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Research Article

Effect of thermal preservative methods on legume based protein tikkies (patty)

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Abstract

The present study was undertaken to develop a legume-based tikki as the protein source and effect of the preservative method on the quality. A total of 3 treatments were used after optimisation of tikkis. Steam under pressure at 15 psi for 15 and 20 min (T₁), hot air treatment at 90°C for 120 min (T₂), and pasteurisation at 85°C for 15 min (T₃). Various batches attempted to optimise the finished products based on sensory acceptability. 60, 65, 70, 75 and 80% legume content in batch 1, 2 and 5 respectively. Batch-3 (70% legume) was the most acceptable concentration for further consideration. Effect of legume content of the textural profile of legume tikkies shown at 80% concentration. The product was evaluated for physicochemical parameters, sensory attributes, and microbial quality. Textural profile analysis revealed that hardness value was negligible in fresh, pasteurised, and cabinet treated samples for moth tikkies whereas autoclaved samples showed a significant reduction in the hardness. At the same time, moong tikki changed significantly after treatments with the effect of the preservation method. The fatty acid profile of the samples was analysed using a gas chromatograph to understand the effect of different processing and preservation treatments on it.

Keywords

moong bean, moth bean, patties, shelf life, textural profile, thermal preservation

Abbreviations

FFA – free fatty acids; PBMA – plant-based meat alternatives; POV – peroxide value; RTC – ready-to-cook; RTE – ready-to-eat; TBA – 2-thiobarbituric acid; TPA – texture profile analysis

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Introduction

In fluctuating to more plant-based protein, there has been growth in food products that would be measured as plant-based meat alternatives. These products exist in the market in both traditional and non-traditional forms. Traditional products include tofu, tempeh, and natto, while non-traditional products include textured vegetable protein, patties, strips, links, and hotdogs (Masson-Delmotte et al. 2014; Mishal et al. 2022). This vegetable, particularly in its milled form, is used to make various dishes – aloo paratha, aloo tikki, and sandwiches. Because of its high fat, creamy, paste-like texture not suitable for a weight loss diet. At a distance from the high-fat content of potatoes, the cream or butter that is extra to it raises the saturated fat content in the dish. Potatoes have been related to increased risk of obesity, cardiovascular disease, and type 2 diabetes mainly because of the high glycemic index (Borch et al. 2016).

RTE consumed without heat processing at the consumer end, whereas RTC products are pre-cooked for serving within food safety time and temperature zone. Most canned products are considered RTE categories, whereas frozen gravies and instant mixtures of gravies are considered RTC products (Patel and Rathod 2017). RTE food that is gaining popularity nowadays is frozen deep-fried foods such as fries, jalapenos rolls and particular foods of Indian origin like samosas, wada, tikki etc., of which tikkies are the most popular. In past decades, plant-based nutrition has received more nutrition. High animal protein intake has been associated with a high risk of cardiovascular disease risk of obesity.

In contrast, plant-based protein can lower the risk of diabetes, cardiovascular disease, obesity, mortality, and metabolic syndrome. High protein diets are an effective weight-loss strategy for overweight and obese individuals by reducing hunger. Replacement of animal proteins with plant-based proteins, such as peas, beans, and legumes, which would be required to meet the good dietary protein content (Lonnie et al. 2018).

Due to this product's popularity, various recipes can be attempted to develop this traditional Indian snack into a healthy, nutritious, and affordable RTE food. The current research focused on remarkably effective substitutes for mashed potatoes-legumes,

i.e. moong beans (*Vigna radiata*) and moth beans (*Vigna aconitifolia*), which are a rich source of protein, fibre, and vitamins.

Many processing techniques have been used to extend the patty's shelf life, but most have limited acceptability and shorter shelf-life at room temperature. The extensive use of chemical preservatives is suspected of having an unacceptable sensory and toxic effect (Biswas et al. 2014). This study focused on patty products' shelf-life study using the physical method to extend shelf life. The study was undertaken to elucidate the effect of autoclave, hot air treatment, hot water pasteurisation on the shelf-life extension of legume tikkies. A few data are available on study of preservation on vegetable protein-based patties (Pankaj 2015).

Materials and Methods

Materials. All the raw materials required to develop legume-based tikkies were purchased from the local market in Mysore (Karnataka).

