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Development And Quality Evaluation Of Low-Fat Chicken Nuggets Incorporated With Brown Rice Flour

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ABSTRACT

Chicken nuggets prepared by incorporating three different levels of brown rice flour along with other non-meat ingredients. The formulations prepared were – Control (0% brown rice flour), T1(2% brown rice flour), T2(4% Brown rice flour), T3(6% Brown rice flour). Among different treatments, brown rice flour at 6% produced significantly (P<0.05) higher emulsion stability, water holding capacity, pH and better sensory scores than rest of the formulations. Proximate composition of the study revealed significant (P<0.05) increase in moisture, protein, fiber and ash content. The texture profile analysis studies revealed a significant(P<0.05) increase in some parameters, which are gumminess, springiness and cohesiveness. The microbiological studies revealed that products were acceptable up to 9 days. Based on the results obtained in the study it might be concluded that chicken nuggets could be prepared satisfactorily on addition up to 6% brown rice flour without adverse effect on the quality of the products.

Key words: Brown rice flour, chicken nuggets, water holding capacity, texture profile analysis and proximate analysis.

INTRODUCTION

Livestock and meat production sector have immense contribution in the improvement of agrarian economy of the nation. Consumption of meat provides adequate quantity of protein, essential fats, dietary fiber, soluble vitamins and minerals and all these components have specific functional effect in our body. Poultry meat is the fastest growing component to cater the need for global demand of meat. During the last few decades, the consumption of poultry meat has increased tremendously. According to recent data for the year 2022, meat production from poultry is 4.78 million tonnes, contributing about 51.44% of total meat production. Along with a rise in productivity, the yearly per capita availability of meat increased to 2.5 Kg. In India, chicken meat accounts for 4.78 million tonnes of the country's 9.29 million tonnes of total meat production.

Many studies have shown that high animal fat intake relates to obesity, hypertension, cardiovascular disease and coronary heart disease because of high amounts of saturated fatty acids and cholesterol. In order to combat this, non-meat components such as dietary fibre could be used in place of animal fat. Dietary fiber can be added to emulsion-based meat products to increase water holding capacity, reduce cooking loss due to its water and fat binding

properties and to enhance the texture. It can also be used as a fat replacer. Brown rice (*Oryza sativa*) acts as a good source of dietary fiber which contains more bioactive compounds such as ferulic acid, oryzanol, and gamma aminobutyric acid (GABA), acylated steryl glycoside (Ohtsubo *et al.* 2005) and has good anti-oxidant properties. These include protocatechuic acid, p-coumaric acid, caffeic acid, ferulic acid, sinapic acid, vanillic acid, methoxy cinnamic acid, and tricin (Naseem Zahra and Shajia Jabeen 2020). Considering the above points, the study was conducted to identify the effects of the incorporation of brown rice flour as extenders at different levels for the preparation of chicken nuggets and to prepare meat product added with functional properties of brown rice.

Hygienically reared broiler birds were dressed and deboned manually in wet market to obtain deboned chicken meat. Neatly packed brown rice was purchased from local market and the brown rice was milled and sieved in nearby local mill shop to get brown rice flour.

Physico chemical properties: Emulsion stability

About 25 g of meat emulsion was taken in low density polyethylene bags and heated in a thermostatically controlled water bath at 80°C for 20 min. Then the exudate was drained out and dried with tissue paper and the cooked mass was weighed and the percentage of cooked mass was expressed as emulsion stability (Kondaiah *et al*., 1985).

Water-holding capacity (WHC)

Water-holding capacity was determined according to Wardlaw *et al.*, (1973). 20 g of sample was placed in a centrifuge tube containing 30 ml NaCl (0.6 M) and was stirred with glass rod for 1 minute. The tube was then kept at refrigeration temperature (4±1°C) for 15 min, stirred again and centrifuged at 3000 rpm using refrigerated centrifuge (Remi) for 15 min. The supernatant was measured and amount of water retained by samples was expressed as % WHC.

Cooking loss

Cooking loss per cent was determined by calculating the difference in weight of chicken meat nuggets before and after cooking in a water bath for 20 min.

