J. Meat Sci. 2018, 13 (2): 24-29 Research paper

Quality Evaluation of 'Air-Fried' and 'Deep-Fat Fried' Chicken Ravioli

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ABSTRACT

The present study aimed to investigate the effect of air frying and deep fat frying on quality attributes of chicken ravioli. Whole wheat flour, "refined wheat flour" (maida) and dehydrated chicken powder in the ratio of 40:40:20 was found to be best for the preparation of dough. A ratio of 4:1 was maintained between the dough and stuffing (dehydrated chicken powder) with a dimension of 4×4 cm ensured proper size of the ravioli for effective frying. Weight reduction was observed to be more in air fried sample. The sensory score for air fried sample was 8.07 on 9 point hedonic scale. FFA and TBARS values followed an increasing trend from 0 to 60 days in both samples. The pH of air fried sample decreased from 5.73 to 5.48 in polypropylene (PP) and to 5.51 in laminate of 45 gsm paper / 37.5µ Al foil / 20µ Poly (PFP). In deep fat fried sample it decreased from 5.65 to 5.41 in PP and to 5.42 in PFP. The hardness of air fried chicken ravioli increased during storage from 12N to 26 N and 24N in PP and PFP, respectively. The hardness of deep fat fried chicken ravioli increased from 15N to 26N and 22N in PP and PFP, respectively. The standardized formulation was amenable to both air fried and deep fat fried processes without resulting in any breakage. The physico-chemical changes were less in PFP packed samples than PP packed ones. Both air fried and deep fat fried chicken samples are acceptable up to 60 days at 25±20C. Air fried chicken ravioli can be considered as a healthy alternative to deep fat fried chicken ravioli.

Keywords: *Ravioli, chicken, air frying, deep fat frying, storage*

Received: 30/6/2019 Accepted: 1/8/2019

INTRODUCTION

Consumers always demand nutritious and convenient food items including snack products. Snacks come in a variety of forms including packaged, processed and also as vehicles for protein fortification and nutritional improvements. Ravioli are a type of dumpling snack product composed of a filling sealed between two layers of dough. These are typically square, though other forms are also available. The development of meat ravioli shows promise in improving the nutritive value of the final product. Meat and meat products are naturally enriched with protein, fat, minerals and vitamins and is conventionally an essential part of the diet (Cosgrove et al. 2005). Chicken meat is highly nutritious, lean and easy to digest. It is an important source of animal protein (Gopinath et al. 2014). It is convenient because of its cheap price and as a substitute for red meat for consumption in high quantities. In addition, chicken meat is rich in B vitamins (B1 and B6) and iron. Furthermore, chicken is cheaper as well as healthier, with lower fat and cholesterol content, compared with red meat (Can and Harun 2015). A reliable consistent access of safe, fresh, natural, nutritious, flavourful and healthier meat products needs to be explored as a priority throughout the world (Biswas et al. 2016). Due to health concerns related to traditional frying, alternative frying methods resulting in healthier products with desirable attributes are gaining attention. Hot air frying is a new technique which reduces the consumption of oil. Chicken ravioli, popular in the west generally contains cooked chicken meat as stuffing and have limited shelf life. The development of air fried chicken ravioli containing dried chicken solids with longer shelf life will be a viable option for defence and civilian populace. Light weight meat snacks add variety to non-vegetarian rations for combat regions. Crispness of such products is directly related to the moisture level. The moisture absorption by the product may lead to loss of crispness and also accelerates the development of oxidative rancidity. Majority of snacks today are packed in flexible bags. For snack food in the Indian market, a range of flexible materials are used depending on the product and the market segment. Non-branded snacks are packed for shorter shelf-life in unprinted low density polyethylene (LDPE) and polypropylene (PP) pouches. For branded snacks and nuts laminated structures are used. Selection of packaging material with low water vapour permeability is essential in enhancing keeping quality of snack items. The objectives of the present investigation are to compare the quality characteristics of air fried and deep fat fried chicken ravioli and also to monitor the storage changes in different packaging materials.

