Original Research Article

EFFECT OF RICE BEER AND PHYTO-INGREDIENTS ON PROXIMATE COMPOSITION, TEXTURE, COLOUR, AND SENSORY EVALUATION OF VACUUM-PACKAGED MARINATED DUCK MEAT

Abstract: This research was carried out to investigate the effect of incorporating rice beer and phyto-ingredients on the proximate composition, texture profile, colour profile, and sensory qualities of vacuum-packaged marinated duck meat. Ducks aged between 9 and 12 months were procured from a local market and hygienically slaughtered and dressed. Five batches of marinated duck meat were prepared, each consisting of four different treatments. Following slaughter and dressing, the ducks were marinated using four altered formulations: a control group (meat + spice paste), T_1 (meat + rice beer + spice paste), T_2 (meat+ phyto-ingredients + spice paste), and T_3 (meat + rice beer + phyto-ingredients + spice paste). These marinated meat samples were then vacuum-packaged and stored under refrigeration for 24 hours. Subsequent quality assessments were carried out on the samples at 5-day intervals for the vacuum-packed samples. The moisture content was significantly higher (P<0.01) in T_3 samples compared to the control sample, while crude protein, ether extract, and total ash were significantly higher (P<0.01) in the control sample. Significant differences in moisture, crude protein, ether extract, and total ash were observed between the control and treated samples. In terms of colour profile, no significant variations were found between the control and treated groups, although treated products exhibited lower L*(colour) values, indicative of decreased lightness. The redness (a*) values displayed a consistent decrease across all treated and control products, while there was a slight reduction in yellowness for both control and treated duck meat samples. The texture profile revealed significant results in terms of hardness values. T_3 exhibited a decrease in hardness compared to the control samples. Springiness and chewiness revealed significant differences (P<0.01) between the control and treated samples, while cohesiveness demonstrated no significant differences (P <0.05) among the treated samples. Resilience consistently decreased from control to T_3 samples. In sensory evaluation, no significant differences were observed in terms of appearance, colour, flavour, and tenderness. However, significant differences were noted in juiciness and overall acceptability.

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Keywords: Meat, Phyto-ingredients, Marination, Fermented beverages

1. Introduction :

Meat, which comprises the muscular tissue from slaughtered animals used for food, is constituted of water, proteins, lipids, minerals, and a minor proportion of carbohydrates and vitamin B complex. Its role in the human diet is indispensable, providing all essential nutrients essential for growth and well-being. Offering substantial protein with elevated biological value, as well as vital fats, minerals, and soluble vitamins, meat and its derivatives serve as significant sources. These components play distinct roles in our physiological functions. With optimal digestibility and a well-balanced composition of crucial amino acids, meat is a suitable element for a nourishing diet. The production of meat in India involves recognized domesticated animals and poultry. Among these, poultry contributes around half of the overall meat output, underscoring its prominence. Among the poultry variety, duck meat is the second-highest contributor to India's poultry production, constituting a substantial portion of the total of 851.81 million tonnes of poultry meat. Duck rearing, particularly the Pati duck (*Anas platyrhynchos domesticus*), holds particular significance in Assam and other coastal Indian states, benefitting small and marginalized farmers by taking advantage of the marshy and waterlogged environment. (Kalita *et al*., 2009) The distinctive attributes of duck meat, possessing characteristics between red and white meat, contain higher red fiber in specific parts compared to chicken. Rich in phospholipids and monounsaturated fatty acids like oleic and linoleic acids, (George *et al*., 2014) duck meat is gaining attention due to its intermediate meat category status. However, despite its popularity in Assam, the consumption of duck meat remains traditional, with limited availability of processed duck meat products in the market compared to chicken.