Cooking loss= weight of raw meat – wt of cooked meat / wt of raw meat x 100

Texture Profile Analysis (TPA)

Cooked nuggets were evaluated for instrumental TPA (Bourne 1978). A Stable Microsystems Texturometer (Stable Microsystems Ltd., Surrey, U.K.) model TA-XT2 texture analyzer attached with software; texture expert was used for TPA analysis. Six cooked nuggets from each group were compressed twice to 50% of their original height. The parameters determined were: hardness (N) = maximum force required to compress the sample, gumminess (N) = force to disintegrate a semisolid meat sample for swallowing (hardness x cohesiveness), chewiness (Ncm) = work to masticate the sample for swallowing (springiness x gumminess), cohesiveness = extent to which sample could be deformed prior to rupture (A2/A1, A2 being maximum force required for the first compression and A2 being maximum force required for second compression), and springiness (cm) = ability of sample to recover to its original shape after deforming force was removed.

pH

The pH of samples was determined by homogenizing 10 g of sample with 50 ml distilled water with the help of tissue homogenizer (Daihan Scientifics, WiseMix, HG-15D, Korea) for 1 min. The pH was recorded using micro controlled based pH system with electrode (Model: 361, Systronics, India).

Proximate composition

The moisture content was determined by hot air oven drying, protein by automatic Kjeldahl method, fat by Soxhlet extraction with petroleum ether and total ash by muffle furnace as described in AOAC (2002). The crude fiber was determined according to the method of Prosky *et al.* (1988)

Free Fatty Acids

The method as described by Koniecko (1979) was followed, in which, exactly 5 g of the nuggets was blended with 30 ml of chloroform in the presence of anhydrous sodium sulphate for 2 min. It was then passed through Whatman No. 1 filter paper and filtrate was collected in a 250 ml conical flask. About 2 or 3 drops of 0.2% phenolphthalein indicator solution were added to the chloroform extract, which was titrated against 0.1 N alcoholic potassium hydroxide to get the pink colour end point. The quantity of potassium hydroxide consumed during titration was recorded. Free

fatty acids content was calculated and expressed as percentage as following

Free fatty acid % = 0.1 x ml 0.1N alcoholic KOH x 0:282/ Weight of sample (g) x 100

TBARS

Was performed using TBA test of Witte et al (1970), in which, TCA extract was first filtered through Whatman No. 1 filter paper (s. d. Fine Chemicals, Mumbai, India), and then 3 ml of this filtrate was mixed with 3 ml of 0.005 M TBA reagent, incubated at 27±2 °C under dark, and finally absorbance (O.D.) was taken at 532 nm wavelength using UV-VIS spectrophotometer (Elico make, USA). TBA value was calculated as mg malonaldehyde kg−1 of sample by multiplying O.D. value with K factor 5.2.

Microbial analysis

The microbiological quality of nuggets was assessed as per the method of APHA-American Public Health Association (1992) [5] for total plate count (TPC) and psychrophilic count

Sensory evaluation

The developed brown rice flour supplemented chicken nuggets were served to 6-member trained sensory panelists and evaluated for various sensory scores using a 9-point hedonic scale (where, 9 = can't think of no improvement, 1 = extremely undesirable) as prescribed by Keeton, (1983) with slight modifications as indicated in Annexure-II. Sensory evaluation was conducted between 3.30 PM to 4.00 PM and potable water was provided to the panelists for rinsing their mouth in between evaluation of different samples.

Statistical analysis

The data collected from different trials in each experiment underwent statistical analysis, which included Analysis of Variance (ANOVA) to assess variations and Duncan's multiple range test (DMRT) for comparing means. This analysis was carried out using the SPSS 20 software package.

RESULTS AND DISCUSSION

Physico chemical properties

Emulsion stability

Functional chicken nuggets extended with 6 per cent brown rice flour had significantly (P<0.05) higher percent emulsion stability than control and other treatments as shown in table 1. This might be due to high functional properties of added flour to hold the moisture in the emulsion. These results were in accordance with those of GV Bhaskar Reddy *et al*., (2018) in flax seed flour and Madane *et al.,* (2019) in drumstick flour and Thomas *et al*., (2006) in restructured buffalo meat nuggets at cold storage.

Cooking loss

Functional chicken nuggets extended with 6 per cent brown rice flour had significantly (P<0.05) lower percent cooking loss than control and other treatments as shown in table 1. This might be due to water binding capacity of the added flour that absorbs moisture from the emulsion lowering the loss of moisture during cooking. These results were in accordance with those of Maheswara Reddy *et al.,* (2017) in oat flour, Huang *et al*. (1999) in sorghum flour and Shoaib *et al.,* (2018) in different extenders (rice protein isolates, pea protein isolates).

