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Development and quality evaluation of protein-rich meat biscuits by utilizing industrial by-products

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Abstract
The present study aimed to develop chicken meat and skin and rice polish incorporated biscuits and evaluate its quality during storage periods. Biscuits are ready-to-eat, convenient and cheap snack that are consumed by all age group. Biscuits are generally cereal based snacks, lacking in essential amino acids and dietary fibre. Incorporating chicken meat and chicken processing byproducts such as skin and rice polish is a by-product of rice obtained in the milling operation of brushing the grain to polish the kernel would increase the nutritive value and functional value of the biscuits. Minced broiler chicken meat and skin were used as protein sources. Chicken meat biscuits prepared with rice polish at 1, 2, 3 per cent and minced chicken skin at 10, 20, and 30 per cent, respectively replaced. Based on the findings of the current study, it was concluded that incorporating up to 20% chicken skin and 2% rice polish into chicken meat biscuit formulations is acceptable. Moreover, the prepared biscuits could be stored up to 90 days without noticeable changes.

Keywords: Chicken meat, rice polish, chicken skin, biscuits, shelf stable products

1. Introduction
Poultry meat consumption has increased continuously and the lifestyle changes have also greatly changed the way, in which poultry meat is marketed and consumed. There is huge demand for processed chicken meat products and its requirement mounting continuously with growing consumer's awareness about nutrition and quality. Chicken meat has a high nutritive value and is relatively cheaper in price (Suriani *et al*. 2014) [28]. In many countries of the world, biscuits are one of the most important popular bakery products for children and adults. They are high in carbohydrates, fat and calorie but low in fibre, vitamin, and mineral which make it unhealthy for daily use. It is an unleavened crisp, sweet pastry made from wheat flour, shortening (hydrogenated fat) and sugar, and is usually made light by the addition of baking powder (a mixture of sodium carbonate, sodium bi phosphate and cereal flour) (O'Brien *et al.* 2003) [20]. Because of its acceptability in all age group, longer shelf life, better taste and its position as snacks it is considered as a good product for protein fortification and other nutritional improvement (Serrem *et al.*2011) [25]. Quality evaluation of chicken meat incorporated biscuits assessed by various author (Berwal *et al.* 2013; Anil Bukya *et al.* 2013, and Kumar *et al.* 2016) [4, 1, 16]. Muthulakshmi *et al.* 2022 reported that broiler chicken meat contains about 24.22±0.16 per cent protein and also containing all essential amino acid. Muthukumar *et al.* 2011 [17] reported that broiler chicken skin and separable fat were around 8-10% of live weight. Chicken Skin and visible fat comprise 8-20% of chicken carcass weight, chicken with higher weight have higher percentage of skin and visible fat (Heydarpour *et al.* 2011) [13]. Vinothraj *et al.* 2020 [31] studied that Consumer's preference for quality attributes of chicken meat- An application of conjoint analysis. The results revealed that the ideal characteristic of chicken meat should be type (broiler bird), appearance (without skin) and form of meat (curry cuts).
Fallah-Delavar & Farmani, (2018) [11] reported that chicken skin is a major byproduct of the poultry industry. Chicken skin is a source rich in lipids (30%–40%) and protein (8%–12%). Chicken skin fat is composed of about 30% saturated fatty acids, 50% monounsaturated fatty

acids, and about 20% polyunsaturated fatty acids. In addition to these, other fatty acids of nutritional importance such as eicosapentaenoic acids and docosahexaenoic acids have also been identified (Dalziel, *et al.* 2015) [8]. Another important factor regarding protein content in the skin is the presence of collagen, about 3% (Choe and Kim 2019) [7]. This protein has some important properties when present in food, such as increased water retention capacity, gel formation, emulsion stability, and texture improvement. For these reasons the skin is a by-product often used mainly in meat products such as sausages and mortadella (Biswas *et al.* 2006, de Oliveira *et al.* 2011, Santos *et al.* 2020) [6, 9, 24]. Poultry meat consumption has increased continuously and the lifestyle changes have also greatly changed the way, in which poultry meat is marketed and consumed. The present study aimed to develop chicken meat and skin incorporated biscuits and evaluate its quality during storage periods.