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DOI : 10.5958/2581-6616.2018.00016.6

MATERIALS AND METHODS

Preparation of Chicken Ravioli

Preparation of dehydrated chicken powder: A process for the preparation of dehydrated chicken powder has been standardized at the laboratory. Chicken was purchased from local market, manually deboned, trimmed of any visible fat, washed and chopped into small pieces. Chicken was marinated with lemon juice and spice powders for half an hour. Marinated chicken was open cooked with other ingredients for about 45 min. Cooled for 10-15 min and minced by using meat mincer (Sirman, Italy) fitted with 5 mm plate at 1400 rpm. The minced meat was then dried in hot air dryer (HEMCO heating instruments, Madras) for 5 hours at ''70˚C". After drying was completed the mince was cooled for about 15-20 minutes and packed in PFP pouches till further use.

Preparation of ravioli: The dough was prepared using whole wheat flour, refined wheat flour (Maida) and dehydrated chicken powder. The dough to meat ratio was (2:1). The dough was kept for half an hour and rolled to a diameter of 28-30 cm. Square boxes of equal size (4×4 cm) were cut and filled with dehydrated chicken powder as stuffing. Prepared ravioli was then air fried and deep fat fired to compare the quality characteristics of both samples. Air frying was carried out using air fryer at 160˚C for 6 minutes

by flipping the side of ravioli once. Deep fat frying was done at 180˚C±5˚C for 30 s. The samples were packed in PP and PFP pouches and kept at 25±20C for 60 days.

Sensory analysis: The sensory characteristics like colour, appearance, crispiness, flavour, taste and overall acceptability of fresh and stored samples was evaluated on a 9 point hedonic scale by panel of judges, keeping 9 for excellent and 1 for very poor as per method of (Murray 2001).

Proximate Analysis: Moisture, protein, fat ash and carbohydrate content (by difference) were determined using the standard (AOAC 1984) procedures. Fat content of chicken ravioli was determined as per (AOAC 1990).

CIE Colour co-ordinates: Product colour was measured using Hunter colorimeter (Hunter Lab Technologies Inc, VA, USA). The instrument was pre-calibrated with black and white reference tiles before each analysis. About 3 readings were taken, average values were calculated. The CIELAB (L*, a*, b*) colour scale was used for the analysis of the samples and products.

The colour change of fresh and stored samples (ΔEC) was estimated using the equation

$$\Delta Ec = \sqrt{(Li - Lr)^2 + (ai - ar)^2 + (bi - br)^2} \quad \text{.....(Eqn.1)}$$

where Li, ai, bi are initial colour values of chicken ravioli and Lr, br, ar are colour values of samples during storage.

Water activity and pH : Water activity of samples was analyzed in Lab master water activity analyzer (Novasina AG, Lachen, Switzerland), equipped with Nova log MC Software. Powdered sample was filled upto 3/4th of the sample cell and placed into the preconditioned (25 ºC) chamber of the analyzer (Pandey et al. 2014).

pH measurements were taken in Lab-scan pH meter (Eutech Instruments, Singapore). Samples (5g) were homogenized thoroughly after grinding and mixed with 15 ml of double distilled water and kept for 15 min. The samples were then mixed thoroughly and filtered through Whatman No.41 filter paper and the pH of the filtrate was recorded (Pandey et al. 2014).

Texture analysis: Texture analysis of the samples was carried out using texture analyzer, (TA Plus model, Lloyd instruments, Hampshire, UK). Three point bending test was performed. Parameters like hardness (Newton, N) and deformation (mm) were calculated from the graph as depicted by (Bourne 1978). Pre test speed and post test speed was 45mm/min, Other test parameters were maintained as clearance 3 mm, and trigger force 5-10 gram force (gf). Sample dimension was 4x4cm (lxb) with total weight of 7.2g.

Storage Analysis: Both air fried and deep fat fried chicken ravioli were packed in PP and PFP pouches and stored at 25±2°C. The changes in pH, colour, water activity and textural attributes were monitored during storage. The changes in TBARS and FFA were evaluated for a period of 60 days at an interval of 15 days. TBARS was determined as per Taraldgis method 1960 and FFA by titrimetric method (AOAC 1984). Microbiological analysis (TPC, Coliforms and Y&M) was carried out according to the standard methods (APHA 2001). Enumeration of E.coli was done by taking 1ml aliquot from 10-1 to 10-3 dilutions of each sample was transferred into sterile petriplates aseptically. The molten MUG-Sorbitol Agar was added and thoroughly mixed and allowed to set. The set plates were incubated at 37oC for 24 h. The plates were examined for blue fluorescence at 366 nm in UV chamber (Betractor). The fluorescent colonies were counted under the UV light.