Water holding capacity (WHC)

Functional chicken nuggets extended with 6 per cent brown rice flour had significantly (P<0.05) higher percent water holding capacity than control and other treatments as shown in table 1. This might be due to higher level of flour retains more water, thereby increasing the water-holding capacity and also due to the formation of more stable meat-protein-matrix which leads to a smaller release of water thus improving binding properties. These results were in accordance with those of Rindhe *et al.,* (2018) in hydrated wheat bran, Maheswara Reddy *et al.,* (2018) in oat flour, GV Bhaskar Reddy *et al*., (2018) in flax seed flour and Shoaib *et al*., (2018) in different extenders (rice protein isolates, pea protein isolates).

Samples	Emulsion stability	Cooking loss	WHC
Control	6.7±0.08^{d}	74.26±0.49^{d}	84.25±0.72^{a}
T1 (2%)	5.84±0.01^{c}	76.6±0.11^{c}	87.09±0.78^{b}
T2 (4%)	3.68±0.18^{b}	78.31±0.06^{b}	93.95±0.78^{c}
T3 (6%)	1.2±0.03^{a}	80.34±0.14^{a}	97.14±0.72^{d}

Texture profile analysis

Hardness

Functional chicken nuggets extended with 6 per cent brown rice flour had significantly (P<0.05) higher hardness than control and other treatments as shown in table 2. The significant increase might be due to 6% brown rice

retains more water thus increasing the penetration value (Reddy *et al.,* 1999). More water binding sites become available to dissociated protein subunits upon heat treatment. The results obtained were on par with studies of Yang *et al.,* (2007,2009) in pork and duck meat sausages respectively. These results were in accordance with those of Choi *et al.,* (2011) in pork brown rice fiber, Mendoza *et al*., (2001) dietary inulin and Santhi D, Kalaikannan *et al.,* (2014) in oat flour.

Springiness

Springiness value of chicken nuggets incorporated with increasing levels of brown rice flour does not differ significantly (P<0.05) from control to the treated formulations. 6 percent brown rice incorporation nuggets show high springiness value as shown in table 2. Springiness values were related to the elastic properties of nuggets, so decrease in the springiness indicated that the elasticity of nuggets is decreased with the increase in level of incorporation of brown rice flour. It might be due to the formation of gel with the incorporation of brown rice flour on cooking which lead to decrease in elasticity properties sarıcoban *et al*., (2007). These results were in accordance with those of Rindhe *et al*., (2018) in hydrated wheat bran, Choi *et al*., (2011) in brown rice fiber, Mendoza *et al*., (2001) extended with dietary inulin and Santhi D, Kalaikannan *et al*., (2014) in oat flour.

Gumminess

Functional chicken nuggets extended with 6 per cent brown rice flour had significantly (P<0.05) higher gumminess than control and other treatments as shown in table 2. Increase in gumminess value might be due to brown rice flour has high water and fat absorption properties and helps meat protein to form a three-dimensional structure by gelatinization of protein and starch. These results were in accordance with those of Choi *et al.,* (2011) in brown rice fiber, Mendoza *et al.,* (2001) extended with dietary inulin, Santhi D, Kalaikannan *et al*., (2014) in oat flour and Devatkal *et al.,* (2011) in sorghum flour.

Cohesiveness

Chicken meat nuggets incorporated with brown rice flour shows non-significant (P<0.05) increases in cohesiveness. Brown rice incorporated at 6% level shows highest cohesiveness value compared to other treatments as shown in table 2. Non-significant (P<0.05) increases in cohesiveness might be due to, addition of dietary fibre to the meat system could disrupt the protein-water or protein-protein gel network which, in turn, could decrease the gel strength of the products (Lin et al., 1988). These results were in accordance with those of Choi et al., (2011) in brown rice fiber, Mendoza *et al.,* (2001) extended with dietary inulin, Santhi D, Kalaikannan *et al.,* (2014) in oat flour and Devatkal *et al.,* (2011) in sorghum flour.