Materials and Methods

Raw materials

Raw materials like broiler Chicken meat and skin, Rice Polish, Fresh refined wheat flour (maida), Wheat Flour, Sugar, Butter, Salt Sodium bi carbonate, sugar powder were procured from the local market.

Preparation of chicken meat and skin mince incorporated biscuits: The deboned frozen chicken meat and skin kept at refrigeration temperature (4±1ºC) before mincing through an meat mincer and then thoroughly kneaded for preparation of chicken meat and skin mince incorporated biscuits. Four types of biscuits were prepared by using different levels of chicken meat mince (CMM), chicken skin mince (CSM), refined wheat flour (maida), sugar, shortening and other ingredients as given in the Tables 1. All the ingredients were mixed in the bowl mixer for 2-3 minutes to make homogenous emulsion. Then the prepared emulsion was made in to desired shape at the end. The shaped emulsion was then dropped into steel trays and baked in preheated hot air oven at 150ºC for 15-20 min or till golden brown. Then ready cookies was cooled and packed in low density polyethylene (LDPE). Based on sensory evaluation up to 20 per cent chicken skin and 2 per cent rice polish incorporated biscuits were accepted by sensory panel. Further storage studies were conducted with T2 as a treated.

Table 1: Formulation for chicken meat biscuits incorporated with chicken skin and rice polish

Ingredients	Control	T1	T2	T3
Chicken meat (minced) (%)	42	31	20	9
Skin with separable fat (minced) (%)	-	10	20	30
Rice Polish (%)	-	1	2	3
Maida (%)	10	10	10	10
Wheat Flour (%)	10	10	10	10
Sugar (%)	25	25	25	25
Butter (%)	12.6	12.6	12.6	12.6
Salt (%)	0.1	0.1	0.1	0.1
Sodium bi carbonate (%)	0.1	0.1	0.1	0.1

Physical properties of chicken skin incorporated biscuit

Physical properties of control and treated biscuits were determined according to the procedure described by Pradhan *et al.* (2015) [21]. The diameter was measured with a calibrated ruler. The weight of the biscuits was measured using weighing balance. The spread ratio was calculated as weight/thickness.

Nutritional analysis

The proximate composition of control and treated biscuits determined by standard AOAC (2000) [2] methods.

Storage quality of chicken skin incorporated biscuit

pH

The pH of biscuits and cookies was determined by method of (Trout 1989) [29] with digital pH tester equipped with a combined glass electrode. For this, 10g of sample was homogenized with 50 ml distilled water for 1 min using pestle and mortar. The electrode was dipped into the suspension and the pH value of the sample was recorded after calibration with standard buffer.

Thiobarbituric acid (TBA) value

TBA, value was determined according to the method of (Witte *et al.* 1970) [32]. Ground biscuits and cookies (5g) sample was blended for 3 min with 25 ml of 20% TCA. Homogenized suspension was kept for 10 min. It was filtered through Whatman No.42 filter paper. Five ml TBA reagent was added to 5 ml of sample aliquot (filtrate). After mixing the contents, tubes were kept in a boiling water bath for 35 min. Optical density was measured at 532 nm spectrophotometrically. Blank was run simultaneously. For standard curve 1, 2, 3, 4 and 5 ml of working standard solution were used.

