evacuating all the air within a package and not replacing with another gas, then sealing that package (Davies, A. R. , 1995, Brody, A. L. 1989). In the process of vacuum packaging, a pressure differential exists between the package exterior and interior. This differential can cause package collapse of rigid packages, but is well suited for some types of flexible packaging. The gaseous atmosphere is likely to change during storage due to respiration of the fresh food product (meat or plant) or the metabolism of microorganisms. (Davies, A. R. , 1995) Consequently, vacuum packaging can be considered a variation of controlled atmosphere The absence of oxygen for vacuum-packaged foods may permit conditions suitable for the growth and toxin production by anaerobic pathogens such as Clostridium botulinum .Additionally, the suppression of aerobic spoilage organisms may create conditions favorable for the growth of pathogenic aerobic bacteria such as Listeria monocytogenes, Yersinia enterocolitica, Aeromonas hydrophila, and enterotoxigenic Escherichia coli. (Brody, A. L. 1989). However, the presence of carbon dioxide in vacuum-packaged products inhibits the growth of Gram-negative spoilage organisms such as Pseudomonas spp., some molds and yeasts; lactic acid spoilage bacteria are less affected by elevated levels of carbon dioxide. Based on this information, vacuum packaging may selectively favor the growth of obligate and facultative anaerobic pathogens on many fresh foods. And modified atmosphere packaging in that the removal of air is an atmospheric modification. D. Narasimha Rao and N. M. Sachindra, (2002) described the Modified atmosphere and Vacuum packaging of meat and poultry products. Extension of the shelf-life of meat and poultry products is one of the technology needs to meet the demands of consumers. In this respect, increasing attention is put on packaging techniques.

Quality changes in vacuum packed meat and meat products during storage

Debashis Bhattacharyya, *et al*., (2013) estimated the optimum storage condition throughout the retail chain of duck sausage. PET/Poly and laminate of metalized PET/Poly with polyethylene pouches under aerobic and vacuum packaging stored in refrigerator (4±1° C) and freezer (-18±1° C) condition were considered in the experiment. TBA value, pH, Tyrosine value, TPC, TPSC and YMC of the samples increased with the storage period whereas a decreasing trend in case of moisture and all the sensory parameters throughout the storage period was observed. Irrespective of the packaging material, duck sausages were acceptable upto 30th and 50th day of refrigerated storage and 4th and 6th month of freezer storage in aerobic and vacuum packaging respectively. Freezer temperature enhanced the product quality upto 3rd and 5th month against 20th and 40th day of refrigerated storage in aerobic and vacuum packaging respectively. V. J. Moore and C. O. Gill (1987) observed that Muscle tissue pH of lamb packaged either under vacuum or in a CO_2 atmosphere rose during prolonged storage at chiller temperatures. Hedonic assessments of meat colour at pack opening did not change significantly during prolonged storage, but the colour stability of displayed meat declined with prolonged storage in a manner that suggests a possible relationship with the observed pH increase.

Naveena, B.M., *et al.*, (2015) studied the effect of aging on the physicochemical, textural, microbial and proteome characteristics of emu (*Dromaius novaehollandiae*) meat under aerobic packaging (AP) and vacuum packaging (VP) conditions at $4 \pm 1C$ for 9 and 15 days, respectively. Improvement ($P < 0.05$) in water-holding capacity, myofibrillar fragmentation index and protein extractability with aging was observed in emu meat cubes under both AP and VP conditions. Reduction ($P < 0.05$) in Warner-Bratzler shear force values was observed on the 6th and 15th day of aging compared with the 0th day in the AP and VP samples, respectively. The sodium dodecyl sulfate–polyacrylamide gel electrophoresis analysis revealed the appearance of 30-kDa protein bands, indicating extensive proteolysis on the 6th day and 9th day of aging in the AP and VP samples, respectively. Proteome analysis using two-dimensional gel electrophoresis revealed significant ($P < 0.01$) changes in the number of differentially expressed protein spots in the AP and VP samples during aging.

