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Development and evaluation of shelf-stable meat pickles from spent hen and duck meat

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A B S T R A C T

The study evaluated the sensory, physicochemical, biochemical, and microbiological stability of spent hen and duck meat pickles over 90 days at room temperature. Sensory attributes showed a slight but insignificant decline over time, confirming acceptability of the pickles throughout storage period. pH decreased significantly ($p<0.05$) but remained below 5.0, ensuring pickle stability. Water activity values (0.93-0.96 a_w) exhibited a slight, statistically insignificant decline and titratable acidity increased slightly, influenced by acetic acid concentration, supporting prolonged shelf life of the pickles. The thiobarbituric acid (TBA) values rose significantly ($p<0.05$), indicating progressive lipid oxidation, though remaining within acceptable limits. Microbiological analysis confirmed a significant ($p<0.05$) increase in total viable counts, yeast, and mold, but all remained within acceptable limits. Pathogenic bacteria were absent, likely due to low water activity, antimicrobial effects of vinegar as well as hygienic processing and optimal cooking conditions. The findings suggest that pickles prepared with aged hen and duck meat remain microbiologically safe, organoleptically and physiochemically satisfactory for up to 90 days when store at room temperature.

INTRODUCTION

Poultry industry is considered as a vital part of the livestock industry and still growing at a much faster rate as compared to others agricultural enterprise worldwide. The World Bank predicts that food demand will increase by 50% and meat demand by 85% by 2030 (Guleria *et al.*, 2015). In Bangladesh, the poultry sector significantly contributes to the economy while also serving as an essential source of protein for the growing population (Rahman *et al.*, 2021). With this growth, the number of aged and culled hens and ducks has also risen substantially. However, consumers often find meat from these aged culled birds less desirable due to its tough texture and lower sensory appeal (Das *et al.*, 2013). Introducing of convenient, suitable and consumer-friendly processing methods to enhance the value of spent hen and duck meat could encourage greater acceptance among consumers (Das *et al.*, 2013 and Anandh *et al.*, 2018). Pickling meat using edible oil, salt, spices, condiments, and vinegar is a widely recognized method that yields a ready-to-eat, highly palatable product with extended shelf life at room temperature (Bhusal *et al.*, 2017). Meat pickles, a traditional convenience food, can be made using vegetables or meat, particularly from spent hen and duck (Kanagaraju & Subramanian, 2012). These products are commonly enjoyed with bread and rice or as standalone snacks. Due to the high perishability of meat, especially in tropical regions with hot and humid climates, spoilage and contamination by

foodborne pathogens pose significant challenges. Unlike fresh meat, pickled meat does not require refrigeration or freezing for storage and distribution, making it a cost-effective, shelf-stable alternative (Gadekar *et al.*, 2010). Pickling also enhances the taste, aroma, and texture of meat while acting as a natural preservative. Acetic acid, a key ingredient in pickling, improves meat texture and digestibility. Moreover, evolving lifestyles, rising per capita income, urbanization, greater consumer perception, and increasing the numbers of working women have led to higher demand for convenient ready-to-eat, ready-to-cook, and heat-and-serve meat products. As a result, there is a growing emphasis on formulating meat products with extended shelf life that can be stored at room temperature (Raut *et al.*, 2024). Currently, there is limited research on utilizing spent hen and duck meat for pickle production and evaluating its storage stability at room temperature. In this regard, producing ready-to-eat meat pickles from these sources is a timely and relevant initiative.

MATERIALS AND METHODS

Materials

Mature hen and duck, approximately 72 weeks old, were sourced from the nearby marketplace in Barishal, Bangladesh. These birds were slaughtered according to the halal method and processed at the Animal Products and By-products Technology (APT) Laboratory, Patuakhali Science and Technology University, Bangladesh. The study took place between April and August (summer season), when the average temperature ranged from 32 to 36°C.