Chewiness

Functional chicken nuggets extended with 6 per cent brown rice flour had significantly (P<0.05) higher chewiness than control and other treatments as shown in table 2. Increase in gumminess value might be due to increase of hardness values (Reddy *et al.,* 1999), Yang *et al*., (2007,2009). These results were in accordance with those of Choi *et al*., (2011) in brown rice fiber, Mendoza *et al.,* (2001) extended with dietary inulin and Santhi D, Kalaikannan (2014) in oat flour.

Effect of different levels of brown rice flour on the texture profile analysis of chicken meat nuggets

Parameter	control	2%(T1)	4%(T2)	6%(T3)
Hardness	0.23 ± 0.14^{a}	0.27 ± 0.15^{ab}	0.31 ± 0.15^{b}	0.41 ± 0.22^{c}
Springiness	0.9 ± 0.21^{a}	0.91 ± 0.22^{ab}	0.92 ± 0.19^{b}	0.92 ± 0.18^{c}
Cohesiveness	0.55 ± 0.18^{a}	0.48 ± 0.20^{ab}	0.52 ± 0.20^{c}	0.54 ± 0.24^{b}
Gumminess	0.14 ± 0.22^{a}	0.20 ± 0.18^{ab}	0.17 ± 0.19^{c}	0.21 ± 0.18^{b}
Chewiness	0.12 ± 0.19^{a}	0.13 ± 0.18^{ab}	0.15 ± 0.17^{c}	0.23 ± 0.13^{b}

Means bearing different superscripts in the column and row differ significantly (p<0.05)

Proximate composition
Percent moisture

Functional chicken nuggets extended with 6 per cent brown rice flour had significantly (P<0.05) higher percent moisture than control and other treatments as shown in table 3. This might be due to increase in the levels of brown rice flour, which absorbs water during the emulsion preparation (Park *et al*., 2017). These results were in accordance with those of K Richa *et al*., (2020) in black rice, Choi *et al*., (2011) in brown rice fiber and Santhi and Kalaikannan (2014) in oat flour.

Percent fiber

Functional chicken nuggets extended with 6 per cent brown rice flour had significantly (P<0.05) higher percent fiber than control and other treatments as shown in table 3. This might be due to increase levels of brown

rice flour as brown rice acts as an excellent dietary fiber source. These results were in accordance with those of G V Bhaskar Reddy *et al*., (2018) in flax seed flour, Santhi and Kalaikannan (2014) in oat flour.

Percent protein

Functional chicken nuggets extended with 6 per cent brown rice flour had significantly (P<0.05) higher percent protein than control and other treatments as shown in table 3. The increase in the protein content might be due to higher percent of protein (8-9g) in brown rice. These results were in accordance with those of G V Bhaskar Reddy *et al.,* (2018) in flax seed flour, Choi *et al.,* (2011) in brown rice fiber. These results were contrary with K Richa *et al.,* (2020) in black rice and Santhi and Kalaikannan (2014) in oat flour.

Percent ash

Functional chicken nuggets extended with 6 per cent brown rice flour had significantly (P<0.05) higher percent ash than control and other treatments as shown in table 3. The increase in the ash content might be due to higher percent of ash in brown rice (choi *et al.,* 2011). These results were in accordance with those of K Richa *et al*., (2020) in black rice, G V Bhaskar Reddy *et al.,* (2018) in flax seed flour and Choi *et al.,* (2011) in brown rice fiber.

Percent fat

The percent fat content of chicken nuggets incorporated with increasing levels of brown rice flour does not differ significantly (P<0.05) in fat content from control to the treated formulations as shown in table 3. 6 percent brown rice incorporation nuggets show high fat content. This might be due to increase in the levels of brown rice flour in the chicken nuggets (Luruena-Martinez *et al.,* 2004). These results were in accordance with those of Choi *et al.,* (2011) in brown rice fiber, K Richa *et al*., (2020) in black rice and Santhi and Kalaikannan (2014) in oat flour.

pH

Chicken meat nuggets extended with brown rice flour shows significantly (P<0.05) increase in pH value of treatments during refrigerated (4±1°C) storage for 9 days as shown in table 4. This might be due to bacteria on exhaustion of stored glucose, utilize amino acids released during protein breakdown and ammonia accumulates as a product of amino acid degradation and the pH rises (Gill 1983) and also due to more amount of iron, phosphorus and calcium (Choi et al., 2011). These results were in accordance with those of choi *et al*., (2011) in brown rice flour and Choudhary *et al.,* (2019) in Bengal gram flour.

