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Development of Low-Fat Chicken Nuggets Using Inulin and Hydroxy Propyl Methyl Cellulose

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A B S T R A C T

This study was aimed to evaluate the effect of Inulin and Hydroxypropyl Methylcellulose (HPMC) as functional fat replacers on the quality characteristics of chicken nuggets. Thirteen formulations (T_1 to T_{13}) were developed with varying levels of Inulin (5%, 10%, 15%) and HPMC (0%, 0.5%, 0.75%, 1.0%), partially replacing chicken skin to reduce overall fat content. The nuggets were assessed for cooking yield, emulsion stability and sensory attributes including appearance, flavour, texture, juiciness, mouth coating and overall acceptability. Results revealed that the T_{13} formulation (15% Inulin and 1% HPMC) significantly ($p < 0.01$) improved cooking yield and emulsion stability, while also achieving the highest scores across most sensory parameters. These improvements were attributed to better cooking yield and emulsion formation facilitated by the functional properties of Inulin and HPMC. In conclusion, the combined use of Inulin and HPMC offers a promising strategy for reducing fat content in chicken nuggets without compromising sensory quality, thereby supporting the development of healthier meat based convenience foods that align with evolving consumer preferences.

Introduction

The poultry industry stands as one of the most rapidly expanding segments within the global livestock sector. Over the last 15 years, both the production and consumption of poultry meat have surged significantly, driven by the growing need for affordable and high-quality animal based protein sources (FAO, 2023). Data from the Basic Animal Husbandry Statistics (BAHS, 2024) indicate that broiler chickens dominate poultry meat output, underlining their crucial role in both economic development and nutritional security. Notably, per capita meat availability increase from 7.10 kg in 2022–23 to 7.41 kg in 2023–24. Factors such as increasing urbanization, evolving food preferences and a rising demand for convenient, ready-to-eat meals have further fueled the expansion of the poultry processing sector (FAO, 2023).

Among value-added poultry products, comminuted meat items are especially popular due to their ease of preparation and favourable taste profile. However, their relatively high production costs can limit accessibility, especially in resource-constrained regions. This challenge has led to growing interest in incorporating economical meat extenders and additives to make such products more affordable (Biswas *et al.,,* 2006). Although chicken fat is an edible by product, it is generally underutilized in India due to low consumer preference, creating a demand for healthier and more acceptable fat alternatives. Chicken nuggets in particular, have gained widespread popularity for their taste, convenience and compatibility with quick service restaurant menus. However, traditional formulations often include substantial amounts of fat mainly from animal sources or added oils which poses health risks such as obesity, hypertension and cardiovascular issues (Mohan *et al.,* 2022). A viable strategy to mitigate fat content in fried meat products involves applying edible coatings, which not only enhance product appearance and texture but also help limit oil absorption during frying. Coated chicken nuggets, therefore, have become a favoured option for health-conscious consumers (Soorgi *et al.,* 2011).

To align with the growing demand for nutritious yet palatable meat options, researchers are exploring the incorporation of functional ingredients like dietary fibers and hydrocolloids. Inulin, a naturally occurring prebiotic fiber, offers dual benefits as a fat replacer and a textural enhancer. Similarly, Hydroxy Propyl Methyl Cellulose (HPMC) a water-soluble cellulose derivative has shown promise due to its emulsifying ability and moisture retention properties. Recent studies advocate for the combined application of Inulin and HPMC in meat products to reduce fat content while maintaining product yield, sensory qualities and consumer acceptance (Kumar *et al.,* 2023; Sharma *et al.,* 2022). In this context, the current study is designed to assess the impact of using Inulin and HPMC as fat substitutes on the quality parameters of chicken nuggets, with the objective of developing a healthier alternative that does not compromise on texture, taste or overall appeal.

Materials and Methods

Raw materials

Fresh, boneless, skinless, chicken breast meat and chicken skin was used in this study. It was obtained from nearby reputed retail shop. The chicken meat was stored in a freezer at -18^{o} C and thawed in the refrigerator at temperature of 4^{o}C overnight before used. Sodium triphosphate, Inulin and Hydroxypropyl methylcellulose was procured from standard approved companies. All other ingredients viz., all-purpose flour, White pepper powder, Salt, Fresh Ginger & Garlic paste, Fresh Onion, bread crumbs and Refined Cooking oil were procured from local super market, Hosur.