Preparation of pickles

The dressed carcasses were manually deboned within an hour of slaughter. Excess noticeable fat, including skin, tendons, and connective tissues were trimmed off. The meat was then cut into one (1) cm^3 cubes and soaked overnight in vinegar (4% acetic acid) with little amount of refined salt and turmeric powder in zip-lock poly bags at 4±1°C. After marination, the meat was taken out of the vinegar and pressure-cooked at 120°C for 10 minutes at 1.2 kg/cm^2 pressure. After cooking, the meat pieces were deep-fried in refined vegetable oil until they achieved a light golden-brown color, and any excess oil was drained off. A spice mixture was blended, based on the recipes of Kanagaraju and Subramanian (2012) and Das *et al.* (2013), with slight modifications (Table 1). After the fried meat was removed, spice mix was then added to the oil and fried for two minutes. The remaining broth was mixed with the spices, stirred continuously, and boiled for one minute. The fried meat and acetic acid were then incorporated into the gravy and simmered with occasional stirring for an additional three minutes. Finally, a preheated and cooled down refined vegetable oil was added to the pickles as of required, which was left to mature for 24 hours at ambient temperature. After cooling, the meat pickle was transferred into PET jars and stored in a dry location at ambient temperature for shelf-life and quality assessments at 15-days interval for up to three months (90 days).

Table 1: Recipe of spices mixture used in the chicken and duck meat pickle as per Das *et al.*, (2013) with some modifications

Sl. no.	Ingredients	Amount (g/100g of fresh lean meat)
1.	Cumin	1
2.	Coriander	0.55
3.	Turmeric	1
4.	Mustard seed	1
5.	Chili powder	3
6.	Black pepper	0.12
7.	Cardamom	0.17
8.	Fenugreek	0.5
9.	Clove	0.11
10.	Cinnamon	0.17
11.	Asafetida	0.5
12.	Commercial chicken masala	1
13.	Onion	5
14.	Garlic	28
15.	Ginger	5
16.	MSG	0.05
17.	Vinegar (ml)	4
18.	Common salt	As per need

Sensory evaluation

Sensory assessment of meat pickles was conducted according to the approaches described by Rahman *et al.* (2014), using a 5-point scale as follows: excellent-5, very good-4, good-3, fair-2 and poor-1. A panel of twenty trained evaluators, including faculty members and postgraduate students (14 males, 6 females; aged between 22 and 45 years) assessed the pickles. The panelists were trained according to AMSA guidelines (1995) at the APT laboratory. Evaluations took place under natural light and at room temperature, with participants providing feedback on color, aroma, sourness, sweetness, texture, taste and overall acceptability. All samples were served in petri dishes.

Determination of pH, water activity and titratable acidity

The pH of the prepared pickles was determined using a pH meter (Model HI 84530, Hanna Instruments Co., USA). Water activity of the samples at 25°C was measured with the Aqua Lab Series 3 (Aqualab, Labcell, Basingstoke). Titratable acidity was analyzed using an Autotitrator (Autotitrator Mettler DL 50, Schwerbach, Switzerland) following the procedure outlined by Hasimah *et al.* (2009).

Biochemical analysis

Thiobarbituric Acid value (TBA) was assessed to evaluate the biochemical quality of pickles. Thiobarbituric Acid value (TBA) was quantified following to Schmedes *et al.* (1989) methods.

Microbiological analysis

The total count of viable microorganisms, including yeast and mold levels, coliform bacteria count, and the presence of *Staphylococcus* and *Salmonella* species in the pickles, were analyzed following the guidelines of APHA (1984).

Statistical analysis

A completely randomized design was employed to conduct the experiment, where all analyses were run in triplicate. Statistical analysis was conducted by means of analysis of variance (ANOVA) (St and Wold, 1989), where mean values were assessed by the Duncan Multiple Range Test (DMRT) (Tallarida *et al*., 1987). All statistical analyses were carried out using RStudio (R version 4.2.2) (Allaire, 2012). A significance level of 5% was applied to p-values (two-sided tests) that were equal to or less than 0.05 (5% level of significance).