Moong beans (*Vigna radiata*), moth beans (*Vigna aconitifolia*), sorghum flour, refined sunflower oil (Sun Pure), soya mini chunks, potatoes, onions, green chillies, garlic, ginger, turmeric powder, chilli powder, coriander powder, salt were procured from the local market.

All other chemicals were procured from Himedia, sigma Aldrich and Merck.

Methods

Tikki preparation and sensory characterisation.

Beans were soaked in regular tap water for 12 h to rehydrate them completely. The water-to-grain ratio was maintained at 1:4. Soaked beans were pressure cooked at 15 psi with an equal proportion of water to make the beans soft, gelatinise their starch, and precipitate their protein. The cooked beans were mixed with boiled potatoes and soaked soya chunks. Other ingredients (chopped onions, garlic, ginger, green chillies, chilli powder, turmeric powder, coriander powder) were fried in the pan or kadhai along with oil, followed by the addition of the above mixture of beans, potato and soya chunks (Table 1). The cooked mixture of beans and spices was then moulded into a traditional round tikki shape, each of 60-65 g and 3 inches in length. Sorghum batter was prepared as a gluten-free coating for tikki by mixing

sorghum flour with water in a ratio of 1:3. The moulded round tikkies were dipped in sorghum flour batter and coated with bread crumbs followed by frying in refined sunflower oil at a temperature

of 190-195°C for 30-45 s. The tikkies were allowed to cool at RT and then packed in PP (Polypropylene), Al (Aluminum) foils, and laminated foils for further shelf-life studies.

Table 1A. The batch-wise moth tikki formulation

Ingredients, %	Batch-1	Batch-2	Batch-3	Batch-4	Batch-5
Moth grains	60	65	70	75	80
Potato	20	15	10	5	0
Chili Powder	1.0	1.0	1.0	1.2	1.2
Salt	1.5	1.5	2.0	2.0	2.0
Other ingredients (Turmeric powder, coriander powder, green chillies, chopped onions, soy chunks, oil)	17.5	17.5	17.0	16.8	16.8

Table 1B. The batch-wise moth tikki formulation

Ingredients, %	Batch-1	Batch-2	Batch-3	Batch-4	Batch-5
Moong	60	65	70	75	80
Potato	20	15	10	5	0
Chilli powder	1.0	1.0	1.0	1.2	1.2
Salt	1.5	1.5	2.0	2.0	2.0
Other ingredients (Turmeric powder, coriander powder, green chillies, chopped onions, soy chunks, oil)	17.5	17.5	17.0	16.8	16.8

Effect of concentration on the textural profile legume tikkies at ambient temperature texture profile analysis. The texture analysis was carried out using TA HD Plus (Young 2012). The tikki samples were evaluated in strain mode using the P/50 probe (1963.50 mm²). The test conditions were as follows; pre-test speed 1.00 mm.s⁻¹, test speed 5.00 mm.s⁻¹, post-test speed 5.00 mm.s⁻¹, target mode strain, strain 60%, trigger type auto force, trigger force 10 g.

Application of preservation methods. The targeted product is RTE tikkies based on legumes. According to their suitability for preservation, three technologies were selected (autoclave, hot air treatment, and hot water pasteurisation) and were analysed based on (Pankaj 2015). The thermal

methods considered were; steam under pressure at 15 psi for 15 and 20 min. (T₁), hot air treatment at 90°C for 120 min (T₂), and pasteurisation at 85°C for 15 min (T₃).

Effect of preservation methods on the textural profile legume tikkies at ambient temperature. The texture analysis was carried out using TA HD Plus (Young 2012) similarly performed above.

Effect of storage period on the texture profile of legume tikkies. The moth and moong patties were stored for duration 30 d. The 0, 15 and 30 d samples were analyzed for moisture, hardness, adhesiveness, springiness, cohesiveness, gumminess, chewiness and resilience (Young 2012).

Shelf-life study of legume tikkies. The 0, 15 and 30 d moong and moth beans patty samples were analyzed for the shelf-life study was conducted based on tikki parameters like pH, acidity, TBA, FFA, peroxide, browning and moisture.

Microbiological changes during shelf-life study of moth and moong tikkies. Microbial analysis of tikki was determined according to the method of (Harrigan and McCance 1976). Total plate count, coli forms, yeast, and mould growth were estimated using the samples.