Davies *et al.*, (1989) described vacuum packaging, in which a pressure differential exists between the package exterior and interior. This differential can cause package collapse of rigid packages, but is well suited for some types of flexible packaging. The gaseous atmosphere is likely to change during storage due to respiration of the fresh food product (meat or plant) or the metabolism of microorganisms. A stable, tender, cured, dried beef product was developed using a pressure cooking and accelerated drying technique. The effects of nitrate, packaging methods and storage time on the sensory properties, residual nitrite, TBA values and microbiological counts were determined. Residual nitrite was significantly reduced in non-vacuum compared to vacuum packaged samples and was reduced by storage time but was not influenced by the addition of nitrate. TBA values were not affected by nitrate of vacuum packaging, but increased significantly with storage time. Flavor scores were slightly less desirable in vacuum packaged product and decreased with storage time. The dried beef was acceptable even at the sixth-week storage period. Total aerobic plate counts were very low and no anaerobic bacteria was detected in any of the dried beef samples. A product produced by this technique without nitrate handled in this manner of post cooking and vacuum packaged would appear to be useful in a high ambient temperature for at least up to 6 weeks.

Naveena, B.M., *et al.*, (2014) described the effect of different cooking methods viz, moist cooking (nuggets), dry cooking (patties) and deep-fat frying (croquettes) on lipid oxidation and microbial quality of few emulsion-based meat products from chicken under vacuum packaging conditions during refrigerated storage. When different cooking methods were studied, croquettes were the most affected ($P < 0.05$) by lipid oxidation as indicated by thiobarbituric acid reactive substances, peroxide value and free fatty acids compared with nuggets or patties. Croquettes had lower ($P < 0.05$) water activity than nuggets and patties. Total plate counts and psychrotrophic counts remained lower

($P < 0.05$) throughout the storage for croquettes compared with nuggets or patties. Based on lipid oxidation and microbial quality, it was concluded that moist-cooked nuggets, dry-cooked patties and deep-fat fried croquettes were stable for 40, 60 and 80 days at refrigerated storage under vacuum packaging. Ismail Yüksel Genç ,et al.,(2013) studied to experimentally assess several quality indices of meagre Argyrosomus regius (Asso, 1801) fillets packed in air (AP) and vacuum (VP) stored chilled (+4 C) for up to 13 days. Considering our experimental data on concentration of bacterial counts, shelf-life is estimated at ca. 6 days for AP fillets and an additional 3–5 days for VP meagre fillets. Total volatile basic nitrogen (TVB-N) and trimethylamine (TMA-N) did not reach the regulated limits (25–35 mg/100 g chilled fish). The models implemented in the software Seafood Spoilage and Safety Predictor predicted a relatively shorter shelf-life of 4.8–6.9 days for fish stored in air at +4 C when compared to AP and VP fillets. Empirical data and the models implemented in the software were used to predict the shelf-life of fillets if packaged under different modified atmospheres (MAP). Chilled, MAP fillets are likely to have a longer shelf-life than AP or VP samples if equilibrium CO_2 concentration is substantially high.

Changes in microbiological characteristics of vacuum packed meat products

Pavankumar, *et al*. (2003) investigated the effects of vacuum packaging on the microbiological quality of tandoori chicken stored at 4 ±1ºC or -18ºC. Chicken stored without vacuum packaging served as a control. Microbiological quality of tandoori chicken under vacuum was unacceptable after 15 days storage at 4 ±1ºC, compared to 6 days storage without vacuum packaging. Aerobic plate counts (APC) increased from an initial level (log cfu/g) of 3.67 to 6.75 by the 15th day in vacuum packaging and to 6.18 in control packs by the 6th day of storage at 4± 1ºC. Psychrotroph counts (log cfu) also increased markedly from an initial level of 0.05 to 6.18 in control packs by the 6th day and 5.69 in vacuum packaging by the 15th day. APC (log cfu/g) of the tandoori chicken increased marginally in vacuum packs during the storage period of 40 days at -18C to reach a level of 4.75 from an initial count of 4.44. Results indicated that the shelf-life of tandoori chicken was extended considerably at lower temperature under vacuum.