Free fatty acids

The method as described by (Koniecko 1979) [15] was followed for the estimation of free fatty acid. Exactly 5g of the Biscuits and Cookies sample was blended for 2 minutes with 30 ml of chloroform in the presence of anhydrous sodium sulphate. Then, it was filtered through Whatman filter paper No. 1 into a 500 ml conical flask. 2 or 3 drops of 0.2 per cent phenolphthalein indicator solution was added to the chloroform extract and titrated against 0.1N alcoholic potassium hydroxide with regular shaking till the end point, permanent pink colour appeared. The quantity of potassium hydroxide consumed during titration was recorded. Free fatty acids percent was calculated as follows:

$$\text{FFA\%} = \frac{0.1 \times \text{ml } 0.1\text{N alcoholic KOH} \times 0.282}{\text{Wt. of sample (g)}} \times 100$$

Microbiological quality: The microbiological quality of the chicken skin incorporated biscuits were assessed by enumerating standard plate count (SPC), *E.coli* coli, *Salmonella Campylobacter jejuni* counts and yeast and mould counts using standard procedure of (APHA,2015) [3].

Sensory evaluation: The sensory quality attribute of chicken skin incorporated biscuits were evaluated by semi trained panelists comprising of scientists and postgraduate students of the Department. sensory quality attributes *Viz.* Appearance and color, flavor, crispiness and overall acceptability using 8-point descriptive scale (Keeton, 1983) [14], where 8 extremely desirable and 1 extremely undesirable. Six sittings (n = 6) were conducted for each replicate. The samples were blind-coded by using 3-digit numbers and presented to the panelists in random order on white color glass plates in late afternoon. Water was served to the assessors for cleaning the palate while testing different samples. The panelists were seated in a room free of noise and odors and suitably illuminated with

natural light. Coded samples at a room temperature were presented to the panelists.

Statistical Analysis: Means and standard errors of the developed products were calculated for different parameters. Data was analyzed statistically on SPSS-16.0 (SPSS Inc., Chicago, IL, USA) software. package as per standard methods (Snedecor and Cochran, 1989) [27] for Analysis of Variance (ANOVA) and Duncan's multiple range test to compare the means. Duplicate samples were drawn for each parameter and whole set of experiment was replicated six (n = 6) for the consistency of the results. Mean values were reported along with standard error. The statistical significance was estimated at 5% level ($P<0.05$).

Results and Discussion

Chicken meat biscuits incorporated with 20% chicken skin and 2% rice polish were accepted by sensory panelist. Therefore, treated biscuits along with control were selected for physico-chemical, proximate analysis and storage stability at ambient temperature up to 90 days. The physical properties of chicken meat and skin incorporated biscuit were presented in table2.

Table 2: Physical properties of chicken skin and rice polish incorporated biscuit

Parameters	Control biscuit	Treated biscuit
Spread ratio (g/cm)	9.0	8.8
Weight (g)	17.0	18.0
Thickness (cm)	0.5	0.5
Diameter (cm)	4.5	4.5

It was observed, the diameter of cookies decreased gradually from 10 to 8.8 mm with addition broiler chicken skin. No trend was observed for weight of cookies because the baking was not performed under strict conditions of temperature and humidity. The spread ratio of cookies decreased significantly from 9 to 8.8 with incorporation of broiler chicken skin. The spread factor of cookies decreased from 100 to 91.5% with addition of broiler chicken skin. Reduced spread ratio and spread factor of cookies were attributed to the fact that composite flours of wheat and skin apparently form aggregates with increased number of hydrophilic sites available for competing, for the limited free water in cookies dough.

Table 3: Proximate composition of chicken skin and rice polish incorporated biscuit

Proximate composition	Control biscuit	Treated biscuit
Moisture (%)	4.65	4.81
Protein (%)	17.27	13.11
Fat (%)	15.85	22.64
Ash (%)	1.33	1.04

The pH, water activity, TBA and FFA of control and treated products during storage studies are presented in Table 4. The mean pH values showed decreasing trends throughout the storage period in control and treated biscuits. Among the biscuits studied, treated one recorded the lowest value and control recorded the highest during entire storage period. The linear decreasing trend of pH value might be due to production of acid by fermentation of sugar. Kumar *et al.* (2016) [16] also reported decreasing trend of pH in chicken meat biscuits incorporated with wheat and oat bran. However, (Singh *et al.* 2011, Muthulakshmi and Muthukumar (2020),) [26, 17] also reported gradual decrease in the pH of chicken snacks stored in laminated pouches at ambient temperature.