Marination, an integral step in food preparation, accelerates maturation, tenderizes meat, and imparts distinct flavours. This process is often enhanced through the inclusion of acidic components that modify the meat's structure. Marinades have been extensively utilized to enhance the tenderness, juiciness, flavour, colour, and cooking yield of meat and poultry. The effectiveness of marinades is contingent upon their constituents. For instance, common ingredients in most marinades include salt and phosphate. Salt enhances flavour, promotes protein extraction, boosts marinade absorption, and increases moisture retention during storage and further processing.

Fermented beverages containing alcohol and natural acids offer potential for food preservation, including meat. Traditional rice beer in North-east India is culturally and religiously intertwined with tribal life and unique in its preparation method and flavour profile. This traditional beverage is derived from fermented rice starch transformed into sugars by microbes. Spices, sourced from plant materials, are integral for tenderizing, flavouring, and preserving foods due to their volatile oils and oleoresins.

Considering the benefits of rice beer as a marinade, this study seeks to develop a standard marinade using rice beer, phyto-ingredients, and spice extracts to prepare duck meat products. The research aims to examine the physicochemical attributes of the resulting products. Additionally, natural antioxidants play a role in enhancing meat quality, either through dietary incorporation, surface application, or active packaging. Green tea extracts, rich in antioxidant polyphenols, are known for their positive impact on lipid oxidation and microbial growth. Pomegranate, native to regions including Iran and Northern India, offers antioxidant, antimicrobial, and anti-inflammatory properties. Citrus fruits are prized for their diverse content, including poly–phenols, flavonoids, fiber, carotenoids and essential oils. Bamboo shoots, comprising dietary fiber, proteins, amino acids, and vitamins are recognized for their potential as health foods.

2. MATERIALS AND METHODS

2.1 Duck:

Pati Duck of the age group of 9-12 months, irrespective of their sexes, were procured from the local Beltola market of Guwahati city. The ducks were slaughtered in a semi-mechanized poultry dressing unit of the Department of Livestock Products Technology and appropriately dressed hygienically. After slaughter, the carcasses were packed in medium-density food-grade polythene bags and kept in a refrigerator at 4±1ºC until further use.

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2.2 Collection of indigenous rice beer

Locally made rice beer was collected from the Bodo community and prepared at the Amtola village, Raha, District Nagaon. The rice beer is known as "Jou" in the local Bodo language. Glutinous Rice (Bora saul) is boiled first, then cooled and allowed to dry up partially. A

mixed starter culture containing dry cake, locally known as "Angkhu", is added to rice, mixed properly, and kept overnight at room temperature. The rice mix is then kept in earthen pots with little water for 3-4 days at room temperature for fermentation. The peculiar "alcoholic" smell indicates the ripening of the mixture. The semi-liquid "alcoholic mass" is filtered to get the liquor called "Rice beer" in this work. Rice beer is bottled in an air-tight amber-coloured glass bottle, brought to the laboratory, and stored at refrigeration temperature until further use.

2.3 Collection of spices

Good quality spices (Cumin, Coriander, Turmeric, Black pepper, Paprika) were collected from the local market, washed, and dried. The spices were made into powder using a conventional grinder mixer and packed in food-grade MDPE packets at room temperature until use.

2.4 Collection of condiments

Fresh condiments (Garlic and Ginger) were collected from the local markets. Raw condiments were washed, cut into small pieces, and ground into a paste using a conventional grinder mixer. The paste was collected in a beaker and stored in a refrigerator at 4±1ºC until use.

2.5 Marination and packaging of meat samples

The wholesale breast cut was used for the present study. The cut was separated from the whole duck carcass. Marinades were prepared and applied to the breast meat samples. The marinated meat samples were then grouped as follows:

Control: Meat + Spice paste.

Treatment 1: Meat + rice beer+ Spice paste.

Treatment 2: Meat + Phyto-ingredients+ Spice paste.

Treatment 3: Meat + Rice beer+ Phyto-ingredients + Spice paste.