Richard James Meldruma, *et al*., (2014) reported the variation in the microbiological quality of commercially produced vacuum-packed cooked sliced meat between production and the end of shelf-life. In their study, the microbiological quality of cooked, sliced vacuum-packed meat was undertaken. Three hundred and eighty-one samples were taken (127 sets of three samples) from 55 commercial premises that produced packets of sliced, cooked, vacuum-packed meat for retail sale. The set of three samples consisted of one from the unsliced, cooked meat, one from the sliced product immediately after slicing, and one sliced packet for end of shelf-life testing. Samples were examined for aerobic colony count (ACC), Enterobacteriaceae, Escherichia coli, Listeria, and Salmonella. When compared to current UK guidelines for the quality of ready to eat food, samples were found to be unsatisfactory for ACC, Enterobacteriaceae, and E. coli. Unsatisfactory rates increased at the end of shelf-life compared to the unsliced meat sample results. No samples were positive for Listeria monocytogenes or Salmonella. This data is important for producers setting the shelf-life of their products. Debashis Bhattacharyya, et al., (2013) estimated the optimum storage condition throughout the retail chain of duck sausage. PET/Poly and laminate of metalized PET/Poly with polyethylene pouches under aerobic and vacuum packaging stored in refrigerator (4±1° C) and freezer (-18±1° C) condition were considered in the experiment. They found that TPC, TPSC and YMC of the samples increased with the storage period.

M.L. Anderson, *et al*., (1989) reported 29 packages of precooked, vacuum-packaged beef and pork products purchased at local and regional supermarkets along with 110 packages of precooked, vacuum-packaged, sliced roast beef obtained from a major meat processor did not disclose the presence of Escherichia coli, coagulase-positive Staphylococcus aureus, Clostridium perfringens or Salmonella. The effects of storage temperature and length of storage on the microflora of 110 packages of sliced roast beef were determined at specific intervals of storage up to 84 days at 1° and 5°C, and up to 28 days at 10°C. The microflora of samples stored at 1° and 5°C was dominated by Lactobacillus spp. when examined on day 28 and throughout the remainder of the 84-day test period. The microflora of samples held at 10°C was dominated by Lactobacillus spp. until late in storage when Hafnia alvei became a major portion of the bacterial population. Precooked, sliced roast beef had a longer shelf life in laboratory controlled evaluations when stored at 1°C as opposed to 5° or 10°C. J. T. Patterson,et al., (1984) reported that, Vacuum packaging and gas packaging (CO_2:N_2; 1:9 or 2:8) gave useful extensions to the shelf-lives of both breast and leg and thigh portions of chicken. Extension of shelf-life was more marked at 1 °C than at 4 to 5 °C and with breast portions rather than leg and thigh portions. Psychrotrophic Enterobacteriaceae were more likely to be a problem at the higher storage temperature on breast portions and Alteromonas putrefaciens on leg and thigh portions. Lactic acid and potassium sorbate pre-treatments were of value in controlling multiplication of Alt. putrefaciens on leg and thigh portions.

Naveena, B.M., *et al.*, (2014) studied the microbial quality of few emulsion-based meat products from chicken under vacuum packaging conditions during refrigerated storage. They found that Total plate counts and psychrotrophic counts remained lower ($P < 0.05$) throughout the storage for croquettes compared with nuggets or patties. Based on lipid oxidation and microbial quality, it was concluded that moist-cooked nuggets, dry-cooked patties and deep-fat fried croquettes were stable for 40, 60 and 80 days at refrigerated storage under vacuum packaging. Naveena, B.M., et al., (2015) found that effect of aging on the microbial characteristics of emu (*Dromaius novaehollandiae*) meat under aerobic packaging (AP) and vacuum packaging (VP) conditions at 4 ± 1C for 9 and 15 days, respectively.

V. Rajkumar *et al*., (2004) found that Patties prepared from goat's meat packed in HDPE under vacuum (VP) and aerobically (AP). It was observed that vacuum and aerobically packed patties were stored at 4±1°C and evaluated for microbiological changes on days 0, 5, 10, 15, 20 and 25 days. The packaging method had no significant effect, storage period influenced microbial counts. The standard plate counts (SPC), which were initially log 5.98 CFU/g decreased significantly. M.L. Anderson,et al., (1989) reported 29 packages of precooked, vacuum-packaged beef and pork products purchased at local and regional supermarkets along with 110 packages of precooked, vacuum-packaged, sliced roast beef obtained from a major meat processor did not disclose the presence of Escherichia coli, coagulase-positive Staphylococcus aureus, Clostridium perfringens or Salmonella. The effects of storage temperature and length of storage on the microflora of 110 packages of sliced roast beef were determined at specific intervals of storage up to 84 days at 1° and 5°C, and up to 28 days at 10°C. The microflora of samples stored at 1° and 5°C was dominated by Lactobacillus spp. when examined on day 28 and throughout the remainder of the 84-day test period. The microflora of samples held at 10°C was dominated by Lactobacillus spp. until late in storage when Hafnia alvei became a major portion of the bacterial population. Precooked, sliced roast beef had a longer shelf life in laboratory controlled evaluations when stored at 1°C as opposed to 5° or 10°C.