Free fatty acid

Chicken meat nuggets extended with brown rice flour shows significantly (P<0.05) increase in free fatty acid value of treatments during refrigerated (4±1°C) storage for 9 days as sown table 4. This might be due to antioxidant property of brown rice and might be due to the process of lipolysis, lipases split the glycerides and forms free fatty acids which are responsible for common off-flavour, frequently referred to as rancidity. These results were in accordance with those of Rahman *et al.,* (2020) in moringa flour and Das *et al.,* (2008) in soy paste.

TBARS

Chicken meat nuggets extended with brown rice flour shows significantly (P<0.05) increase in 2-TBARS value of treatments during refrigerated (4±1°C) storage for 9 days as shown in table 4. This might be due to non-air tight packaging of chicken nuggets and also due to increase of lipid oxidation and production of volatile metabolites during storage. These results were in accordance with those of Anandh (2014) in chicken meat balls during refrigerated storage, Kumar *et al*., (2011) in green banana and soybean hull flours and Kumar *et al.,* (2020) in groundnut flour**.**

Effect of different levels of brown rice flour on the proximate composition of chicken meat nuggets

Parameter	control	2%(T1)	4%(T2)	6%(T3)
Moisture	58.13±0.72^{a}	58.84±0.77^{b}	59.38±0.78^{c}	60.25±0.76^{d}
Protein	12.96±0.77^{a}	13.73±0.77^{b}	14.6±10.77^{c}	15.53±0.77^{d}
Fiber	3.36±0.34^{d}	4.33±0.33^{c}	4.91±0.39^{b}	6.24±0.45^{a}
Total ash	0.97±0.24^{a}	1.33±0.24^{b}	1.52±0.34^{c}	1.98±0.33^{d}
Fat	29.69±0.76^{a}	29.68±0.76^{ab}	29.64±0.76^{c}	29.62±0.76^{b}

Means bearing different superscripts in the column and row differ significantly (p<0.05)

MICROBIAL COUNT

Total plate count

Chicken meat nuggets extended with brown rice flour shows significant (P<0.05) increase in total plate count of treatments during refrigerated (4±1°C) storage for 9 days. This may be due to permissive temperature and relative availability of moisture and carbohydrate substrate for microbial growth (Zargar et al., 2014) also due to permissive temperature and relative availability of moisture and nutrients for the growth of mesophilic bacteria (Nagamallika 2003) and also might be due to contamination during handling of meat during the processing meat products (Lukose *et al.,* 2015). These results were in accordance with those of Reddy G V (2023) in dried powders, Choudhary *et al*., (2019) in Bengal gram flour and Zargar *et al.,* (2014) in pumpkin flour.

Psychrophilic count

Chicken meat nuggets extended with brown rice flour shows significant (P<0.05) increase in psychrophilic count of treatments during refrigerated (4±1°C) storage for 9 days. In first 5 days of storage growth of bacteria was nil due to bacteria need some lag phase before active multiplication is initiated (Bhat 2013). Absence of psychotrophs in the initial phase of storage may be due to cooking of product at high temperature followed by storage at low temperature resulting in retardation of microbial growth due to temperature shock (Zargar *et al*., 2014), also due to temperature variance for the growth of psychrophilic bacteria during refrigerated (4±1°C) storage. The results were in accordance with those of K Richa *et al*., (2020) in chicken nuggets extended with black rice, Reddy G V (2023) in chicken koftas extended with dried powders and Choudhary *et al.,* (2019) in quail meat nuggets extended with Bengal gram flour.

Sensory evaluation

Colour

Chicken meat nuggets extended with brown rice flour shows significant (P<0.05) decrease in colour score of treatments during refrigerated (4±1°C) storage for 9 days.