Fatty acid profile of legume tikkies analysed by gas chromatogram. The sample's chemical parameter (FFA, peroxide value) was analysed based on (Ackman 1972; Sae-leaw and Benjakul 2014). The browning index of moong and moth-based tikki was determined as per (Krishnan et al. 2010). TBA value in legume-based tikki was determined as per (Goldberg and Stern 1977). The samples' pH change during storage was determined using a digital METTLER TOLEDO (Five easy plus-FEP20) pH meter. The titrimetric method determined the change in acidity during the storage of samples. Chemi to-1000 analysed total fatty acids, model gas chromatograph fitted with BPX 70 column (25 mt, 0.32 mm ID), and flame ionisation detector. The samples were esterified as per the procedure (Ackman 1972) with slight modifications.

Results and Discussions

Sensory characterisation of legume tikkies. Preparing legume-based tikkies (moong bean and moth) was optimised concerning organoleptic acceptability. The below radar chart shows the various batches that attempted to optimise the finished products based on sensory acceptability. It was challenging to prepare a tikki having a legume fraction of more than 60%, hence different concentrations of legumes viz. 60, 65, 70, 75 and 80% (batch 1, batch 2 to batch 5, respectively) were tried along with other ingredients, which were boiled and mashed potatoes as a binding principle, soy chunks as an aided protein source, and texturizing agent to impart desired mouth feel, rest

of the ingredients for flavour and taste. Batch-3 having 70% Moth and moong and 10% potato, was noted to be most acceptable concerning aesthetic attributes as desired in any tikki or similar products Fig. 1A and Fig. 1B.

Effect of concentration on the textural profile legume tikkies at ambient temperature TPA.

Textural attributes of the tikkies were presented graphically in Fig. 2. It was pretty apparent that bean concentration will affect the textural properties of the tikki, which is among deciding factors for the acceptability by the consumers. The test consists of compressing a bite-size piece of tikki two times in a reciprocating motion that imitates the action of the jaw. It is observed that the hardness of tikkies significantly increases. moth beans ranged from 60.816 to 88.033 N, and moong tikkies ranged from 85.116 to 122.949 N. The increase in hardness may be attributed to the seed coat of the cooked and turgid grains. Springiness showed a reverse trend ranging from 0.340 for 80% bean content and 0.405 for 60% for moth tikkies; however, the trend was reciprocal for moong tikkies which was in the range of 0.317 (60%) to 0.507 (80%). The cohesiveness parameter was in the increasing trend for both tikkies ranging from 0.118 to 0.136 for moth and 0.134 to 0.171 for moong tikki. None of the tikkies showed any amount of adhesiveness. The results for chewiness were also in line with the cohesiveness of moong tikki, valued at 2.894 to 4.072 for both and 3.616 to 10.642 for moong tikki. The chewiness was 20 to 60% higher in moong tikki, which is the most desirable quality parameter for such delicacies. The change observed in the resilience of the tikkies seems insignificant, ranging from 0.031 to 0.036 for moth tikki and 0.036 to 0.045 for moong tikki. Resilience is not a parameter from the original TPA work but instead has developed from looking more closely at the elastic recovery of the sample. The objective and subjective textural analysis of tikkies prepared from different composition has showed a positive correlation and the results complimenting each other. Both tikkies was found to be significantly similar with respect to textural properties. (Table 2A and 2B).