Statistical Analysis: All experiments were repeated three times and data sets were subjected to analysis of variance (ANOVA) using the general linear models. Significant differences between the samples means were determined at $p < 0.05$ levels by ANOVA.

RESULTS AND DISCUSSIONS

Dough was standardized after experimenting different ratios of whole wheat flour and white flour (maida) with incorporation of dehydrated chicken powder. The ratio 40:40:20 improved flavour, texture and sensory quality of the final product. The ratio of dough to chicken powder stuffing was maintained as 4:1 to avoid opening of the dough casing during frying. For ease of handling and consumption, dimension of 4×4 cm was standardised. The product was subjected to air frying and deep fat frying. The standardised formulation was amenable to both frying processes without resulting in any breakage. The results pertaining to weight reduction, chemical composition and sensory scores of the both products along with the storage are discussed in the following subsections.

Physical Parameters

Weight reduction : There was a significant weight reduction ($p<0.05$) in air fried chicken ravioli compared to deep fat fried chicken ravioli (Table 1). This may be due to loss of moisture from the sample during air frying and absorption of oil in the deep fat fried sample. This finding has significance in including these types of products in light weight rations.

Table 1: Weight reduction in air fried and deep fat fried chicken ravioli

Product	Weight before frying(g)	Weight after frying(g)	Weight reduction (%)
Air fried	5.78±0.25	4.42±0.65	23±0.56
Deep fat fried	5.42±0.45	5.32±0.12	1±0.23

Sensory Analysis: Air fried and deep fat fried products are not considered as competitive products. The processes lead to two different types of snack products from the same blend. Considering the reduction in oil usage, the size reduction possible, and the air fried product can be considered as a healthier option, even though taste and texture wise it may not be similar to the deep fat fried

counterpart. The crispiness and taste values of air fried sample on 9 point hedonic scale were 8.42 and 8.4 while colour and flavour values were 6.85 and 7.85, and the OAA score was 8.07. For deep fat fried sample the crispiness and taste values were 5.85 and 8.28 while colour and flavour values were 8.14 and 8.21, the OAA score was 7.5. The crispiness was found to be lesser in deep fat fried sample (Table 2). Panellist liked air fried sample rather than deep fat fried. Similar findings were observed by (Shakher 2015) during comparison of air fried and deep fried potato chips. The air fried samples were more appealing and healthier due to lesser oil uptake and were crispier than the deep fat fried samples.

Table 2: Sensory attributes of air fried and deep fat fried chicken ravioli

Sensory attributes	Air fried	Deep fat fried
Colour and appearance	6.85±1.06	8.14±0.47
Crispiness	8.42±0.53	5.85±0.89
Flavour	7.85±0.69	8.21±0.80
Taste	8.40±0.81	8.28±0.75
Overall acceptability	8.07±0.18	7.50±0.76

Proximate composition: The proximate composition of both air fried and deep fat fried chicken ravioli is shown in (Table 3). The moisture content of deep fat fried sample was recorded higher than air fried which might be due to better water retention. Similar increase in moisture content of chicken patties has been reported by (Talukder and Sharma 2010). The fat content of deep fat fried chicken ravioli was recorded highest whereas for air fried ravioli, it was low. This could be due to usage of increased oil content in deep fat frying.

Table 3: Proximate analysis of air fried and deep fat fried chicken ravioli

	Composition (g/100g)	
Parameter	Air fried	Deep fat fried
Moisture	7.20 ± 0.25	10.06 ± 0.02
Fat	9.88 ± 0.03	27 ± 0.05
Ash	3.82 ± 0.02	2.88 ± 0.31
Protein	24.93 ± 0.23	17.4 ± 0.33
Carbohydrate	54.17 ± 0.41	42.66 ± 0.37
Energy(Kcal)	405.32 ± 0.22	483.24 ± 0.48