TABLE 1. MARINATION WAS DONE AS PER FOLLOWING FORMULATIONS

SL.	Ingredients	Control	Treatment	Treatment	Treatment

No.			1	2	3
1.	Duck Breast meat	93%	90%	88%	85%
2.	Assamese rice beer	-	3%	-	3%
3.	Phyto-ingredients (Tea extract, Pomegranate, Lemon, Bamboo shoot extract)	-	-	5%	5%
4.	Salt	1.5%	1.5%	1.5%	1.5%
5.	Sodium tripolyphosphate	0.5%	0.5%	0.5%	0.5%
6.	Spices (Cumin, Coriander, Turmeric, Black pepper, Paprika)	1.5%	1.5%	1.5%	1.5%
7.	Condiments (Garlic, Ginger)	3.5%	3.5%	3.5%	3.5%
	Total	100%	100%	100%	100%

2.6 Packaging

The marinated samples were vacuum and aerobically packed. The packets were marked and stored at refrigeration temperature (4±1ºC) for 24 hours. After this period, the samples were subjected to various quality assessments. Proximate composition, texture profile, colour profile and sensory evaluation were analyzed in bit longer intervals of 1st, 5th, 10th and 15th days for vacuum-packed samples.

3. PROXIMATE COMPOSITION

The Moisture, Crude Protein (CP), Ether Extract (EE) and Total Ash (TA) contents of the control and treated products were estimated as per the standard procedure (AOAC, 2005).

4. TEXTURE PROFILE

The texture profile of the product (Hardness, Fracturability, Springiness, Cohesiveness, Chewiness and Resilience) was determined with the help of a texture analyzer (TAHD plus, Stable micro systems, UK).

5. COLOUR PROFILE

The colour (L*, a*, b*) of the product was evaluated with the help of a UV-Visual Spectrophotometer (Cary 100 bio) using the solid sample holder. The L*.a*, b* values were recorded on the day of preparation of the product.

6. SENSORY EVALUATION

The sensory evaluation of the control and the treated samples was carried out by serving the products to a 7-member panel of semi-trained judges of different age groups and sexes. All the product samples were evaluated for appearance, colour, flavour, tenderness, juiciness, and overall acceptability by using a 9- point hedonic scale card as described by Ingham *et al*. (2002).

7. Statistical analysis

Data obtained in the study were analyzed statistically on the "SPSS-16.0" software package as per standard methods (Snedecor and Cochran, 1995). Five batches of the products were prepared and used as replicates in this study.

The permission to use poultry birds, i.e., ducks, for research was taken from the Institutional Animals Ethics Committee (IAEC), AAU, Khanapara, Guwahati, Assam.

8. RESULTS AND DISCUSSION

8.1 Proximate composition

The mean percent proximate composition of marinated duck meat for vacuum-packaged samples is presented in Table 2.

TABLE 2. EFFECT OF RICE BEER AND PHYTO-INGREDIENTS OF MARINATED VACUUM PACKAGED ON PROXIMATE COMPOSITION OF DUCK MEAT PRODUCTS AT REFRIGERATION TEMPERATURE (MEAN ± S.E)

Treatment	Moisture	Protein	Ether Extract	Total ash
Control	73.06±0.01^{A}	20.45±0.18^{A}	1.90±0.01^{A}	0.90±0.01^{A}
Treatment 1	73.17±0.01^{B}	20.28±0.07^{B}	1.83±0.01^{B}	0.85±0.02^{B}
Treatment 2	74.53±0.01^{C}	19.54±0.24^{C}	1.82±0.01^{B}	0.84±0.01^{B}
Treatment 3	76.13±0.00^{D}	19.23±0.48^{D}	1.81±0.00^{B}	0.83±0.01^{B}

n=5, VP=Vacuum Packaging
Means with different superscripts within a column differ significantly

The mean values of moisture percent revealed highly significant (P<0.01) differences between the control and treated samples under vacuum packaging. An increase in moisture percent in T_1, T_2, and T_3 samples as compared to control samples. The comparatively higher moisture content recorded in the treated meat samples might be due to the addition of aqueous extract of phyto-ingredients and rice beer. Lopez *et al*. (2012) also found a greater moisture percentage (P < 0.05) in the marinated products when compared with the control. Kumar *et al*. (2017) reported that the marination of spent hen breast fillets with lemon juice and ginger extract significantly (P<0.05) increased moisture content compared to the control, and they concluded that the Increase in the moisture content might be attributed to the marinade absorption.