Development of low fat Chicken Nuggets using Inulin and HPMC

The Chicken nuggets were prepared as the method suggested by Verma *et al.,* (2024) with slight modification based on the needs of the research study. The thawed meat was then chopped into small pieces and minced using a 4 mm grinder plate. Measured amounts of salt, all-purpose flour, sodium tripolyphosphate, pepper and condiments were added according to the formulation.

Meat emulsions were prepared using a bowl chopper. Initially, minced meat was blended with salt and sodium tripolyphosphate for approximately 1.5 minutes. Crushed ice was then incorporated, followed by additional blending for 1 minute. Chicken skin was added next and mixed for 1–2 minutes. Subsequently, condiments, white pepper powder, flour and Inulin were added and the mixture was chopped until a homogenous emulsion with desired consistency was formed. Different levels of Inulin was added in gel form (1 part Inulin: 3 parts water), prepared 24 hours prior to use (Table.1). Before nugget formulation, the gel was thawed at refrigeration temperature and incorporated directly to the mixture (Cegielka and Tambor, 2012).

Meat emulsion was placed into square molds and compressed to eliminate air pockets. Molded samples were frozen at −20 ± 1°C for 30 minutes to retain shape before further processing. Batter was prepared using different levels of HPMC solutions prepared following the method described by Lim *et al.,* (2009) (0.5%, 0.75% and 1%) (Table.1). the frozen molded nuggets were immersed in chilled batter (0–2°C). Uniform coating was ensured by manual dipping prior to the breading stage. The breaded nuggets were fried in refined cooking oil at 175±5°C for 3 minutes. Fried nuggets were drained on absorbent paper towels and cooled to room temperature (25°C). The samples were packed in HDPE bags and stored at -18°C. Hygienic practices were applied during the preparation, packaging and storage processes of the chicken nugget products.

Sensory Evaluation of developed Chicken Nuggets

Prepared nugget samples from each treatment were presented to semi-trained panellists from the College of Poultry Production and Management, Hosur. Sensory attributes such as appearance, flavor, texture, juiciness, mouth feel and overall acceptability were assessed using a 9-point hedonic scale, where 1 indicated "extremely undesirable" and 9 denoted "extremely desirable." The treatment with the highest sensory score was identified for standardization (Abialal *et al.,* (2022)).

Emulsion stability and Cooking yield

Emulsion stability was determined following the method of Baliga and Madaiah (1970) with slight modifications. A 20 g portion of the meat emulsion was sealed in LDPE bags and heated in a thermostatically controlled water bath at 80 ± 1 °C for 20 minutes. After heating, the samples were cooled to room temperature and the exuded liquid was drained. The final weight of the sample was recorded and emulsion stability was calculated as described by Eswarapragada *et al.,* (2010). Cooking yield was calculated by recording the weight of nuggets before and after cooking using the formula provided by Yogesh *et al.,* (2013).

Result and Discussion

Sensory Evaluation of Developed Chicken Nuggets

The sensory evaluation of chicken nuggets for appearance, flavor, texture, juiciness, mouth coating and overall acceptability revealed distinct variations among the treatment groups are summarized in Table 2. Appearance scores remained consistent across treatments, ranging between 7.41 ± 0.03 (T_1) and 7.52 ± 0.04 (T_{13}), with no significant differences ($p < 0.01$), suggesting that incorporation of Inulin and HPMC did not compromise the visual appeal of the product. Flavor scores varied from 7.84 ± 0.10 in T_1 to 8.49 ± 0.02 in T_{13}, with the latter showing a statistically higher preference, followed by notable improvements in T_3, T_5, T_8, T_9 and T_{12}. Texture evaluation showed values ranging from 8.16 ± 0.05 (T_1) to 8.43 ± 0.03 (T_{13}), where the superior textural quality in T_{13} was attributed to improved binding and moisture retention. Juiciness was rated between 8.15 ± 0.04 (T_1) and 8.54 ± 0.02 (T_{12} and T_{13}), with treatments T_8, T_{12} and T_{13} showing significant improvements over the control, reflecting better water holding capacity. Mouth coating scores, though closely ranged showed a marginal yet significant increase in T_{13} (7.44 ± 0.04) compared to T_1 (7.33 ± 0.04), while other treatments did not differ significantly. Overall acceptability followed a similar trend, with values between 7.96 ± 0.08 (T_1) and 8.46 ± 0.02 (T_{13}), wherein T_{13} was rated the highest, and formulations T_{12}, T_5, T_8 and T_9 also demonstrated high consumer acceptance, whereas the control recorded the lowest score.