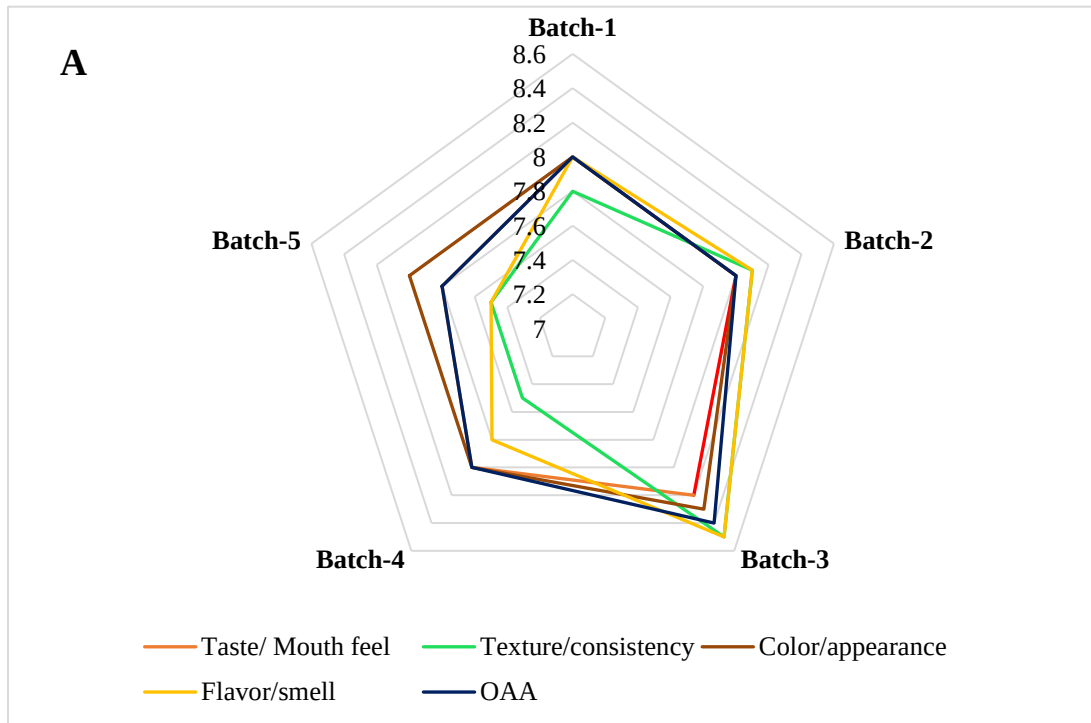


Figure 1A. Sensory quality of moth tikki

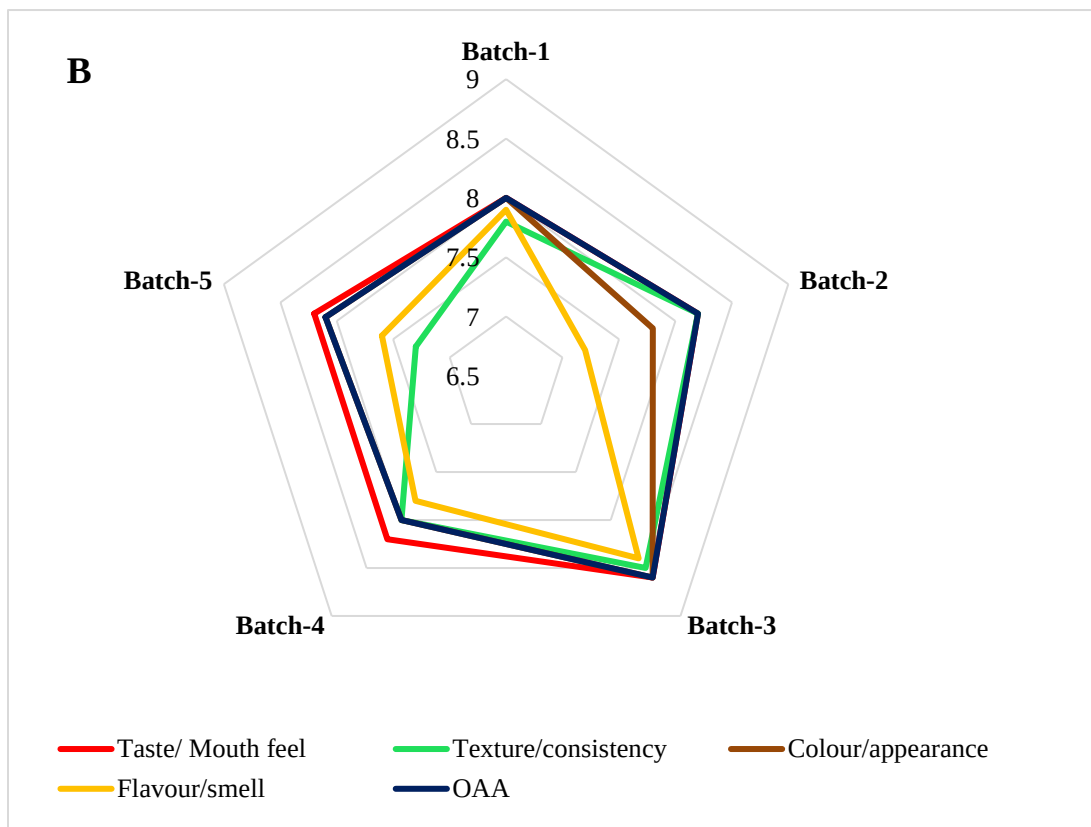


Figure 1B. Sensory quality of moong tikki