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In the current study, the average protein content values exhibited a gradual and significant decrease (P<0.01) from the control samples to the T_1, T_2, and T_3 samples. This trend could be attributed to a progressive reduction in the percentage of lean meat with higher protein content, as the levels of phyto-ingredients increased in the treated formulations, resulting in formulations with substantially lower protein content. Such a decrease in protein percentage in the marinated chicken breast fillets was also reported by Lopez *et al*. (2012). Kumar *et al.* (2017) also reported decreased protein content in spent hen breast fillets due to marination and opined that a decrease in the protein content could be due to increased moisture content. The mean values for percent ether extract revealed significant (P<0.01) differences among

the control and treated samples for vacuum packaging systems. A gradual decrease in ether extract was recorded for T_1, T_2, and T_3 as compared to control samples. Kumar *et al*. (2017) also observed significantly (P<0.05) lower fat content in spent hen breast fillets marinated with lemon juice and ginger extract compared to the control. They also reported that the fat content significantly (P<0.05) differed among treatments. The decrease in fat content in the treatment groups might be due to the absorption of marinade solution.

In the present study, the replacement of the fat content of the duck meat by the increased levels of phyto-ingredients might have contributed to the overall decreased fat percentage in the treated meat samples.

The ash percent of the treatment products was found to be lower compared to the control sample. The mean values for percent total ash content revealed significant (P<0.01) differences between the control and T_3 samples. Kumar *et al*. (2015) noticed that the lemon-marinated (LM) and ginger-marinated (GM) chicken tikkas had lower protein, fat, and ash levels than the control. The washout of sarcoplasmic fluids in the marinades was the cause of the lowering of these nutrients in the marinated solutions. Rahman *et al*. (2023) concluded that the results on the nutritional parameters of marinated products differed according to the different marinades. In the present study, from the results of the proximate composition; it was observed that overall proximate composition was better in control samples than that of treated samples.

8.2 Colour profile

The results of mean colour values of control and treated samples for vacuum-packaged marinated duck meat products are presented in Table 3.

Table 3. EFFECT OF RICE BEER AND PHYTO-INGREDIENTS OF MARINATED VACUUM PACKAGED ON COLOUR PROFILE DUCK MEAT PRODUCTS (MEAN ± SE)

Treatments	Lightness (L)	Redness (a*)	Yellowness (b*)

	VP	VP	VP
Control	80.98 ±0.38	28.60 ±0.24	26.72 ±0.20
Treatment 1	81.04 ±0.30	27.30 ±0.01	27.21 ±0.05
Treatment 2	80.72 ±0.20	27.17 ±0.01	27.19 ±0.03
Treatment 3	80.33 ±0.13	27.25 ±0.03	27.02 ±0.01

n=5, VP=Vacuum packaging
Means with different superscripts within a column differ significantly.

The lightness values showed there are no significant differences for all the control and treated samples. The L*(colour) value was lower for treated products than that for control products. It might be due to the addition of rice beer and phyto-ingredients, which lead to a lowering in lightness values. Augustyn *et al*., (2019) also reported no significant differences ($P > 0.05$) in the brightness parameter L∗ between the marinades used in the pheasant breast muscles were found. The brightening of the colour of marinated in acidic marinades could be due to a decrease in its pH and a higher amount of extracellular water introduced into the meat during marinating.

The mean redness values showed there were no significant differences between the control and treated samples. Redness (a*) followed a decreasing trend in all the treated products as well as in control products. A decrease in a* value indicates the change in colour from red to brown, which could be due to the formation of metmyoglobin due to the oxidation of myoglobin pigment. Redness is used as an indicator of colour stability in meat and meat products and showed pronounced fading with the increase in storage period for samples (Gogoi *et al.*, 2020).