Storage changes

Colour values: The colour characteristics of the air fried and deep fat fried chicken ravioli during storage in two different packaging materials at 25±2˚C is measured using Hunter colorimeter and expressed in terms of 'L' 'a' 'b' values. The overall colour change in these products is expressed in terms of ΔE *. These values are depicted in Table 4. These values can be correlated with the sensory acceptability of product in terms of colour and appearance. The results showed that there was an increase in the values of chromatic parameters a* and b* regardless of the frying methods used. The a* value in PP packed air fried sample increased from 13.20 to 14.52 and b* value from 41.47 to 46.34. The ΔE * value changed from 53.9 to 58.32. The a* value in PFP packed air fried sample increased from 13.18 to 14.23 and b* value from 41.47 to 42.67. The ΔE * value changed from 53.69 to 57.25. Similarly the a* value in PP packed deep fat fried sample increased from 14.91 to 16.12 and b* value from 37.92 to 44.29. The ΔE * value changed from 62.19 to 64.09. The a* value in PFP packed deep fat fried sample increased from 15.15 to 16.41 and b* value from 37.92 to 44.02. The ΔE * value changed from 62.19 to 65.23. The colour change was less in PFP packed air fried sample compared to PP packed air fried sample. The increase in a* and ΔE * value was significantly higher in deep-oil frying as a result of Maillard reaction. (Heredia et al. 2014) reported that the values of chromatic parameters a* and b* increased in french fries obtained by hot air frying. Similar findings were also reported by (Can and Harun 2015) during storage evaluation of chicken meat balls.

Water activity and pH : The water in food, its location and availability is one of the most important factors influencing microbial growth and enzymatic activity. The dried products usually have water activity (aw) below 0.7 (Rahman and Labuza 2007). The aw scores followed decreasing trend from day 0 to 60 in case of both air fried and deep fat fried samples. The aw of air fried sample decreased from 0.542 to 0.516 in PFP and to 0.459 in PP at the end of storage period. In deep fat fried sample it decreased from 0.641 to 0.6 in PFP and to 0.567 in PP. The aw of deep fat fried sample was higher compared to air fried sample. This might be possible due to absorption of moisture content in deep fried sample as compared to air fried one. The decrease in aw found to be lesser in PFP compared with PP. The change in aw values of both air fried and deep fat fried chicken ravioli packed in PP and PFP are shown in (Table 5).

The pH values showed decreasing trends for both air fried and deep fat fried sample. Initial pH value for air fried chicken ravioli packed in PFP was 5.752 and at the end of storage it was 5.51 and for PP packed sample it was 5.481. Similarly for deep fat fried sample initially the pH was 5.65 and after storage it was 5.426 for PFP packed sample and 5.412 for PP packed sample (Table 5). Singh et al. 2011 reported gradual decrease in the pH of chicken snacks stored in laminated pouches at ambient temperature. Similar results were reported by (Verma et al. 2014) during storage of chicken noodles.

Texture profile: Hardness (N) of both air fried and deep fat fried chicken ravioli packed in PP and PFP were studied during storage. The hardness of air fried sample varied between 12.28 to 26.21 N in PP and to 24.12N in PFP. The hardness of deep fat fried sample varied between 9.25 to 20.15 N in PP and to 18.31 N in PFP. The hardness values showed an increasing trend during storage (Table 6). Hardness was more in air fried sample compared to deep fat fried sample, but sensorially acceptable as a snack product. Further compared to PP packed samples, hardness was less in PFP. This can be correlated with the decrease in water activity of the samples during storage which may be due to moisture desorption

Table 4: Changes in colour values of air fried and deep fat fried chicken ravioli packed in PP and PFP during storage at 25±2˚C

Packaging material	Storage period (days)	Sample							
		AF				DFF			
		L*	a*	b*	dE *	L*	a*	b*	dE *
PP	0	57.90±0.89	13.20±0.07	41.47±0.61	53.90±0.09	52.78±0.34	14.91±0.46	37.92±0.40	62.19±0.24
	15	60.33±0.33	13.59±0.24	43.40±0.47	55.73±0.58	44.58±0.04	14.90±0.69	39.58±0.44	63.23±0.33
	30	61.59±0.67	14.19±0.12	43.44±0.39	57.69±0.17	46.61±0.09	15.21±0.42	41.95±0.51	63.63±0.40
	45	59.90±0.12	14.21±0.13	44.42±0.20	57.39±0.11	50.12±0.29	15.75±0.54	44.37±0.89	64.40±0.56
	60	58.19±0.31	14.52±0.14	46.34±0.87	58.32±0.18	44.85±0.41	16.12±0.21	44.29±0.48	64.09±0.09
PFP	0	61.59±0.67	13.18±0.12	41.47±0.61	53.69±0.17	52.78±0.34	15.15±0.46	37.92±0.40	62.19±0.24
	15	58.84±0.33	13.53±0.27	41.92±0.59	53.45±0.47	42.62±0.62	15.53±0.32	39.83±1.57	63.22±0.38
	30	58.31±0.43	13.69±0.24	42.42±0.30	56.50±0.13	47.69±0.21	15.62±0.31	41.23±0.36	64.88±0.14
	45	61.86±0.17	14.23±0.21	42.53±0.49	56.74±0.33	46.01±0.17	15.91±0.39	42.39±0.07	64.67±0.19
	60	56.17±1.23	14.94±0.15	42.61±1.79	57.25±0.40	44.88±0.79	16.41±0.61	44.02±0.82	65.23±0.62