The water activity of biscuits has a significant impact on their shelf life. Biscuits with lower water activity have a longer shelf life, as they are less prone to microbial growth and enzymatic reactions that can lead to spoilage. The water activity of biscuits is an important factor in determining their shelf life. A water activity value between 0.35 and 0.56 indicates appropriate storability. Microbial growth is promoted with increasing water activity but cannot occur where a w < 0.6 (26). The water activity scores followed decreasing trend from day 0 to 90 in case of control and treated biscuits. The decreasing of water activity is agreed the study by Duta *et al.*,(2019) [10] it was observed that the moisture and water activity of biscuits decreased during storage, and the biscuits packed in BOPP/CPP_50 and PE/EVOH/PP_50 films had better moisture retention and lower water activity, resulting in improved physicochemical and sensory properties even after 90 days of storage. Similarly, in the study by (Duta *et al.* 2019) [10]., it was found that the occurrence of checking and breakage in biscuits was related to the distribution of water, with very small amount of water gradients playing a role. Therefore, controlling the water activity of biscuits through appropriate packaging materials can help extend their shelf life and maintain their quality. In contrast to present study results the water activity scores followed increasing trend from day 0 to 180 in case of control and bran added biscuits (kumar *et al.* 2016)) [16]. This might be possible due to absorption of moisture content in control as compared to bran added biscuits.

Thiobarbituric acid reacting substances (TBARS) values followed increasing trend from day 0 to 90 in case of both control and treated biscuits. Between control and treated biscuits, broiler chicken skin added biscuit showing highest values as compared to control biscuits. This may be due to the

Table 4: Physico-chemical characteristic of chicken skin and rice polish incorporated biscuit

Parameters		Storage period (days)						
		0	15	30	45	60	75	90
pH	C	6.79 ± 0.01^{e}	6.78 ± 0.00^{e}	6.75 ± 0.01^{d}	6.75 ± 0.00^{d}	6.73 ± 0.00^{c}	6.71 ± 0.01^{b}	6.69 ± 0.00^{a}
	T	6.76 ± 0.00^{e}	6.74 ± 0.00^{d}	6.73 ± 0.00^{c}	6.72 ± 0.00^{c}	6.67 ± 0.00^{b}	6.67 ± 0.01^{b}	6.64 ± 0.01^{a}
aw	C	0.38 ± 0.00^{e}	0.38 ± 0.00^{e}	0.37 ± 0.00^{d}	0.36 ± 0.01^{bc}	0.35 ± 0.01^{b}	0.35 ± 0.00^{b}	0.32 ± 0.01^{a}
	T	0.34 ± 0.00^{c}	0.35 ± 0.01^{c}	0.34 ± 0.01^{c}	0.32 ± 0.00^{b}	0.32 ± 0.00^{b}	0.31 ± 0.00^{a}	0.31 ± 0.00^{a}
TBA	C	0.64 ± 0.00^{a}	0.67 ± 0.01^{b}	0.72 ± 0.00^{c}	0.76 ± 0.01^{d}	0.82 ± 0.02^{e}	0.86 ± 0.01^{f}	0.92 ± 0.01^{g}
	T	0.66 ± 0.01^{a}	0.68 ± 0.00^{b}	0.74 ± 0.01^{c}	0.78 ± 0.00^{d}	0.86 ± 0.01^{e}	0.89 ± 0.00^{f}	0.94 ± 0.01^{g}
FFA	C	0.14 ± 0.01^{a}	0.14 ± 0.01^{a}	0.16 ± 0.00^{b}	0.18 ± 0.01^{c}	0.21 ± 0.00^{d}	0.23 ± 0.02^{d}	0.25 ± 0.01^{d}
	T	0.15 ± 0.00^{a}	0.15 ± 0.02^{a}	0.18 ± 0.00^{b}	0.21 ± 0.01^{c}	0.22 ± 0.01^{c}	0.24 ± 0.01^{c}	0.27 ± 0.01^{d}