Effect of adding various concentrations of brown rice flour on pH, FFA, 2-TBARS and microbial count of chicken nuggets at refrigerated storage (4±1°C)

Parameters	treatments	Storage days			
		0	3	6	9
pH	control	6.46±0.02^{a}	6.48±0.01^{a}	6.52±0.01^{a}	6.54±0.01^{a}
	2%(T1)	6.54±0.02^{b}	6.59±0.01^{b}	6.62±0.01^{b}	6.64±0.01^{b}
	4%(T2)	6.64±0.02^{c}	6.64±0.01^{bc}	6.66±0.01^{bc}	6.68±0.01^{bc}
	6%(T3)	6.64±0.02^{c}	6.67±0.01^{c}	6.68±0.01^{c}	6.71±0.01^{c}
Free fatty acid	control	0.12±0.02^{a}	0.12±0.02^{a}	0.18±0.02^{a}	0.24±0.02^{a}
	2%(T1)	0.13±0.02^{a}	0.12±0.01^{a}	0.23±0.02^{b}	0.26±0.02^{b}
	4%(T2)	0.16±0.02^{a}	0.17±0.02^{a}	0.26±0.02^{ab}	0.29±0.02^{b}
	6%(T3)	0.14±0.02^{a}	0.17±0.02^{a}	0.27±0.02^{a}	0.37±0.02^{b}
2-TBARS	control	0.19±0.04^{a}	0.51±0.04^{a}	1.00±0.04^{a}	1.95±0.04^{a}
	2%(T1)	0.17±0.03^{a}	0.35±0.03^{ab}	0.67±0.03^{c}	1.08±0.03^{b}
	4%(T2)	0.25±0.03^{a}	0.41±0.03^{b}	0.42±0.03^{ab}	1.05±0.03^{c}
	6%(T3)	0.30±0.02^{a}	0.63±0.02^{a}	0.88±0.02^{ab}	1.67±0.02^{b}
Total plate count	control	3.68±0.03^{a}	3.98±0.03^{b}	4.28±0.03^{c}	4.58±0.03^{ab}
	2%(T1)	3.34±0.03^{c}	3.64±0.03^{b}	3.94±0.03^{a}	4.24±0.03^{c}
	4%(T2)	3.04±0.03^{a}	3.34±0.03^{a}	3.64±0.03^{b}	3.94±0.03^{c}
	6%(T3)	2.88±0.03^{b}	3.18±0.03^{c}	3.48±0.03^{a}	3.78±0.03^{a}
Psychrophilic count	control	NS	NS	2.47±0.02^{a}	3.09±0.01^{b}
	2%(T1)	NS	NS	2.45±0.01^{a}	3.05±0.01^{b}
	4%(T2)	NS	NS	2.47±0.02^{b}	3.07±0.01^{a}
	6%(T3)	NS	NS	2.46±0.01^{a}	3.03±0.01^{b}

Means bearing different superscripts in the column and row differ significantly (p<0.05)

Effect of adding various concentrations of brown rice flour on sensory properties of chicken nuggets at refrigerated storage (4±1°C)

Parameters	treatments	Storage days			
		0	3	6	9
Colour	control	7.85±0.34^{a}	7.64±0.34^{b}	7.50±0.36^{a}	6.92±0.30^{c}
	2%(T1)	7.75±0.34^{a}	7.55±0.34^{ab}	7.35±0.32^{b}	6.82±0.30^{a}
	4%(T2)	7.64±0.34^{b}	7.45±0.34^{a}	7.29±0.34^{c}	6.52±0.30^{a}
	6%(T3)	7.55±0.34^{c}	7.35±0.34^{b}	6.73±0.31^{a}	6.32±0.30^{a}
Flavour	control	7.36±0.26^{a}	7.16±0.26^{ab}	6.96±0.26^{a}	6.76±0.26^{b}
	2%(T1)	7.65±0.22^{c}	7.50±0.22^{c}	7.30±0.22^{b}	7.11±0.22^{a}
	4%(T2)	8.08±0.26^{a}	7.88±0.26^{c}	7.67±0.26^{c}	7.47±0.26^{b}
	6%(T3)	8.27±0.29^{c}	8.07±0.29^{ab}	7.87±0.29^{a}	7.67±0.29^{b}
Texture	control	7.37±0.26^{b}	7.16±0.27^{b}	6.96±0.27^{b}	6.76±0.27^{a}
	2%(T1)	7.70±0.27^{a}	7.50±0.27^{a}	7.30±0.27^{a}	7.10±0.27^{b}
	4%(T2)	8.45±0.25^{b}	8.25±0.25^{bc}	8.05±0.25^{b}	7.85±0.25^{a}
	6%(T3)	8.37±0.30^{ab}	8.19±0.30^{a}	8.00±0.30^{b}	7.80±0.30^{a}
juiciness	control	8.70±0.23^{c}	8.50±0.23^{c}	8.30±0.23^{a}	8.10±0.23^{b}
	2%(T1)	8.47±0.24^{b}	8.27±0.24^{b}	8.07±0.24^{b}	7.87±0.24^{a}
	4%(T2)	8.37±0.24^{a}	8.17±0.24^{a}	7.97±0.24^{c}	7.77±0.24^{b}
	6%(T3)	7.43±0.27^{a}	7.23±0.27^{c}	7.03±0.27^{a}	6.83±0.27^{b}
Overall acceptability	control	7.80±0.22^{b}	7.60±0.22^{a}	7.40±0.22^{c}	7.20±0.22^{a}
	2%(T1)	8.28±0.16^{c}	8.08±0.16^{c}	7.88±0.16^{a}	7.68±0.16^{b}
	4%(T2)	8.57±0.14^{ab}	8.37±0.14^{b}	8.17±0.14^{a}	7.97±0.14^{a}
	6%(T3)	8.44±0.15^{ab}	8.24±0.15^{b}	8.04±0.15^{a}	7.84±0.15^{c}