The current findings are supported by Mahmud *et al.,* (2024), who reported that HPMC oleogel and curcumin incorporation improved juiciness and texture without compromising sensory quality. El-Anany *et al.,* (2020) also found that texture improved with cauliflower based fat replacements, while appearance remained largely unaffected. Similarly, Kiran *et al.,* (2019) concluded that even with minor physico-chemical changes during formulation, sensory scores remained high across poultry products. Verma *et al.,* (2012) also reported that the strategic inclusion of binders and functional ingredients improved flavour, texture and moisture retention findings consistent with the positive effects observed from Inulin and HPMC in the present study.

Cooking Yield

The cooking yield percentages of Chicken Nuggets for all treatments are presented in Table 3. The cooking yield of chicken nuggets across different treatments ranged from 89.46 ± 0.19% to 92.93 ± 0.29%. The lowest yield was observed in T_5 (89.46 ± 0.19%), which was statistically comparable with the control (T_1) 89.52 ± 0.76%, while the highest values were recorded in T_{13} (92.93 ± 0.29%), followed closely by T_{12} (92.88 ± 0.16%) and T_{11} (92.24 ± 0.27%). Statistical analysis ($p < 0.01$) confirmed that these treatments showed significantly higher cooking yields compared to the control.

Fig.1 Preparation of chicken nuggets (Verma *et al.,* 2024)

Frozen deboned chicken meat at -18±1°C

⇩

Thawing of chicken meat 4±1°C for 16-18 hours

⇩

Deboned thawed chicken meat

⇩

Cutting into small chunks

⇩

Mincing of meat using a meat mincer fitted with a 4mm plate

⇩

Meat was chopped in bowl chopper for 1 minute

⇩

Chopping with salt and STPP for 1.5 minutes

⇩

Addition of water in the form of ice flakes & Chopping for 1 minute

⇩

Addition of chicken skin& Chopping for 1-2 minutes

⇩

Addition of condiments mixture, white pepper powder, all purpose flour and Inulin & Chopping for 1.5-2 minutes

⇩

Emulsion/ Nugget mixture

⇩

Molding chicken nuggets using a cuboid-shaped mold

⇩

Battering (HPMC)

⇩

Breading

⇩

Deep frying at 180°C

⇩

Cooling

⇩

Sensory analysis

Table.1 Experimental Design of Chicken Nuggets

Ingredients (%)	T_1 (Control)	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	T_{13}
Boneless Chicken	70	70	70	70	70	70	70	70	70	70	70	70	70
Chicken skin	13	12.35	11.85	11.6	11.35	11.7	11.2	10.95	10.7	11.05	10.55	10.3	10.05
Water/ice	5	5	5	5	5	5	5	5	5	5	5	5	5
Inulin (5%)	-	0.65	0.65	0.65	0.65	-	-	-	-	-	-	-	-
Inulin (10%)	-	-	-	-	-	1.3	1.3	1.3	1.3	-	-	-	-
Inulin (15%)	-	-	-	-	-	-	-	-	-	1.95	1.95	1.95	1.95
HPMC (0.5%)	-	-	0.5	-	-	-	0.5	-	-	-	0.5		-
HPMC (0.75%)	-	-	-	0.75	-		-	0.75	-	-	-	0.75	-
HPMC (1%)	-	-	-	-	1.0	-	-	-	1.0	-	-	-	1.0
Salt	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Fresh Ginger & Garlic paste	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Fresh Onion	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
White pepper powder	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Sodium tripolyphosphate	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
All Purpose flour (Maida)	5	5	5	5	5	5	5	5	5	5	5	5	5
Total	100	100	100	100	100	100	100	100	100	100	100	100	100

Table.2 Effect of incorporation of Inulin and HPMC on Sensory qualities of Chicken Nuggets (Mean ± SE)

(n=24)