Mean ± SE with at least one common superscript within classes do not differ significantly (p>0.05).
n =6 for each treatment

high fat content chicken skin. The increase in TBARS values on storage might be attributed to oxygen permeability of packaging material that led to lipid oxidation (Raja *et al.* 2014) [22]. Ratanatriwong *et al.* (2011) [23], Berwal *et al.* (2013) [4], kumar *et al.* (2016) [16] Berwal *et al.* (2018) [5], and Muthulakshmi and Muthukumar (2020) [18], reported gradual increase in the TBARS values in fish and chicken snacks, chicken meat mince incorporated biscuits, chicken pappad, chicken powder incorporated biscuits, chicken meat biscuits incorporated with oats and wheat bran respectively stored at ambient temperature. TBARS value of treated biscuits was higher as compared to control during entire storage period. This might be possibly due to high fat content in treated as compared to control biscuits. However, present study TBARS values were much lower than threshold value of 2 mg/kg.

FFA values followed a linear increasing trend from 0 to 90 days in skin added biscuit as well as control. FFA values of control were comparable at 0 and 30 days and thereafter showed significant increase (P<0.05) afterwards. FFA value of skin added biscuits recorded significant increase (P<0.05) after 30 days of storage. There was no significant difference observed among treatment and control products during entire storage. The increase in FFA value might be due to formation of lipid peroxides during storage (32). Similar findings have also been reported by Berwal *et al.* (2013) [4], Kumar *et al.* (2016) [16], Berwal *et al.* (2018) [5] and Muthulakshmi *et al.* 2020 [18] reported gradual increase in the FFA values in fish and chicken snacks, chicken meat mince incorporated biscuits, chicken pappad, chicken powder incorporated biscuits, chicken meat biscuits incorporated with oats and wheat bran respectively stored at ambient temperature.

Microbial Quality

The microbial quality of control and chicken skin incorporated biscuits was presented in Table 5. Total plate counts and Yeast and mould growth were only detected after the 90th day of storage and had very less growth 2 to 4 $\log_{10}$ cfu/g in both biscuits. Berwal *et al.* (2018) [5] reported that SPC values increased gradually by the 75th day in control and chicken meat powder-incorporated cookies. In control and treated biscuits, E.coli, Salmonella, Campylobacter jejuni and Staphylococcus aureus were not detected throughout storage periods. Biscuits are mostly unaffected by microbial activities because of low moisture content and water activity. Moreover processing (baking) at high temperatures destroys large number of micro-organisms. The noticed low microbial counts may be due to the post-processing contamination of biscuits. Fontana, 2020 [12] reported that microbial growth is promoted with increasing water activity but cannot occur where a w < 0.6.

Sensory Evaluation

The mean values of various sensory attributes *viz*. appearance and color, flavor, crispiness and over all acceptability of biscuits incorporated chicken skin along with control during ambient storage are presented in Table 5. The appearance and color score recorded a decreasing trend with the advancement of storage days. There was no significant difference among treatments. The gradual decrease in color and appearance scores on storage might be due to pigment and lipid oxidation resulting in nonenzymatic browning (Kumar *et al.* 2016) [16]. The color and appearance of meat biscuits were found to be acceptable by all sensory panelists throughout the storage period.

