International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(1): 840-844

Received: 28-11-2017
Accepted: 29-12-2017

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Effect of vacuum packaging on physico-chemical and sensory attributes of guinea fowl meat sausages during storage at refrigeration temperature (4±1 °C)

Ruma Devi and Praneeta Singh

Abstract
The aim of present study was to investigate the effect of vacuum packaging on physico-chemical and sensory attributes of guinea fowl meat sausages during storage at refrigeration temperature (4±1 °C). Guinea fowl meat sausages were subjected to two different types of packaging treatment i.e. aerobic packaging with low density polyethylene bags (control) and vacuum packaging using barrier bags (treatment) and stored at refrigeration temperature (4±1 ^{0}C). Physico-chemical and sensory attributes were analyzed on 0th, 3rd, 7th, 14th, 17th, 21th and 30th day. pH of the aerobically packaged product was found to be non-significantly higher than vacuum packaged product during storage. Water activity decreased during the storage both in vacuum as well as aerobically packaged product, but the values were non-significantly higher for aerobically packaged as compared to vacuum packaged product. TBA and FFA values for vacuum packaged product were significantly (P<0.01) lower then aerobically packaged product throughout the observation period. Highly significant (P<0.01) reduction was observed in scores for sensory attributes with advancement of storage period. Vacuum packaged product showed significantly higher (P<0.01) score for appearance/colour, flavour, texture, juiciness and overall acceptability throughout the storage period. Vacuum packaging was found to be much more effective to preserve the physic-chemical and sensory quality of the product. Aerobically packaged product showed signs of spoilage in between 14th to 17th day of storage and sensory scores were also very low for almost all sensory attributes from 14th to 17th day onward. Vacuum packaged product maintained a higher score till 21st day, however, scores decreased significantly (P<0.05) with advancement in storage period, but the product was within the acceptable range.

Keywords: Vacuum, physico-chemical, guinea fowl, packaging, refrigeration

Introduction
India has vast resources of livestock and poultry, which play a vital role in improving the socioeconomic conditions of the rural masses. Though guinea fowl is not widely domesticated, it has provided human with meat and eggs for centuries and can therefore be classified as both poultry and game. Meat is edible muscle, fat and other tissues obtained from an animal when it is slaughtered (Lawrie and Ledward, 2006) [15]. Guinea fowl meat is a product that requires more research to be conducted (Hancock *et al*., 2002) [8]. In Europe, Guinea fowl (*Numeda meleagris*) has long been domesticated, raised for food and used for income generation (Mongin, 1991) [18]. Mongin (1991) [18] reported that compared to chicken farming, guinea fowl farming incurs low production costs. Guinea fowls have a better resistance to common poultry parasites and diseases, they produce premium quality meat that is dark and delicate with the flavour resembling that of game, though the meat is tough and takes longer time to cook. Nutritionally guinea fowl meat is said to be rich in essential fatty acids and is leaner than chicken (Serre, 2002) [22]. Guinea fowl population is comes at the third place after chicken and duck (Kumar, 2009) [14]. Guinea fowl is an interesting poultry component of developing countries and it is now gaining attention as an alternative poultry resource in our country and it is raised primarily for meat production. The meat of guinea fowl is white, tender and easily digestible like that of chicken and has less fat and delicate flavour (Singh *et al*., 1984) [23].
Pearl, Lavender and White are three major varieties of guinea fowl. The guinea fowl meat has ready acceptability among poultry eating population and forms a good substitute of chicken meat. The lean spent meat obtained is good source of myofibrillar proteins, omega-3 fatty acids and there is less cholesterol especially in breast muscle.

Guinea fowl meat is a good source of iron and protein. Guinea fowl meat, particularly of young guineas is tender and very flavoursome.

Sausages are convenient ready to eat meat products which contain ground meat mixed with fat, salt, other seasonings, preservatives and sometimes fillers and stuffed into casings. Sausages can differ dramatically depending on their ingredients, additives, shape, curing technique, level of dryness and whether fresh or cooked (Aidells and Bruce, 2000) [1].

The addition of chemical additives (Preservatives, antioxidants, colorants, etc.) has frequently been associated with certain health problems, including allergies, and other more serious illnesses such as the initiation of carcinogenesis (Halliwell *et al*., 1995) [7]. Thus, there is a need to utilize techniques like vacuum packaging or MAP to maintain the natural qualities of cooked ready to eat foods without using chemical preservatives (Day, 1998) [5].