The mean yellowness value showed there are no significant differences in all the control and treated samples. A slight decrease in yellowness might be due to the addition of antioxidant-rich in phyto-ingredients and rice beer, which imparted a lower colour reaction between oxygen and muscle pigments. The findings of the present study compared with the reports of (Lopez *et al*. 2012), who reported that yellowness was lower ($P< 0.05$) in the treatments marinated with various concentrations of salt when compared with the control.

8.3 Texture analysis

The results of the texture profile of control and treated samples under vacuum-packaged marinated duck meat products are presented in Table 4.

Table 4. EFFECT OF RICE BEER AND PYTO-INGREDIENTS OF MARINATION OF VACUUM PACKAGED ON TEXTURE PROFILE OF DUCK MEAT PRODUCTS AT REFRIGERATION TEMPERATURE (MEAN ± SE)

Treatments	**Hardness** ***(kg/cm)***	**Springiness** **(*cm or mm)***	**Cohesiveness** ***(ratio)***	**Chewiness** ***(kg/cm/or mm)***	**Resiliance (cm/ or mm)**
Control	4118.16 ±254.63^{A}	0.59 ±0.03^{A}	0.414 ±0.02	1705.81 ±30.32^{A}	0.136 ±0.00
Treatment 1	3148.58 ±285.41^{B}	0.62 ±0.00^{AB}	0.4064 ±0.03	1686.18 ±29.18^{A}	0.132 ±0.19
Treatment 2	2680.20 ±212.10b^{C}	0.64 ±0.01^{B}	0.418 ±0.01	1716.28 ±69.14^{A}	0.131 ±0.00
Treatment 3	2571.00 ±103.23^{C}	0.47 ±0.04^{C}	0.4238 ±0.03	1491.19 ±22.47^{B}	0.129 ±0.00

n=5, VP=Vacuum packaging
Means with different superscripts within a column differ significantly.

In the present study, it was shown that marinating had a beneficial effect on the reduction of the hardness ($P < 0.01$) of marinated duck meat samples compared to the control. The hardness values showed a decreasing trend in the treatments compared to control samples. The acid breaks the transversal bounds of collagen, leading to the unstable structure loss of this connective tissue protein (Cholan *et al*., 2008).

The mean values for springiness scores for control and treated samples revealed highly significant differences (P<0.01) among the control and treated samples. The T_2 had the highest, and T_3 had the lowest springiness value among all the treated and control samples.

The cohesiveness scores for control and treated samples revealed non-significant (P>0.05) differences among all the treated samples. Cohesiveness followed an increasing and decreasing trend, which might be due to products having gotten tougher initially and followed by softer consistency due to the loss of integrity of the muscle cells and, thus, the muscle tissue losing its regaining capacity to its original form.

The mean values for chewiness score revealed a highly significant (P<0.01) difference between the control and treated samples. There is a decreasing trend of chewiness values from control to treated samples. This might be due to the offering of higher resistance by the control, T_1, and T_2 samples compared to T_3 samples during chewing. The T_3 samples offered less resistance during chewing because of the loss of cell integrity and disruption of muscle fiber. The mean values for resiliance scores for control and treated samples revealed non-significant (P>0.05) differences among all the control and treated samples. Marination decreased cohesiveness, hardness, and chewiness (P< 0.05) and increased juiciness (Maxwell *et al*. 2018).

8.4 Sensory evaluation

The results of the sensory evaluation of control and treated samples for vacuum-packaged marinated duck meat products are presented in Table 5. The sensory evaluation of the control and the treated samples was performed 1 day after marination. The different sensory quality traits were evaluated by scorecard methods employing semi-trained panellists.

Table 5. EFFECT OF RICE BEER AND PHYTO-INGREDIENTS ON SENSORY EVALUATION OF MARINATED VACUUM PACKAGED DUCK MEAT PRODUCTS (MEAN ± SE) AT REFRIGERATION TEMPERATURE.