Treatment	Sensory attributes (9-point hedonic scale)					
	Appearance	Flavor	Texture	Juiciness	Mouth Coating	Overall Acceptability
T_1(Control)	7.41 ± 0.03	$7.84^b \pm 0.10$	$8.16^c \pm 0.05$	$8.15^d \pm 0.04$	7.33 ± 0.04	$7.96^b \pm 0.08$
T_2	7.41 ± 0.04	$7.90^b \pm 0.09$	$8.23^{abc} \pm 0.05$	$8.08^d \pm 0.05$	7.39 ± 0.04	$7.96^b \pm 0.08$
T_3	7.43 ± 0.03	$8.41^a \pm 0.04$	$8.28^{abc} \pm 0.06$	$8.37^{abc} \pm 0.07$	7.38 ± 0.04	$8.41^a \pm 0.04$
T_4	7.45 ± 0.04	$8.06^b \pm 0.07$	$8.20^{bc} \pm 0.07$	$8.19^{cd} \pm 0.06$	7.41 ± 0.04	$8.16^b \pm 0.05$
T_5	7.45 ± 0.05	$8.31^a \pm 0.06$	$8.41^a \pm 0.05$	$8.44^{ab} \pm 0.04$	7.38 ± 0.04	$8.43^a \pm 0.05$
T_6	7.45 ± 0.04	$7.98^b \pm 0.08$	$8.26^{abc} \pm 0.06$	$8.23^{bcd} \pm 0.06$	7.36 ± 0.03	$7.97^b \pm 0.02$
T_7	7.48 ± 0.04	$8.04^b \pm 0.06$	$8.17^c \pm 0.04$	$8.19^{cd} \pm 0.06$	7.41 ± 0.03	$8.17^b \pm 0.06$
T_8	7.50 ± 0.04	$8.42^a \pm 0.05$	$8.43^a \pm 0.04$	$8.45^a \pm 0.04$	7.39 ± 0.04	$8.38^a \pm 0.02$
T_9	7.50 ± 0.05	$8.46^a \pm 0.02$	$8.40^{ab} \pm 0.03$	$8.42^{ab} \pm 0.06$	7.40 ± 0.04	$8.43^a \pm 0.02$
T_{10}	7.47 ± 0.05	$8.02^b \pm 0.07$	$8.27^{abc} \pm 0.07$	$8.20^{cd} \pm 0.07$	7.40 ± 0.04	$8.02^b \pm 0.03$
T_{11}	7.51 ± 0.04	$8.03^b \pm 0.04$	$8.27^{abc} \pm 0.03$	$8.23^{bcd} \pm 0.06$	7.40 ± 0.03	$8.13^b \pm 0.08$
T_{12}	7.48 ± 0.04	$8.33^a \pm 0.05$	$8.42^a \pm 0.05$	$8.54^a \pm 0.05$	7.41 ± 0.04	$8.45^a \pm 0.04$
T_{13}	7.52 ± 0.04	$8.49^a \pm 0.02$	$8.43^a \pm 0.03$	$8.54^a \pm 0.02$	7.44 ± 0.04	$8.46^a \pm 0.02$
F. value	**0.75^{NS}**	**13.3^{**}**	**4.05^{**}**	**9.17^{**}**	**0.47^{NS}**	**15.51^{**}**

Mean values bearing different superscripts within rows (a, b, c, d) differ significantly ($p < 0.01$),

^{NS} no significant

*** Statistically highly significant (P<0.01)*

T_1 (Control)

T_2 – Inulin (5%) + HPMC (0%)

T_3 – Inulin (5%) + HPMC (0.5%)

T_4 – Inulin (5%) + HPMC (0.75%)

T_5 – Inulin (5%) + HPMC (1.0%)

T_6 – Inulin (10%) + HPMC (0%)

T_7 – Inulin (10%) + HPMC (0.5%)

T_8 – Inulin (10%) + HPMC (0.75%)

T_9 – Inulin (10%) + HPMC (1.0%)

T_{10} – Inulin (15%) + HPMC (0%)

T_{11}– Inulin (15%) + HPMC (0.5%)

T_{12}– Inulin (15%) + HPMC (0.75%)

T_{13}– Inulin (15%) + HPMC (1.0%)

Table.3 Effect of incorporation of Inulin and HPMC on emulsion stability and cooking yield of Chicken Nuggets (Mean ± SE)

(n=6)

Treatment	Emulsion stability %	Cooking Yield %
T_1(Control)	$87.16^{c} \pm 0.22$	$89.52^{c} \pm 0.76$
T_2	$87.85^{c} \pm 0.36$	$89.68^{c} \pm 0.94$
T_3	$90.54^{b} \pm 0.27$	$90.69^{abc} \pm 0.54$
T_4	$90.54^{b} \pm 0.18$	$89.69^{c} \pm 0.75$
T_5	$92.15^{a} \pm 0.23$	$89.46^{c} \pm 0.19$
T_6	$87.88^{c} \pm 0.25$	$89.54^{c} \pm 0.54$
T_7	$87.49^{c} \pm 0.35$	$90.60^{bc} \pm 0.36$
T_8	$90.47^{b} \pm 0.14$	$91.15^{abc} \pm 0.53$
T_9	$91.49^{ab} \pm 0.35$	$91.40^{abc} \pm 0.58$
T_{10}	$86.85^{c} \pm 0.24$	$89.84^{c} \pm 0.44$
T_{11}	$90.9^{b} \pm 0.13$	$92.24^{ab} \pm 0.27$
T_{12}	$92.03^{a} \pm 0.30$	$92.88^{a} \pm 0.16$
T_{13}	$92.39^{a} \pm 0.15$	$92.93^{a} \pm 0.29$
F. value	65.402^{**}	5.729^{**}