Means bearing different superscripts in the column and row differ significantly ($p<0.05$)

The gradual decrease in colour on storage might be due to pigment and lipid oxidation resulting in nonenzymatic browning. The results were in accordance with those of Pavan Kumar *et al.,* (2016) in oat bran and Devalakshmi *et al.,* (2010) in different extenders (Bengal gram flour, black gram, cooked mashed potato).

Flavour

Chicken meat nuggets extended with brown rice flour shows significant (P<0.05) decrease in flavour score of treatments during refrigerated (4±1°C) storage for 9 days. The gradual decrease in flavour on storage might be due to fat oxidation and formation of free fatty acids and loss of volatile flavour components from spices and condiments. The results were in accordance with those of Pavan Kumar *et al*., (2016) in wheat and oat bran and Devalakshmi *et al*., (2010) in different extenders (Bengal gram flour, black gram, cooked mashed potato).

Juiciness

Chicken meat nuggets extended with brown rice flour shows significant (P<0.05) decrease in juiciness score of treatments during refrigerated (4±1°C) storage for 9 days. The gradual decrease of juiciness on storage might be due to dehydration and moisture reduction of product with progression of refrigerated storage and also might be due to moisture loss coupled with increasing microbial load leading to altering disulphide bonds and protein denaturation lowering water binding activity (Jay 1996). The results were in accordance with those of Reddy G V (2023) in vegetable dried powders and Kumar *et al.,* (2006) in different extenders (sorghum flour, barley flour and pressed rice flour).

Texture

Chicken meat nuggets extended with brown rice flour shows significant (P<0.05) decrease in texture score of treatments during refrigerated (4±1°C) storage for 9 days. The gradual decrease of texture on storage might be due to some dehydration which leads to hardening of the texture and also due to breakdown of fat as well as protein (Bhat *et al.,* 2013). The results were in accordance with those of Reddy G V (2023) in vegetable dried powders and Kumar *et al.,* (2006) in different extenders (sorghum flour, barley flour and pressed rice flour).

Overall acceptability

Chicken meat nuggets extended with brown rice flour shows significant (P<0.05) decrease in overall acceptability score of treatments during refrigerated (4±1°C) storage for 9 days. The gradual decrease of overall acceptability score might be due to lowering of colour, flavour, juiciness and texture of the product during storage (Verma *et al*., 2016). The results were in accordance with those of Reddy G V (2023) in vegetable dried powders, Pavan Kumar et al., (2016) in what and oat bran, Devalakshmi *et al.,* (2010) in different extenders (Bengal gram flour, black gram, cooked mashed potato) and Kumar *et al*., (2006) in different extenders (sorghum flour, barley flour and pressed rice flour).

CONCLUSION

The inclusion of 6% brown rice flour in chicken meat nuggets resulted in superior physico-chemical attributes, such as emulsion stability, water holding capacity, cooking loss, pH, 2-TBARS and free fatty acid when compared to the control and other treatment groups. Additionally, these nuggets received higher sensory scores for colour, texture and overall acceptability. Consequently, it can be recommended that the use of 6% brown rice flour is a viable option to maintain the quality of meat products.

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