RESULTS AND DISCUSSION

Sensory evaluation

The mean variations in the sensory qualities of meat pickles made from spent hen and duck are shown in Table 2. Sensory aspects such as color, aroma, sourness, sweetness, texture, taste, and overall acceptability showed a slight but statistically insignificant ($p>0.05$) decline over 90 days of storage at room temperature. Despite this, sensory evaluation confirmed that spent hen and duck meat pickles remained acceptable throughout the storage period at ambient temperature. These findings align with those of Khanna *et al*. (2004) regarding bone-in meat pickles from spent hens and Kanagaraju and Subramanian (2012) for spent duck meat pickles, both of whom reported no significant variation in panel scores during storage. Similarly, the present study findings are closely matched with the findings of Das *et al*. (2013) for pickles made from spent hen and Dey *et al*. (2021) for pickles made from duck, chicken and turkey. Sen and Karim (2003) observed a slight decline in flavor scores with extended storage of rabbit meat pickle. This minor decrease in flavor scores at room temperature may be linked with increasing TBA values in the meat products. The slight decline in overall acceptability scores for spent chicken and duck meat pickles may be attributed to the gradual decrease in average scores for color, aroma, sourness, sweetness, texture, and taste. Similar observations were reported by Kanagaraju and Subramanian (2012), Das *et al*. (2013), and Dey *et al*. (2021).

Table 2: Changes in sensory attributes of spent chicken and duck meat pickle during storage periods at room temperature

Parameters	Storage Periods in Days														Significance level
	0 Day		15th Day		30th Day		45th Day		60th Day		75th Day		90th Day		
	Chicken Pickle	Duck Pickle	Chicken Pickle	Duck Pickle	Chicken Pickle	Duck Pickle	Chicken Pickle	Duck Pickle	Chicken Pickle	Duck Pickle	Chicken Pickle	Duck Pickle	Chicken Pickle	Duck Pickle	
Color	4.50±0.50	4.67±0.50	4.44±0.53	4.61±0.49	4.00±0.25	4.17±0.71	3.94±0.58	4.00±0.25	3.83±0.25	4.00±0.25	3.56±0.53	3.67±0.43	3.50±0.50	3.56±0.53	NS
Aroma	4.00±0.50	4.11±0.60	3.89±0.78	4.11±0.60	3.78±0.44	4.11±0.60	3.78±0.44	3.89±0.78	3.61±0.49	3.89±0.78	3.56±0.53	3.78±0.44	3.50±0.50	3.56±0.53	NS
Sourness	3.62±0.44	3.44±0.46	3.56±0.46	3.39±0.22	3.44±0.46	3.39±0.22	3.39±0.22	3.39±0.22	3.39±0.65	3.28±0.67	3.39±0.65	3.28±0.67	3.22±0.26	3.22±0.26	NS
Sweetness	3.17±0.56	3.61±0.49	3.28±0.36	3.61±0.49	3.33±0.43	3.56±0.39	3.33±0.43	3.56±0.39	3.28±0.36	3.56±0.39	3.39±0.42	3.56±0.39	3.44±0.46	3.44±0.46	NS
Texture	3.50±0.50	3.67±0.43	3.44±0.30	3.61±0.49	3.44±0.30	3.56±0.46	3.39±0.33	3.56±0.46	3.39±0.33	3.50±0.50	3.28±0.36	3.33±0.50	3.28±0.36	3.33±0.50	NS
Taste	3.50±0.50	3.61±0.42	3.61±0.42	3.78±0.36	3.67±0.43	3.78±0.36	3.56±0.46	3.61±0.42	3.56±0.46	3.61±0.42	3.44±0.39	3.50±0.50	3.39±0.49	3.50±0.50	NS
Overall acceptability	3.78±0.44	4.00±0.50	3.89±0.78	4.50±0.61	4.00±0.50	4.67±0.50	3.67±0.86	4.00±0.50	3.67±0.50	3.98±0.49	3.78±0.44	4.00±0.50	3.56±0.46	3.89±0.78	NS