Table 5: Physico-chemical analysis of air fried and deep fat fried chicken ravioli at 25±2˚C

Storage in days (25±2˚C)	Air Fried				Deep fat fried			
	Water activity (a_w)		pH		Water activity (a_w)		pH	
	PFP	PP	PFP	PP	PFP	PP	PFP	PP
0	0.542	0.542	5.752	5.752	0.641	0.641	5.650	5.650
15	0.538	0.520	5.642	5.670	0.630	0.621	5.562	5.581
30	0.520	0.492	5.642	5.631	0.621	0.595	5.511	5.569
45	0.518	0.462	5.559	5.529	0.618	0.581	5.461	5.475
60	0.516	0.459	5.510	5.481	0.600	0.567	5.426	5.412

to equilibrate with storage environment. Deformation (mm) was more in deep fat fried sample than air fried sample. The textural attributes of these snacks are important in terms of their crispiness and appropriate hardness. Too soft a product may not be acceptable. An improved process for beef ravioli with meat sauce, having firmness and texture superior to retorted pasta products has been patented by Nestec (US 4597976A). An acidified meat filling for ravioli was used in the study, which comprises of whole eggs, cheese and flavourings. The study by (Heredia et al. 2014) on mechanical and optical properties of French fries obtained by hot air frying reported a first stage of initial softening related to starch gelatinization followed by a second stage where the maximum force increased due to gradual formation of a crust, both stages being faster in deep-oil frying.

Significant change in hardness was observed between 0 and 15 days in both PFP and PP stored air fried chicken ravioli, after 15 days the change was gradual, however hardness was more in PP stored sample compared to PFP packed sample after 60 days of storage. In deep fat fried sample a gradual increase in hardness was observed throughout storage in both PFP and PP packed samples; however hardness was more in PP (20N) than PFP packed sample (18.3N). But the hardness of deep fat fried sample cannot be compared to hardness of air fried sample because air fried sample was crispy in nature while deep fat fried sample was comparatively soft because of oil absorption.

Storage analysis:

FFA and TBARS: Chemical stability of the products was evaluated in terms of lipid oxidation profile. Hydrolytic rancidity which can be considered as a marker of the evaluation of quality parameters of the product was estimated in terms of FFA. FFA values followed an increasing trend from 0 to 60 days in air fried as well as deep fat fried samples (Table 7). But the increase in FFA value was found to be more in deep fat fried sample. The changes were very less in PFP compared to PP. The FFA value of air fried sample increased from 0.58 to 0.74 in PFP and to 0.82 in PP. The FFA value of deep fat fried sample increased from 1 to 1.65 in PFP and to 2 in PP. The increase in FFA value might be due to formation of lipid peroxides during storage (Umesha et al. 2014). The TBARS value of air fried sample increased from 0.01 to 0.025 in PFP and to 0.058 in PP. The TBARS value of deep fat fried sample increased from 0.03 to 0.07 in PFP and to 0.11 in PP (Table 7). 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). Ratanatriwong et al. (2011) reported gradual increase in the TBARS values in fish and chicken snacks, respectively stored at ambient temperature. This is because of the formation of many

volatile components during storage which may contribute towards the rancidity development

(Jayathilakan et al. 2015). The product in discussion is contributed by chicken fat and protein which are prone for oxidative changes during storage. The phospholipids and other unsaturated fractions of the fat component act as a substrate lipid per oxidation (Catala 2009). Similar findings have also been reported by (Singh et al. 2015) during storage of chevon cutlets.