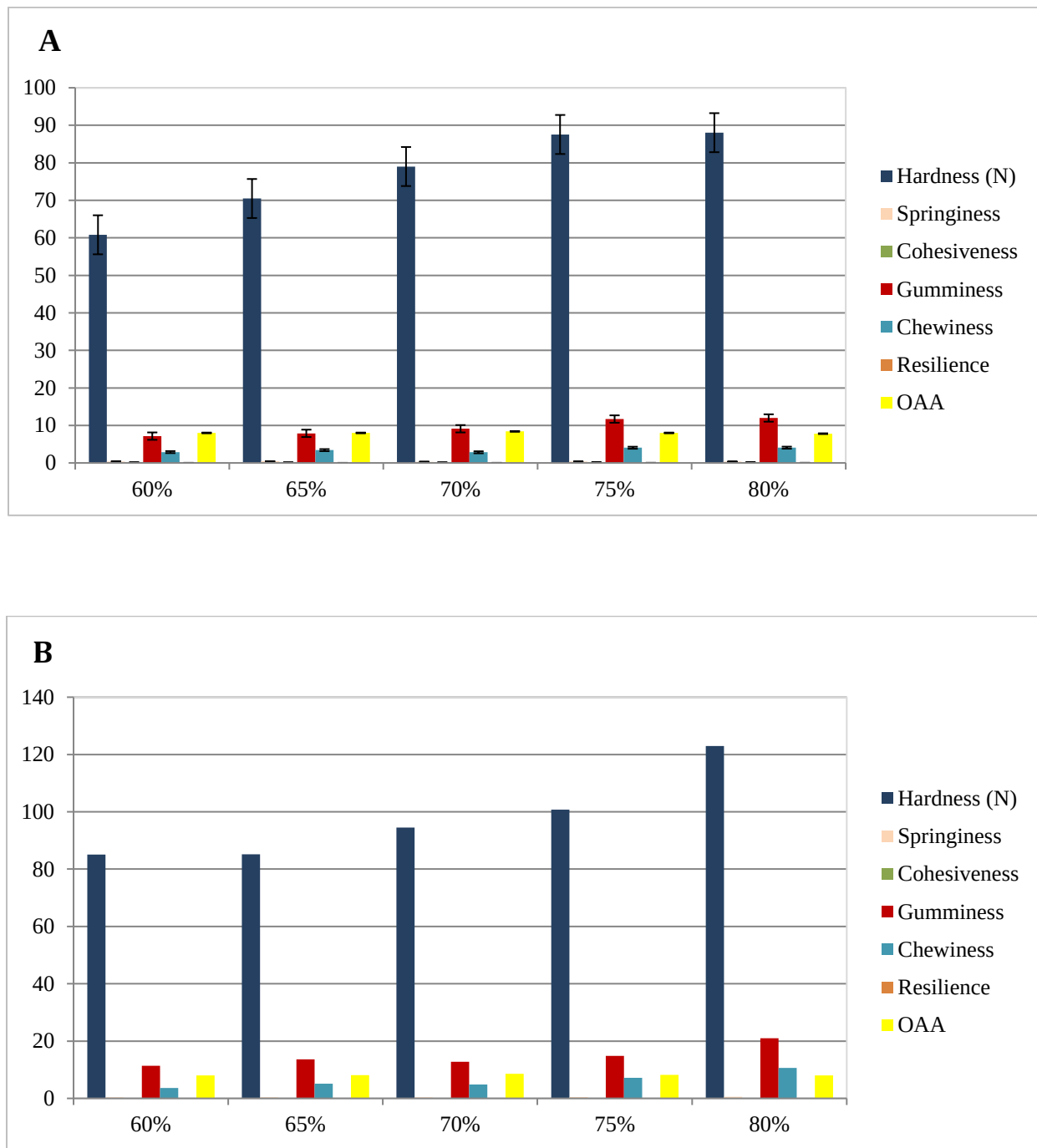


Figure 2. Effect of concentration of components on textural profile of (A) Moth Patty (B) Moong patty