Vacuum Packaging preserves the product with complete removal of oxygen. Though, there is development of objectionable colour in Vacuum packaging. The colour can be regained when meat is removed from Vacuum packaged packets and exposed to air. Microbial profile of meat in Modified Atmospheric packaging and Vacuum packaging do not differ significantly (Rao and Sachindra, 2002) [21]. In this study effect of vacuum packaging on physico-chemical and sensory attributes of guinea fowl meat sausages were studied during storage at refrigeration temperature (4±1 °C).

Materials and methods

Raw materials and chemicals

Live birds (Guinea fowl) were procured from Instructional Poultry Farm, Pantnagar and were brought to the Department of Livestock Products Technology. Slaughter and dressing was carried out following standard procedure under humane conditions. The hot carcasses were stored in refrigerator at 4±1 ^{0}C overnight. Next day carcasses were manually deboned and lean meat was collected and stored at -20 ^{0}C till further use. The Refined wheat flour, table salt, spice mix, condiments were purchased from local market. All the chemicals and media used in the study were of analytical grade and from standard firms (Hi media, Merck).

Preparation of Guinea fowl meat Sausages

Partially thawed deboned meat was cut into small cubes and ground in a Hobart Mincer with 5 mm plate followed by 3mm plate. Emulsion was prepared using the formulation: Guinea fowl meat 65%, Vegetable oil (fat) 10%, Ice flakes 11%, Refined wheat flour 4%, Condiments 5.5%, Table salt 2%, Spices mix 2.5%, Sodium nitrite 150 ppm and STPP 0.2% in bowl chopper by adding these ingredients. Then the emulsion was stuffed into 17 mm diameter cellulose casings using hydraulic sausage filler and linked manually. Stuffed raw sausages were cooked in water at 80±5 ^{0}C for 45 min.

The product was vacuum packed (anaerobically) and aerobically in adequate number of multilayer barrier bags and LDPE bags respectively. For the vacuum packaging weighed samples were vacuum packaged in Multilayer poly bags by using 15 lb pressure, softener 03 and sealing 2.5 as parameters. After that the packets were stored at refrigeration temperature (4±1 ^{0}C). The samples of Guinea fowl sausages were analyzed for Physico-chemical and sensory characteristics at regular intervals of 0, 3, 7, 14, 21 and 30 days. The experiment was carried out in three replicates with each analysis done thrice.

Analytical Procedure

The emulsion stability was determined by the method of Baliga and Madaiah (1970) [3] with minor modifications. Twenty five grams of meat emulsion was taken in polyethylene bag and heated in thermostatically controlled water bath at 80 ^{0}C for 20 min. Then the exudate was drained out and the cooked mass was weighed. The percentage of cooked mass was expressed as emulsion stability.

The water activity (a_w) of the product was measured by water activity meter (Rotronic Hygrolab 3). The product was sliced into small pieces and filled into the water activity meter cup and the reading was taken in quick mode (4 minutes).

Thiobarbituric acid (TBA) value was estimated as per procedure given by Tarladgis *et al*. (1960) [26].

For determination of pH, the sample from each treatment was blended with distilled water, five times the weight of the sample to get uniform suspension and the pH was recorded using a digital pH meter by immersing the electrode of pH meter into aliquot of the sample.

Free fatty acid (FFA) value was determined by modified AOAC method (Koniecko, 1979) [12].

The sensory quality of samples was evaluated using 8 point descriptive scale (Keeton *et al*., 1984) [11] where 8 denoted extremely desirable and 1 denoted extremely poor. A sensory panel (semi trained) of seven judges drawn from post-graduate students and staff of Veterinary College, Pantnagar was requested to evaluate the product for different quality attributes viz., colour and appearance, texture, juiciness, flavour and overall acceptability. In order to assess acceptability of the guinea fowl meat sausages by the residents of the campus, consumer trial consisting of 100 people was conducted on 0 day. The consumers were asked to score the product on the basis of Appearance/Colour, Flavour, Texture, Juiciness and Overall acceptability.

Statistical analysis

Statistical analysis of the data obtained, was done using ANOVA technique according to the method described by Snedecor and Cochran (1994) [25].