Table 6: Textural studies of air fried and deep fat fried chicken ravioli during storage at 25±2˚C

Storage in days (25±2˚C)	Air Fried				Deep fat fried				Material	hardness (N)	Deformation (mm)
	Water activity (a_w)		pH		Water activity (a_w)		pH				
	PFP	PP	PFP	PP	PFP	PP	PFP	PP			
0	0.542	0.542	5.752	5.752	0.641	0.641	5.650	5.650	PP	12.28±0.20a	1.28±0.23a
15	0.538	0.520	5.642	5.670	0.630	0.621	5.562	5.581	PP	22.03±0.03b	1.24±0.45a
30	0.520	0.492	5.642	5.631	0.621	0.595	5.511	5.569	PP	23.85±0.23 b	1.23±0.52a
45	0.518	0.462	5.559	5.529	0.618	0.581	5.461	5.475	PP	24.32±0.12 b	2.12±0.15b
60	0.516	0.459	5.510	5.481	0.600	0.567	5.426	5.412	PP	26.21±0.62 b	3.14±0.21b
Storage in days	**Air Fried**								**Deep fat fried**		
(25±2˚C)	**Water activity (a_w)**		**pH**		**Water activity (a_w)**		**pH**				
	PFP	PP	PFP	PP	PFP	PP	PFP	PP			
	0.542	0.542	5.752	5.752	0.641	0.641	5.650	5.650	PFP	12.28±0.20a	1.28±0.23a
	0.538	0.520	5.642	5.670	0.630	0.621	5.562	5.581	PFP	20.11±0.24 b	1.22±0.56a
	0.520	0.492	5.642	5.631	0.621	0.595	5.511	5.569	PFP	21.45±0.65 b	1.23±0.25a
	0.518	0.462	5.559	5.529	0.618	0.581	5.461	5.475	PFP	22.78±0.32 b	2.12±0.78b
	0.516	0.459	5.510	5.481	0.600	0.567	5.426	5.412	PFP	24.12±0.48 b	2.65±0.95b

Table 7: FFA and TBARS analysis of air fried and deep fat fried chicken ravioli at 25±2˚C

Storage in days (25±2˚C)	Air Fried				Deep fat fried			
	FFA (& oleic acid)		TBARS (mg MDA / Kg sample		FFA (& oleic acid)		TBARS (mg MDA / Kg sample	
	PFP	PP	PFP	PP	PFP	PP	PFP	PP
0	0.58	0.58	0.010	0.010	1.00	1.00	0.030	0.030
15	0.60	0.68	0.012	0.016	1.20	1.50	0.035	0.043
30	0.63	0.73	0.014	0.023	1.52	1.70	0.041	0.055
45	0.70	0.77	0.017	0.040	1.60	1.80	0.051	0.062
60	0.74	0.82	0.025	0.058	1.65	2.00	0.070	0.110

Microbiological analysis: The data for the microbial analysis of the chicken ravioli during storage is shown in Table 8. Microbiological status of the product initially and during storage was examined in terms of TPC, Yeast & Molds, and coliforms. Coliforms and Yeast & moulds were absent in both the samples throughout storage period. Pathogen E. Coli was absent in both the samples. Overall, the product exhibited good microbiological safety throughout the storage period. There were no significant differences due to packaging material in terms of microbiological stability

Table 8: microbial analysis of air fried and deep fat fried chicken ravioli at 25±2˚C

Storage period (Days)	Air Fried Total plate count (cfu/g)		Deep fat fried Total plate count (cfu/g)	
	PP	PFP	PP	PFP
0	2×10^1	2×10^1	3×10^1	3×10^1
30	3×10^1	2×10^1	2×10^1	1×10^1
60	2×10^1	1×10^1	2×10^1	1×10^1

CONCLUSIONS

The standardised formulation of chicken ravioli was amenable to both air frying and deep fat frying processes without resulting in any breakage of product and having good sensory attributes. There was a significant reduction in weight of air fried sample compared to deep fat fried one. The physico-chemical changes were less in PFP compared to PP packed samples. Both air fried and deep fat fried chicken ravioli was acceptable upto 60days at 25±2°C. Considering reduction in oil usage, size and processing parameters the air fried product can be considered as a healthier option compared to other snack products available. The development of smaller size air fried chicken ravioli with longer shelf life is of great importance for defence and civilian populace.

COMPETING INTERESTS: The authors have no known competing interests either financial or personal between themselves and others that might bias the work.

ETHICS STATEMENT: Not Applicable

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