*NS= Not significantly differ

pH, water activity and titratable acidity

Figure 1 illustrates the pH levels of duck and chicken meat pickles. Throughout the study, the pH of spent duck and chicken meat pickles ranged from 4.47 to 4.83 and 4.42 to 4.79, respectively. A notable decrease ($p<0.05$) in pH was observed over time, consistently staying below the critical threshold of 5.0, which is essential for pickle stability (Dziezak, 1986). These findings are coherent with previous research by Das *et al*. (2007), Nayak *et al*. (2011), Anandh *et al*. (2018), and Dey *et al*. (2021), who analyzed pH variations in different meat pickles stored at room temperature.

Figure 2 illustrates the water activity values of duck and chicken meat pickles, which ranged from 0.93 a_w to 0.95 a_w and 0.94 a_w to 0.96 a_w, respectively, throughout the study period. According to Barron (2007), foods with a water activity (aw) above 0.85 and a final stable pH of 4.6 or lower are classified as "pickles" or "pickled" products. Over a 90-day storage period, there was a minor decrease in water activity, though the change was not statistically significant ($P<0.05$). Lower water activity (aw) enhances shelf stability and inhibits mold growth (Ockerman & Basu, 2004). These findings are also coherent with Ranade *et al*. (2020), who studied various cooking techniques for Kadaknath meat pickle.

Graphical representations of titratable acidity values of duck and chicken meat pickles are shown in Figure 3. The range of total titratable acidity of duck and chicken meat pickle was 145 to 2.15 and 1.37 to 1.99 respectively. A slight but meaningful difference ($p<0.05$) in overall measurable acidity was observed in duck and chicken meat pickles during extended storage at room temperature, influenced by the acetic acid concentration. Sahu *et al*. (2012) also observed a notable variation in the titratable acidity of Murrel fish pickle when preserved with different concentrations of acetic acid. Likewise, Khanna *et al*. (2004) noted a decline in the pH of chicken pickle from 4.9 to 4.3 in PET jars and 4.2 in laminated pouches, while its titratable acidity increased from 1% to 1.1% over six months. Furthermore, Anandh *et al*. (2018) found that the titratable acidity (% acetic acid) was significantly ($p<0.05$) higher in pickles made from indigenous desi chicken meat.

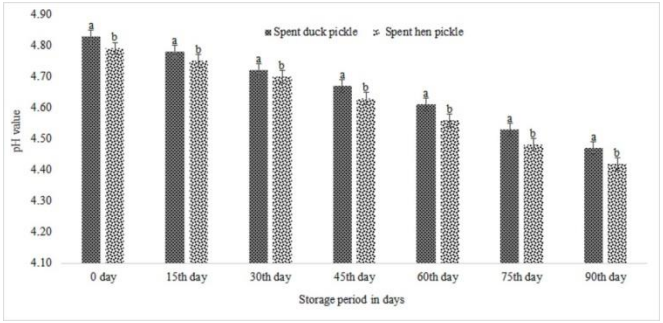

Figure 1. Changes in pH of spent duck and hen meat pickle during storage at room temperature

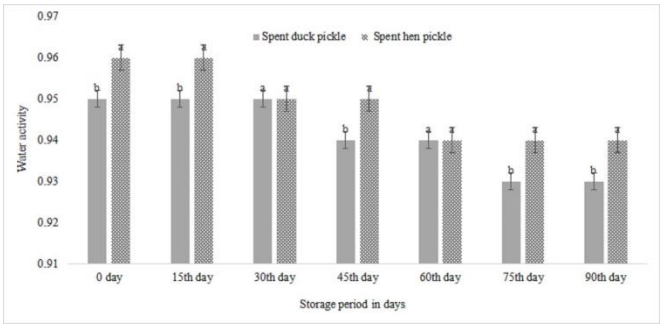

Figure 2. Variation in water activity of spent duck and hen meat pickle during storage at room temperature