Results and Discussion

Emulsion stability

The results for emulsion stability of guinea fowl meat sausages were 96.93%, 98.80%, 97.60% and 96.23% respectively for 1st, 2nd, 3rd and 4th trial.

pH

The data presented in Table.1 showed an increasing trend in the pH of guinea fowl meat sausages both in aerobic as well as vacuum packed sausages with advancement in storage period. However the increase in pH was more in aerobically packed sausages as compared to vacuum packed sausages but the difference was non significant. Significant (P<0.05) rise in pH was seen with advancement in storage period in both the packaging.

The results of above findings are in agreement with the findings of Kenawoi, (2003) [13] who reported higher pH values for aerobically packed beef slices than vacuum packed one which was stored for 6 month period under frozen condition. Dushyanthan *et al*. (2005) [6] also observed that mutton packed under vacuum in multilayer material and stored up to 120 hr at 4±1 ^{0}C, recorded lower pH and higher WHC as compared to mutton packaged in LDPE mono layer.

Table 1: Effect of vacuum packaging and storage period on pH values of guinea fowl meat sausages (Mean±S.E.)

Storage days	Aerobic packaging	Vacuum packaging	Day mean
0	6.173^{aA} ±0.039	6.173^{aA} ±0.039	6.173^{aA} ±0.039
3	6.238^{bA} ±0.058	6.220^{abA} ±0.056	6.229^{abA} ±0.057
7	6.243^{bA} ±0.045	6.225^{bA} ±0.048	6.234^{bcA} ±0.046
14	6.270^{bA} ±0.046	6.245^{bA} ±0.048	6.258^{bcA} ±0.047
17	6.285^{bcA} ±0.430	6.270^{bcA} ±0.046	6.278^{cdA} ±0.238
21	6.323^{cdA} ±0.425	6.293^{cdA} ±0.045	6.308^{deA}±0.235
30	6.358^{dA} ±0.042	6.325^{dA}±0.033	6.342^{eA} ±0.016
Treatment mean	6.27±0.155	6.250±0.045	
CD at 5%	0.048		

Values bearing different superscript in each row by capital letters (A,B,C) and in each column by small alphabet (a,b,c) differ significantly (P<0.05)

Water activity (a_w)

As shown in Table.2 water activity (a_w) of guinea fowl meat sausages of treatment and control did not differ significant with the advancement of storage period. The effect of vacuum packaging on water activity (a_W) was not significant and interactions between these two factors were not significant. Kenawoi (2003) [13] found that loss of moisture content was not significant in vacuum packaged samples compared with LDPE packaged samples.

Table 2: Effect of vacuum packaging and storage period on a_w values of guinea fowl meat sausages (Mean±S.E.)

Storage days	Aerobic packaging	Vacuum packaging	Day mean
0	0.948^{aA} ±0.022	0.948^{aA} ±0.022	0.948^{aA} ±0.022
3	0.941^{abA} ±0.015	0.924^{bB} ±0.009	0.933^{bAB} ±0.012
7	0.939^{abA} ±0.015	0.921^{bB} ±0.005	0.930^{bcAB} ±0.009
14	0.936^{abcA} ±0.005	0.920^{bB} ±0.003	0.928^{bcAB} ±0.004
17	0.928^{bcA} ±0.011	0.917^{bA} ±0.070	0.923^{bcA} ±0.040
21	0.929^{bcA} ±0.019	0.916^{bB} ±0.060	0.923^{bcAB} ±0.039
30	0.924^{cA} ±0.003	0.914^{bA} ±0.050	0.919^{cA} ±0.027
Treatment mean	0.935±0.013	0.923±0.031	
CD at 5%	0.013		

Values bearing different superscript in each row by capital letters (A,B,C) and in each column by small alphabet (a,b,c) differ significantly (P<0.05)

TBA

Data presented in Table 3 indicated a highly significant (P<0.01) effect of treatment as well as storage period on TBA (mg malonaldehyde/1000gm) values of guinea fowl meat sausages observed throughout the storage period.