Treatments	Appearance	Colour	Flavour	Tenderness	Juiciness	Overall acceptability
	VP	VP	VP	VP	VP	VP
Control	6.80 ±0.12	6.60 ±0.18	6.90 ±0.18	6.70 ±0.12	6.60 ±0.19^{A}	6.70 ±0.07$^{\mathbf{A}}$
Treatment 1	6.90 ±0.10	6.90 ±0.10	6.90 ±0.10	6.60 ±0.10	6.60 ±0.10$^{\mathbf{A}}$	6.80 ±0.04$^{\mathbf{A}}$
Treatment 2	6.80 ±0.12	6.90 ±0.10	7.00 ±0.22	7.10 ±0.18	6.90 ±0.10$^{\mathbf{AB}}$	6.90 ±0.05$^{\mathbf{AB}}$
Treatment 3	7.20 ±0.12	7.00 ±0.00	7.10 ±0.24	7.30 ±0.20	7.30 ±0.20$^{\mathbf{C}}$	7.30 ±0.20$^{\mathbf{B}}$

n=5, VP=Vacuum packaging

Means with different superscripts within a column differ significantly.

The mean appearance score revealed no significant differences (P>0.05) among the control and treated samples. The colour scores did not differ significantly between the control and treated samples. However, the panellist offered a marginally higher score for colour in T_3 samples. This might be due to the portion of the reduction in conversion of oxy myoglobin to met-myoglobin due to the use of phyto-ingredients and rice beer.

The flavour scores did not differ significantly (P>0.05) between the control and treated samples. Marginally higher non-significant scores in T_3 samples as compared to other treated samples were recorded in the study. Contrary to the present findings, Maxwell *et al*., (2018) reported that marination enhanced the flavour and aromatic sensory attributes of chicken breast fillets measured in their study.

The mean juiciness scores revealed significant differences (P<0.05) among the control and treated samples. The highest juiciness scores in T_3 samples as compared to the control samples were found. This might be due to the addition of rice beer and phyto-ingredients,

which contributed to higher retention of moisture in the meat samples as well as the taste of juiciness among the test panellists (Kyriakopoulou *et al* 2021].

The mean tenderness scores revealed no significant differences (P>0.05) among the control and treated samples. The marginally higher tenderness score offered by the panellist for T_3 samples. The mechanism by which marinade influences meat tenderization appears to involve several factors including weakening of structures due to meat swelling, an increase in proteolysis caused by cathepsins, and an increase in the conversion of collagen to gelatin at a low pH during cooking (Ertbjerg, *et al*., 1999).

8.5 Overall acceptability

The mean overall acceptability scores revealed significant differences (P<0.05) between the control and the treated samples. It has been observed from overall acceptability scores that the panellist offered the highest scores in T3 samples. Augustyn *et al*., (2019) recorded that the use of marinade has improved the sensory characteristics of pheasant breast muscles compared to the control group. It was shown that the muscles marinated with whey and buttermilk were characterized by significantly higher juiciness and tenderness and lower odour desirability as compared to the muscles marinated using lemon juice. Kim *et al.,* (2011)also stated that the use of acid whey for marinating beef improved the tenderness and juiciness of the product compared to the control group.

9. CONCLUSION

Based on the above findings, it can be concluded that the marination of duck meat with a marinade prepared in a combination of rice beer, phyto-ingredients and spice paste would be a helpful method to develop duck meat products with certain acceptable microbiological properties. It was clearly observed that the marinade prepared combining all the ingredients had significant effect on proximate composition, texture profile, colour profile and sensory evaluation. Considering the combined effect of rice beer, phyto-ingredients and spice paste as marinating ingredients in duck meat during refrigeration storage, it can be recommended that there is scope for commercial exploitation of this technology.

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Better of you could highlight the microbial involvement also – throughout the manuscript

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