Table 4: Sensory quality of chicken skin incorporated biscuit

Biscuits/Sensory quality	Storage period (days)							Overall treatment mean
	0	15	30	45	60	75	90	
Colour and Appearance								
Control	7.71±0.06	7.68±0.07	7.67±0.05	7.63±0.08	7.58±0.04	7.53±0.03	7.44±0.04	7.60±0.04
Treatment	7.77±0.05	7.65±0.1	7.64±0.03	7.58±0.04	7.53±0.05	7.47±0.05	7.41±0.06	7.58±0.05
Overall storage period mean	7.74±0.05^{a}	7.67±0.08^{ab}	7.65±0.04^{ab}	7.60±0.06^{bc}	7.55±0.04^{bc}	7.50±0.04^{cd}	7.43±0.05^{d}	7.59±0.05
Flavour /taste								
Control	7.64±0.05	7.61±0.05	7.56±0.02	7.49±0.04	7.34±0.04	7.23±0.04	7.24±0.12	7.46±0.06
Treatment	7.72±0.02	7.63±0.07	7.62±0.07	7.56±0.05	7.38±0.05	7.21±0.05	7.18±0.06	7.46±0.07
Overall storage period mean	7.68±0.04 ^{a}	7.62±0.06 ^{ab}	7.59±0.05 ^{ab}	7.53±0.05 ^{b}	7.36±0.04^{c}	7.22±0.05^{d}	7.21±0.09 ^{d}	7.46±0.06
Texture/ Crispness								
Control	7.7±0.05	7.61±0.08	7.60±0.07	7.54±0.07	7.35±0.04	7.25±0.03	7.26±0.04	7.47±0.06
Treatment	7.8±0.06	7.53±0.07	7.58±0.02	7.45±0.04	7.34±0.04	7.37±0.1	7.23±0.04	7.47±0.06
Overall storage period mean	7.75±0.06^{a}	7.57±0.07^{b}	7.59±0.05^{b}	7.49±0.06^{b}	7.35±0.04^{c}	7.31±0.07^{c}	7.25±0.04^{c}	7.47±0.06
Over all acceptability								
Control	7.58±0.04	7.55±0.03	7.36±0.05	7.46±0.04	7.47±0.08	7.47±0.05	7.39±0.04	7.47±0.04
Treatment	7.52±0.07	7.48±0.05	7.5±0.06	7.46±0.06	7.41±0.08	7.38±0.07	7.39±0.07	7.45±0.05
Overall storage period mean	7.55±0.05^{a}	7.51±0.04 ^{ab}	7.43±0.06 ^{ab}	7.46±0.05 ^{ab}	7.44±0.07 ^{ab}	7.42±0.06 ^{ab}	7.39±0.05^{b}	7.46±0.04

Mean ± SE with at least one common superscript within classes do not differ significantly (p>0.05).
n =6 for each treatment

Flavour scores of control as well as skin incorporated biscuits showed a decreasing trend with the increasing storage days. This might be due to fat oxidation and formation of FFA. Berwal *et al.* (2013) [4], kumar *et al.* (2016) [16] and Berwal *et al.* (2018) [5] reported the same decreasing trends for flavour scores of meat biscuits. Among treatments, chicken skin incorporated biscuits showed numerically higher flavour scores as compared to control. This might be due to subcutaneous fat present in the chicken skin. Crispiness is an important parameter for the evaluation of the sensory attribute in snack products. There was no significant difference in crispiness score between skin incorporated chicken biscuit and control. This score decrease with progressive of storage period. Similar results were reported by Pasha *et al.* (2008) in wheat flour cookies supplemented with fiber from different sources. Significant decrease (P<0.05) was noticed in crispiness score with the progression of storage period; This might be due to hygroscopic nature of biscuit. Like other sensory attributes, Overall acceptability scores also showed similar pattern. The dressing trends concur with results of Berwal *et al.* (2013) [4], kumar *et al.* (2016) [16], Berwal *et al.* (2018) [5]. Overall acceptability for skin incorporated biscuits was similar to score of control biscuits during entire storage period and remained within acceptable limit.

Conclusion
The chicken meat biscuits formulated with up to 20% minced chicken skin and up to 2% rice polish were accepted. It could be stored at ambient temperature up to 90 days without any changes.

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Conflict of Interest
Not available

Financial Support
Not available

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