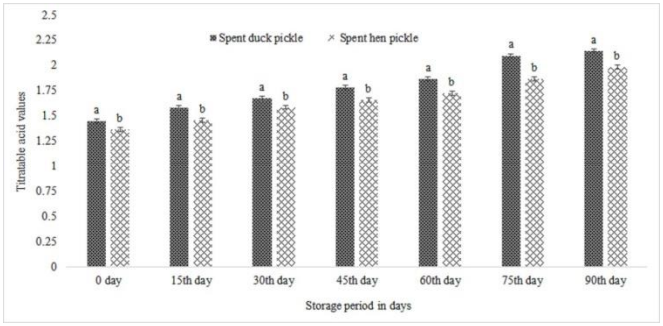

Figure 3. Variation in titratable acidity of spent duck and hen meat pickle during storage at room temperature

Biochemical analysis

The TBA values of duck and chicken meat pickles are depicted in Figure 4. The initial TBA values (mg malonaldehyde/kg meat) for duck and chicken meat pickles were 0.334 and 0.233, respectively at 0 days of storage, significantly increased to 0.775 and 0.643 at room temperature over time. Poultry meat, being richer in phospholipids than red meat, is more prone to oxidative rancidity (Acousta *et al.*, 1966). A similar pattern was noted by Reddy and Rao (1996), where chicken parts showed a rise in TBA values from 0.24 to 2.12 mg malon/kg over 80 days of ambient storage. This aligns with earlier findings (Schultz, 1963), attributing TBA increases to lipid oxidation and volatile metabolite production in aerobic packaging. Similar patterns have been observed in meat pickles, as noted by Anandh *et al.* (2018), Das *et al.* (2013), Pal and Agnihotri (1994), Nayak *et al.* (2011), and Maiti *et al.* (2009) in studies on tenderized chicken gizzard and goat meat pickles.

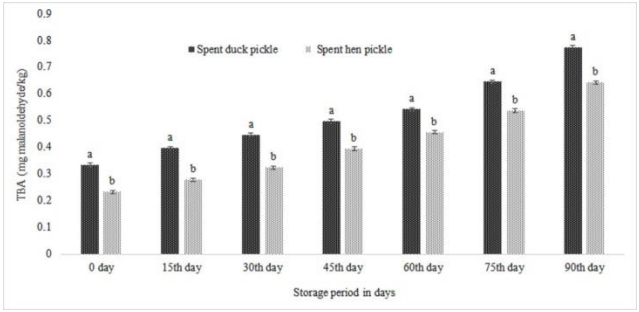

Figure 4. Changes in biochemical quality (TBA value) of spent duck and hen meat pickle during storage at room temperature

Microbiological analysis

The mean variations in microbiological properties of duck and chicken meat pickles stored at ambient temperature are depicted in Figures 5 and 6. The total viable count was measured to evaluate the shelf stability and safety of the product. The initial mean total viable count (TVC) of duck and chicken pickle was recorded to be 3.64 log cfu/g and 3.46 log cfu/g which increased significantly ($p<0.05$) to 4.34 log cfu/g and 4.22 log cfu/g respectively on 90 days of storage. The microbiological count in this study remained within a satisfactory range (Ranade *et al.*, 2020), as meat products typically spoil when microbial load exceeds 6 log cfu/g. Throughout the 90-day storage period, microbiological analysis confirmed the absence of pathogenic bacteria, including *Coliform spp.*, *Salmonella spp.*, *Clostridium spp.*, and *Staphylococcus spp.* This could be attributed to low water activity, heat treatment during cooking and the antimicrobial properties of vinegar used in pickling (Wani & Majeed, 2014). A significant increase in TVC, yeast, and mould counts was observed with prolonged storage, with variations between different meat pickles (Dey *et al.*, 2021). However, Anandh *et al.* (2018) found statistically insignificant difference in total plate, yeast, and mould counts between native desi and broiler chicken pickles, while coliforms remained undetected in both.