Mean values bearing different superscripts within (a, b, c) differ highly significantly ($p < 0.01$)

*** Statistically highly significant (P < 0.01)*

Fig.2 Preparation of Chicken Nuggets

(a) Emulsion **(b) Molding of Emulsion** **(c) Chicken Nuggets**

These findings suggest that the combined incorporation of 15% Inulin and 1% Hydroxypropyl methylcellulose effectively enhanced cooking yield, thereby improving the processing quality of chicken nuggets.

The increased cooking yield may be attributed to better water and fat retention during thermal processing, as supported by Mahmud *et al.,* (2024), who reported similar improvements in nuggets formulated with HPMC based oleogels and curcumin. These ingredients contributed to reduced fat uptake and improved textural characteristics.

Emulsion Stability

Emulsion stability results for all treatments are also shown in Table 3. The emulsion stability of chicken nuggets across different treatments ranged from 86.85 ± 0.24% to 92.39 ± 0.15%. The lowest stability was recorded in T_{10} (86.85 ± 0.24%), which was statistically comparable with T_1, T_2, T_6 and T_7, while the highest value was observed in T_{13} (92.39 ± 0.15%). Statistical analysis ($p < 0.01$) indicated that T_{13} was on par with T_5 (92.15 ± 0.23%) and T_{12} (92.03 ± 0.30%), all of which showed significantly higher stability than the control T_1. These findings demonstrate that the combined incorporation of 15% Inulin and 1% Hydroxypropyl methylcellulose effectively improved emulsion stability, thereby enhancing the functional quality of chicken nuggets.

In a related study, El-Anany *et al.,* (2020) also found that cauliflower based fat replacements significantly increased cooking yield ($p \leq 0.05$) in chicken nuggets as the level of substitution increased. Comparable results have been observed by Silva-Vazquez *et al.,* (2018) in meat batters and Suradkar *et al.,* (2013) in chicken nuggets, confirming the effectiveness of dietary fiber-based fat replacers in improving yield characteristics.

The findings align with the observations of Reddy and Vani (2017), who reported increased emulsion stability in broiler meatballs due to superior fat and moisture retention. They noted that broiler meat emulsions had significantly higher stability compared to those made from spent hens. Similarly, Suradkar *et al.,* (2013) observed that lower fat content in broiler meat contributed to reduced fat separation and improved emulsion binding.

However, the current results differ from those of Naghdi *et al.,* (2025), who reported increased emulsion stability through the incorporation of quinoa flour and date seed powder in chicken nuggets, suggesting that emulsion behaviour could vary depending on the type of additive used.

In conclusion, the present study clearly demonstrates the effectiveness of using Inulin and Hydroxypropyl Methylcellulose (HPMC) as functional fat replacers in the formulation of chicken nuggets. Among the thirteen treatment combinations evaluated, the formulation containing 15% Inulin and 1% HPMC (T_{13}) exhibited significantly higher cooking yield, enhanced emulsion stability and superior sensory attributes particularly with respect of flavour, texture, juiciness and overall acceptability compared to the control and other treatment groups.

The incorporation of Inulin and HPMC not only contributed to fat reduction but also improved product quality by enhancing structural integrity and palatability. These functional ingredients did not adversely affect appearance or mouth feel, making them suitable alternatives for developing healthier meat products. Overall, the findings support the application of Inulin and HPMC as viable, cost effective ingredients for improving sensory qualities of comminuted poultry products. This approach aligns well with current consumer demands for low fat, high quality convenience foods and offers promising potential for the poultry processing industry to develop value-added products with improved health appeal.

Author Contributions

G. Vignesh: Investigation, formal analysis, writing—original draft. K. Sudha:—Formal analysis, writing—review and editing. P. Muthusamy: Resources, investigation writing—reviewing. D Jayanthi: Validation, formal analysis, writing—reviewing. A. K. Thiruvenkadan : Conceptualization, methodology, data curation, supervision, writing—reviewing the final version of the manuscript.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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