Lin and Lin (2002) [16] reported inhibitory effect of vacuum packaging on lipid oxidation and observed significantly lower TBARS value of vacuum packaged sausages than modified atmosphere packaging stored under refrigeration at 4±1 ^{0}C for 10 weeks. These results are also in agreement with Rajkumar *et al*. (2004) [20] who concluded that aerobically stored chevon patties under refrigeration showed higher values of TBA than stored under vacuum and with the advancement of storage period TBA value for product increased for both aerobic and vacuum packed patties. Similar trend in TBA value was observed by Maca *et al*. (1997) [17] in ground meat patties at refrigeration storage, but values were very low in vacuum packaged patties throughout the storage period (30 days).

Table 3: Effect of vacuum packaging and storage period on TBA values (mg malonaldehyde/1000gm) of guinea fowl meat sausages (Mean±S.E.)

Storage days	Aerobic packaging	Vacuum packaging	Day mean
0	0.083^{aA} ±0.024	0.083^{aA} ±0.024	0.083^{aA} ±0.024
3	0.200^{abA} ±0.096	0.200^{aA} ±0.096	0.200^{abA} ±0.096
7	0.351^{bA} ±0.0765	0.358^{bA} ±0.061	0.355^{bA} ±0.069
14	0.784^{cA} ±0.106	0.404^{bB} ±0.028	0.594^{cC} ±0.067
17	1.290^{dA} ±0.207	0.478^{bB} ±0.125	0.884^{dC} ±0.166
21	1.565^{eA} ±0.155	0.685^{cB} ±0.138	1.125^{eC}±0.147
30	1.776^{fA} ±0.097	0.965^{dA} ±0.122	1.371^{fC} ±0.109
Treatment mean	0.864±0.109	0.453±0.085	
CD at 1%	0.157		

Values bearing different superscript in each row by capital letters (A,B,C) and in each column by small alphabet (a,b,c) differ significantly (P<0.05)

FFA

The FFA values (% oleic acid) showed a highly significant (P<0.01) effect of treatments as well as storage period throughout the observation period and interaction between these two factors were also highly significant (P<0.01). Increase was observed in FFA values with the advancement of storage period.

The observations are similar to (Arafa and Chen, 1976) [2] who reported that increase in free fatty acid was more in aerobic than vacuum packaging. Bhoyar *et al*. (1998) [4] also observed that the free fatty acid content increased significantly (P<0.05) with storage time in vacuum packaging as well as in LDPE, but rate of increase was slow with vacuum packaging. Huang *et al*. (1992) [10] reported a significantly (P<0.05) higher free fatty acid content in over wrapped fish than vacuum packaged fish sample.

Table 4: Effect of vacuum packaging and storage period on FFA values (% oleic acid) of guinea fowl meat sausages (Mean±S.E.)

Storage days	Aerobic packaging	Vacuum packaging	Day mean
0	0.215^{aA} ±0.115	0.215^{aA} ±0.115	0.215^{aA} ±0.115
3	0.429^{bA} ±0.132	0.379^{bA} ±0.103	0.404^{bA} ±0.117
7	0.494^{bA} ±0.019	0.444^{bA} ±0.047	0.469^{bA} ±0.033
14	0.861^{cA} ±0.017	0.756^{cB} ±0.014	0.809^{cAB} ±0.015
17	1.272^{dA} ±0.000	0.827^{cB} ±0.000	1.049^{dBC} ±0.000
21	1.762^{eA} ±0.094	0.848^{cB} ±0.003	1.305^{eC} ±0.048
30	1.922^{fA} ±0.019	0.883^{cB} ±0.06	1.403^{fC} ±0.393
Treatment mean	0.994±0.056	0.622±0.049	
CD at 1%	0.099		

Values bearing different superscript in each row by capital letters (A,B,C) and in each column by small alphabet (a,b,c) differ significantly (P<0.05)

Sensory Analysis

Appearance and colour

The effect of storage period and treatment on appearance and colour of guinea fowl meat sausages was found to be highly significant (P<0.01), as well as interaction between storage period and treatment was also found to be highly significant (P<0.01).

These findings are in agreement with the findings of Bhoyar *et al*. (1998) [4] who also observed that vacuum packaged product were rated higher in colour score than LDPE packed product during frozen storage. Zhao *et al*. (1996) [27] also reported that improvement of surface colour and odour in irradiated pork can be achieved by suitable packaging environment i.e. vacuum and CO_2 atmospheric packaging.