Sensory characteristics of vacuum packaged meat and meat products

Pavankumar, *et al*. (2003) observed that sensory quality of vacuum packed tandoori chicken deteriorated significantly during storage at 4± 1ºC; however, it was still acceptable on the 15th day of storage. Bhoyar et al., 1997 found that also detected the vacuum packaged products were rated higher in colour, flavor, juiciness, texture and overall acceptability score then LDPE packed products during frozen storage. Sensory evaluation showed significant reduction in colour, flavor, texture and overall acceptability score with slight off flavor after 7 th day of packaging in air and after 10th day of vacuum packaging.

Singh *et al*., (2002) observed that the product packed under vacuum or nitrogen gas remain organoleptically acceptable for 10 and 15 days under refrigerated and frozen storage as against 8 and 10 days long shelf life of aerobically packed samples under same storage conditions. Bhoyar et al., 1998) reported that sensory evaluation of both aerobically packaged and vacuum packaged restructured chicken steak sample showed that the product from both packaging group were quit acceptable at the end of day 60 during frozen storage. However, vacuum packaged product wre rated higher in colour, flavor, juiciness, texture and overall acceptability, whereas, finding of Rajkumar et al.,(2004) proposed that vacuum packaging has definite advantages in preserving the sensory quality of patties but not enable extension of shelf life beyond 15 days. Sahoo et al., (1998) described the sensory quality of frozen ground buffalo meat by preblending with natural antioxidant and vacuum packaging and they observed that, vacuum packaging samples had lower amount of salt extractable proteins and colour and odour score as compared to aerobically packed samples. Zhao et al., (1996) studied the physical chemical and sensory characteristics of irradiated pork loin cut and reported that improvement of surface colour and odour in irradiated pork can be achieved by suitable packaging environment i.e. vacuum and CO_2 atmospheres. Debashis Bhattacharyya, et al., (2013) found that all the sensory parameters of aerobic and vacuum packed duck sausage during the storage period was observed. They observed that duck sausages were acceptable upto 30th and 50th day of refrigerated storage and 4th and 6th month of freezer storage in aerobic and vacuum packaging respectively. Freezer temperature enhanced the product quality upto 3rd and 5th month against 20th and 40th day of refrigerated storage in aerobic and vacuum packaging respectively. V. Rajkumar et al., (2004) evaluated the sensory quality of vacuum package (VP) and aerobically (AP) patties. Patties prepared from goats meat and both packed patties were stored at 4±1°C and evaluated for sensory quality changes on days 0, 5, 10, 15, 20 and 25. All samples of AP patties revealed swollen, greasy and sticky surface with spongy texture on day 20 whereas only some of the VP patties shown such changes on day 20. Results indicated that vacuum packaging had definite advantage in preserving the sensory quality of patties than aerobic packaging but it did not help in extending the shelf-life beyond 15 days.

II. Conclusion

Vacuum packaging is used as preservation method to retards the microbial growth and preserve the qualities of meat and meat products. There are many undesirable changes in color, texture, flavor, and odor due to spoilage of meat and meat products. A high microbial total count is only one of the factors influencing the shelf-life of vacuum packaged meat.

Bibliography

[1] Bhoyar,A.M., Pandey ,N.K., Anand ,S.K. and Verma ,S.S. 1997. Effect of packaging on refrigerated storage stability of restructured chicken steaks. Indian J. Poult. Sci. 32(3) :259-265.

[2] Bhoyar,A.M., Pandey ,N.K., Anand ,S.K. and Verma ,S.S. 1998.Quality characteristics of restricted chicken steaks as influenced by packaging during frozen storage. Indian J. Poultry Sci. 33(1): 56-60

[3] Brody, A. L. (1989) Microbiological safety of modified/controlled atmosphere/vacuum packaged foods. In: Brody, A. L., Ed., Controlled/Modified Atmosphere Vacuum Packaging of Foods. Trumbull, CT: Food & Nutrition Press, Inc.,pp 159–174.