Yeast and mold were undetectable until day 30 but appeared by day 45 as 1.12 log cfu/g and 1.08 log cfu/g in duck and chicken pickles, respectively. By the end of the study at day 90, their counts reached 1.52 log cfu/g in duck pickles and 1.34 log cfu/g in chicken pickles. Pickles have low water activity (a_w), which helps prevent mold from growing (Ockerman and Basu, 2004). Similarly, Kanagaraju and Subramanian (2012) reported yeast and mold growth only after 60 days in meat pickles, aligning with these findings. Gupta *et al.* (2011) attributed low yeast and mold counts to hygienic processing and optimal cooking conditions.

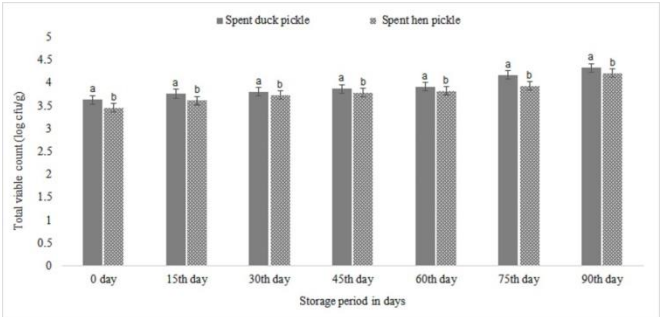

Figure 5. Changes in total viable count (TVC) of spent duck and hen meat pickle during storage at room temperature

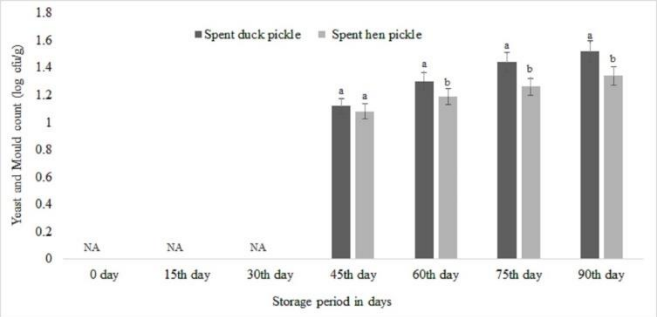

Figure 6. Changes in yeast and mould count of spent duck and hen meat pickle during storage at room temperature

The absence of coliforms throughout storage suggests adherence to good hygienic practices during preparation and the effectiveness of heat treatment (Kumar *et al.*, 2015). Similar findings in meat products (Kumar & Sharma, 2004) reaffirm that stringent hygiene and cooking processes play a crucial role in ensuring microbiological safety. The present study confirmed that microbial characteristics maintain a good condition up to 90 days at room temperature, consistent with findings in pork (Kumar & Bachil, 1993), chevon (Pal & Agnihotri, 1994), and spent hen meat pickles (Jayanthi *et al.*, 2008).

CONCLUSION

The study confirms that spent hen and duck meat pickles remain sensory acceptable and microbiologically safe for 90 days at room temperature. Though sensory attributes, pH, and water activity declined slightly, the pickles remained stable, with a slight increase in acidity. Oxidative rancidity (TBA values) increased over time but remained within acceptable limits. Microbial counts increased but stayed below spoilage thresholds, with no pathogenic bacteria detected. These findings highlight the stability, safety, and shelf life of spent hen and duck meat pickles, supporting their viability as preserved meat products.

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Ethical Statements

Conflicts of Interest: The authors declare that they do not have any conflict of interest.

Ethical Review: "This study was approved by the Institutional Ethical Committee of Patuakhali Science and Technology University, Bangladesh".

Authorship

Rahman MH: Project administration, supervision, conceptualization, methodology, investigation, data collection, writing the original draft and review and editing.

Monir MM: Project administration, supervision, conceptualization, methodology, investigation, data collection, writing the original draft and review and editing.

Hossain A: Investigation, data collection, formal analysis, and writing the original draft.

Jahan I: Investigation, data collection, and writing the original draft.

Rahman SME: Supervision, review and editing, given final approval of the version to be published.

All Authors are agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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