Table 5: Effect of vacuum packaging and storage period on appearance/colour score of guinea fowl meat sausages (Mean±S.E.)

Storage days	Aerobic packaging	Vacuum packaging	Day mean
0	7.154^{aA} ±0.243	7.154^{aA} ±0.243	7.154^{aA} ±0.243
3	7.154^{aA} ±0.243	7.154^{aA} ±0.243	7.154^{aA} ±0.243
7	6.773^{bA} ±0.065	6.829^{bA} ±0.065	6.801^{bA} ±0.065
14	5.768^{cA} ±0.086	6.793^{bB} ±0.065	6.281^{cC} ±0.075
17	4.555^{dA} ±0.185	6.473^{cB} ±0.065	5.514^{dC} ±0.125
21	4.374^{dA} ±0.119	6.295^{dB} ±0.065	5.335^{eC} ±0.0918
30	3.700^{eA} ±0.108	6.173^{dB} ±0.065	4.937^{fC} ±0.086
Treatment mean	5.639±0.149	6.696±0.116	
CD at 1%	0.221		

Values bearing different superscript in each row by capital letters (A,B,C) and in each column by small alphabet (a,b,c) differ significantly (P<0.05)

Flavour

A highly significant effect of treatment and storage period was observed on flavour scores of the guinea fowl meat sausages (Table. 6) and interaction between these two factor were highly significant (P<0.01). Significantly (P<0.01) declining trend for flavour score was observed in aerobic packaging as well as vacuum packaging groups with the advancement of storage period.

Huang *et al*. (1990) [10] also observed that after storage and reheating, flavour and aroma of samples in vacuum and N_2/CO_2 packaging were more meaty and less warmed over than those in air containing packages.

Table 6: Effect of vacuum packaging and storage period on flavour score of guinea fowl meat sausages (Mean±S.E.)

Storage days	Aerobic packaging	Vacuum packaging	Day mean
0	6.987^{aA} ±0.233	6.987^{aA} ±0.233	6.987^{aA} ±0.233
3	6.745^{bA} ±0.092	6.745^{bA} ±0.092	6.745^{bA} ±0.092
7	6.385^{cA} ±0.034	6.485^{cA} ±0.065	6.435^{cA} ±0.049
14	5.496^{dA} ±0.156	6.473^{cB} ±0.065	5.985^{dC} ±0.110
17	4.382^{eA} ±0.065	6.374^{cB} ±0.065	5.378^{eC} ±0.065
21	4.306^{eA} ±0.065	5.784^{dB} ±0.065	5.045^{fC} ±0.065
30	2.317^{fA} ±0.048	4.213^{eB} ±0.041	3.265^{gC} ±0.045
Treatment mean	5.231±0.099	6.152±0.089	
CD at 1%	0.163		

Values bearing different superscript in each row by capital letters (A,B,C) and in each column by small alphabet (a,b,c) differ significantly (P<0.05)

Juiciness

The effect of treatment and storage period on juiciness of guinea fowl meat sausages was found to be highly significant (P<0.05) as per the data presented in the Table.7

A highly significant (P<0.01) reduction in the juiciness score was observed with the advancement of storage period for aerobic packaging and vacuum packaging.

Table 7: Effect of vacuum packaging and storage period on juiciness score of guinea fowl meat sausages (Mean±S.E.)

Storage days	Aerobic packaging	Vacuum packaging	Day mean
0	6.817^{aA} ±0.065	6.817^{aA} ±0.065	6.817^{aA} ±0.065
3	6.718^{bA} ±0.065	6.718^{bA} ±0.065	6.817^{bA} ±0.065
7	6.617^{cA} ±0.005	6.638^{bA} ±0.076	6.628^{bA} ±0.040
14	6.396^{dA} ±0.065	6.531^{cB} ±0.061	6.464^{cAB} ±0.063
17	6.282^{eA} ±0.053	6.429^{dB} ±0.042	6.355^{dAB} ±0.047
21	5.793^{fA} ±0.065	6.384^{dB} ±0.058	6.089^{eC} ±0.061
30	5.597^{gA} ±0.107	6.286^{eB} ±0.029	5.942^{fC} ±0.068
Treatment mean	6.317±0.060	6.543±0.056	
CD at 1%	0.095		

Values bearing different superscript in each row by capital letters (A,B,C) and in each column by small alphabet (a,b,c) differ significantly (P<0.05)

Texture

Data presented in Table.8 indicated that storage period as well as treatment highly significantly (P<0.01) affected the texture value of guinea fowl meat sausages and interaction between these two factor were also found to be highly significant (P<0.01).