[4] D. Narasimha Rao and N. M. Sachindra,(2002) Modified atmosphere and Vacuum packaging of meat and poultry products, food reviews international, Vol. 18, No. 4, pp. 263–293

[5] Davies, A. R. (1995) Advances in modified-atmosphere packaging. In: Gould, G. W., Ed. New Methods of Food Preservation. New York: Blackie Academic & Professional, 1995, pp 304–320.

[6] Debashis Bhattacharyya A, Mita Sinhamahapatra B and Subhasish Biswas (2013) Effects of Packaging Materials and Methods on Physical Properties and Food Safety of Duck Sausage, International Journal of Development Research Vol. 3, Issue, 05, pp.032-040. ISSN: 2230-9926

[7] Ismail Yüksel Genç , Eduardo Esteves , Jaime Aníbal , Abdullah Diler, (2013) Effects of chilled storage on quality of vacuum packed meagre fillets, Journal of Food Engineering 115 ,486–494

[8] J. T. Patterson, C. W. Gillespie[a]& B. Hough (1984) Aspects of the microbiology of vacuum- and gas-packaged chicken, including pre-treatments with lactic acid and potassium sorbate, British Poultry Science, Volume 25, Issue 4, pages 457-465

[9] M.L. Anderson,J.T. Keeton , G.R. Acuff, L.M. Lucia and C. Vanderzant (1989) Microbiological characteristics of precooked, vacuum-packaged uncured beef and pork,Meat Science,Volume 25, Issue 1, Pages 69–79

[10] Naveena, B.M., Muthukumar, M., Kulkarni, V.V., Praveen Kumar, Y., Usha Rani, K. and Kiran, M. (2015), Effect of Aging on the Physicochemical, Textural, Microbial and Proteome Changes in Emu (*Dromaius Novaehollandiae*) Meat Under Different Packaging Conditions. Journal of Food Processing and Preservation. doi: 10.1111/jfpp.12499

[11] Naveena, B.M., Muthukumar, M., Muthulakshmi, L., Anjaneyulu, A.S.R. and Kondaiah, N. (2014), Effect of Different Cooking Methods on Lipid Oxidation and Microbial Quality of Vacuum-Packaged Emulsion Products from Chicken. Journal of Food Processing and Preservation, 38: 39–47. doi: 10.1111/j.1745-4549.2012.00740.x

[12] Pavankumar, K. R. and Sachindra, N. M. and Narasimha Rao, D. (2003) Quality characteristics of vacuum packed tandoori chicken. Journal of Food Science and Technology, 40 (3). 313-315.

[13] Richard James Meldruma , Deborah Charlesb , Philip Mannionc and Paul Ellisb, (2014) Variation in the microbiological quality of commercially produced vacuum-packed cooked sliced meat between production and the end of shelf-life, International Journal of Environmental Health Research, Vol. 24, No. 3, 269–277

[14] Sahoo,J.,Anjaneyulu,A.S.R. and Srivastava,A.K.1998. Improvement in the quality of frozen ground buffalo meat by preblending with natural antioxidant and vacuum packaging. J.Food Sci&Technol.35 (3):209-215.

[15] Singh, R.P., Yadav,A.S. and Verma,S.S.2002. Effect of filleting and marination process on quality of roasted chicken breast fillets. J. Food Sci&Technol.Mysore 39(2):155-157.

[16] V. J. Moore and C. O. Gill (1987) The pH and display life of chilled lamb after prolonged storage under vacuum or under CO2, New Zealand Journal of Agricultural Research, Vol. 30: 449-452.

[17] V. Rajkumar, M. K. Agnihotri and N. Sharma (2004) Quality and Shelf-life of Vacuum and Aerobic Packed Chevon Patties under Refrigeration, Asian-Aust. J. Anim. Sci.. Vol 17, No. 4 : 548-553

[18] Zhao,Y.,Sebranek,J.G.,Dilkson,J.and Leen, M.1996. Bacteriological, physiochemical and sensory quality of fresh pork chops with low dose irradiation and vacuum packaging .J. Food Packt. 59(5):493-501