Bhoyar *et al*. (1998) [4] found that during sensory evaluation of both aerobically packaged and vacuum packaged restructured chicken steak, vacuum packaged product were rated higher for texture value.

Table 8: Effect of vacuum packaging and storage period on texture score of guinea fowl sausages (Mean±S.E.)

Storage days	Aerobic packaging	Vacuum packaging	Day mean
0	6.978^{aA} ±0.216	6.978^{aA} ±0.216	6.978^{aA} ±0.216
3	6.498^{bA} ±0.048	6.673^{bB} ±0.064	6.586^{bAB} ±0.056
7	6.373^{bcA} ±0.065	6.562^{bcB} ±0.065	6.468^{bAB} ±0.065
14	6.273^{cA} ±0.065	6.539^{bcdB} ±0.065	6.406^{bAB} ±0.065
17	5.826^{dA} ±0.065	6.423^{cdeB} ±0.041	6.125^{cC} ±0.053
21	4.742^{eA} ±0.086	6.401^{deB} ±0.305	5.572^{dC} ±0.195
30	4.495^{fA} ±0.065	6.311^{eB} ±0.013	5.403^{eC} ±0.039
Treatment mean	5.884±0.0869	6.555±0.100	
CD at 1%	0.141		

Values bearing different superscript in each row by capital letters (A,B,C) and in each column by small alphabet (a,b,c) differ significantly (P<0.05)

Overall acceptability

Overall acceptability scores of guinea fowl meat sausages presented in Table.9 shows that there was highly significant (P<0.01) variation in the mean values of overall acceptability due to treatment and storage period.

A highly significant (P<0.01) declining trend was observed in the score of overall acceptability of guinea fowl meat sausages in aerobic packaging and vacuum packaging. Data presented in Table.9 revealed that there was a highly significant (P<0.01) interaction between storage period and treatment.

These findings are in agreement with the findings of Singh *et al*. (2002) [24] who also observed that the product packed under vacuum or nitrogen gas remained 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. However, Pandey and Yadav (2005) [19] found that overall acceptability rating declined with storage time irrespective of packaging and storage condition but the vacuum packed products were consistently preferred.

Table 9: Effect of vacuum packaging and storage period on overall acceptability score of guinea fowl meat sausages (Mean±S.E.)

Storage days	Aerobic packaging	Vacuum packaging	Day mean
0	6.838^{Aa} ±0.065	6.838^{aA} ±0.065	6.838^{aA} ±0.065
3	6.709^{bA} ±0.046	6.809^{aA} ±0.045	6.759^{aA} ±0.046
7	6.626^{bA} ±0.045	6.781^{aB} ±0.007	6.704^{bAB} ±0.026
14	6.485^{cA} ±0.104	6.764^{aB} ±0.007	6.625^{bC} ±0.055
17	5.509^{dA} ±0.165	6.589^{bB} ±0.013	6.049^{cC} ±0.089
21	4.409^{eA} ±0.132	5.863^{cB} ±0.077	5.136^{dC} ±0.104
30	3.471^{fA} ±0.086	4.263^{cB} ±0.065	3.867^{eC} ±0.075
Treatment mean	6.698±0.298	6.272±0.0396	
CD at 1%	0.113		

Values bearing different superscript in each row by capital letters (A,B,C) and in each column by small alphabet (a,b,c) differ significantly (P<0.05)

Conclusion

From the above study it can be concluded that the sausages prepared from guinea fowl meat were highly acceptable as judged by a large number of consumers in the consumer trial. Vacuum packaging improved the Physico-chemical and sensory quality of the product over the aerobic packaging. Aerobically packaged product showed signs of spoilage in between 14th to 17th day of storage under refrigeration (4±1 °C) and sensory panel score were also very low for almost all sensory attributes from 14th to 17th day onwards. Vacuum packaged product maintained a higher score till 21st day, though the scores decreased significantly (P<0.05) but the product was within the acceptable range. Hence, it can be concluded that vacuum packaging improved the storage stability of Guinea fowl meat sausages.

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