Table 2A. Effect of preservation methods on the textural profile of moth tikkies

Samples	Hardness, N	Springiness	Cohesiveness	Gumminess	Chewiness	Resilience	OAA
Fresh	72.77±1.98	0.38±0.01	0.13±0.00	9.31±0.26	3.51±0.00	3.62±0.15	8.4±0.1
Sterilisation (at 15 psi for 15 min)	55.38±4.06	0.39±0.04	0.16±0.01	8.70±0.11	3.39±0.42	4.36±0.27	8.2±0.1
Pasteurised by dipping in boiling water (85°C for 15 min)	72.36±8.58	0.42±0.05	0.13±0.00	9.72±1.08	3.98±0.01	3.83±0.14	8.3±0.0
Pasteurisation by heating in cabinet dryer (90°C for 2h)	80.70±19.34	0.44±0.17	0.18±0.06	13.66±3.21	5.80±2.61	5.80±2.69	8.3±0.1

Table 2B. Effect of preservation methods on the textural profile of moong tikkies

Samples	Hardness, N	Springiness	Cohesiveness	Gumminess	Chewiness	Resilience	OAA
Fresh	99.65±7.56	0.61±0.07	0.14±0.01	13.79±1.84	8.23±0.16	4.32±0.21	8.6±0.1
Sterilisation (at 15 psi for 15 min)	67.49±1.04	0.37±0.01	0.14±0.01	9.46±0.60	3.46±0.16	4.00±0.15	8.1±0.1
Pasteurised by dipping in boiling water (85°C for 15 min)	72.36±8.58	0.42±0.05	0.13±0.00	9.72±1.08	3.98±0.01	3.83±0.14	8.3±0.0
Pasteurisation by heating in cabinet dryer (90°C for 2h)	80.70±19.34	0.44±0.17	0.18±0.06	13.66±3.21	5.80±2.61	5.80±2.69	8.3±0.1

Effect of preservation methods on the textural profile legume tikkies at ambient temperature.

The change in hardness was negligible in fresh, pasteurised, and cabinet treated samples for moth tikkies with the corresponding values of 72.77, 72.36 and 80.70 N, respectively. In contrast, autoclaved samples showed a significant reduction in hardness. The change in hardness may be due to moisture loss during high-pressure moist heat treatment in an autoclave making the upper crust soft. On the other hand, hardness of moong tikki changed significantly after treatments. The springiness of moth tikkies showed an increasing

trend concerning this parameter ranging from 0.38 for fresh tikki to 0.44 for the hot air-treated sample, whereas moong tikki showed a common trend. The change in the cohesiveness of the tikkies after treatments were insignificant for both moth and moong tikkies, indicating that the different preservation methods employed do not have any notable effect on the cohesiveness of the tikkies. The chewiness of both the tikkies showed an uneven trend with an initial decrease and then an increase in the parameter, which may be due to the change in the moisture of the tikkies and variance in concentration of other materials in the tikkies. The

resilience of moth tikki showed an initial increase from 3.62 for the fresh sample to 4.36 for the autoclaved sample, followed by a decrease in value for the pasteurised sample and again a further increase for the hot air-treated sample.

On the other hand, moong tikki showed a decreasing trend of resilience. Thus it may be concluded that the different preservative methods used affect these parameters and the reason may be attributed to the difference in the physical and textural properties of the legumes and the method of preservation employed for preservation (Jiao et al. 2018) found that the hardness, springiness, chewiness, and cohesiveness of the porcine patty significantly decreased during the chilled storage; the patty treated with 0.5% honeysuckle extract showed a higher hardness value and reduced the loss of texture, indicating that honeysuckle extract and chlorogenic acid could increase the cross-linked network of protein-water and gel network.

Effect of storage period on the texture profile of legume tikkies. Moth and moong tikkies were

analysed for their textural properties during shelf-life studies. Hardness, springiness, and chewiness showed an increasing trend concerning the storage period for both the tikkies. Whereas cohesiveness and resilience showed a decreasing trend for moth tikki, there was a significant difference in the cohesiveness observed for moong tikkies (Fig. 3) however, resilience showed a decreasing trend during storage. The change recorded in these parameters may be explained based on changes in moisture content during storage.

The hardness of the patty increases with increase as storage time increases. Protein oxidation brings increased hardness in patties through the loss of protein functionality, and the creation of cross-links between proteins ultimately leads to undesirable textural changes (Bai et al. 2017).

The data recorded for the moong tikki concerning the parameters explained graphically in the similar line and that may be due to the similar processing methodology and storage condition employed for this product too (Fig. 4.).

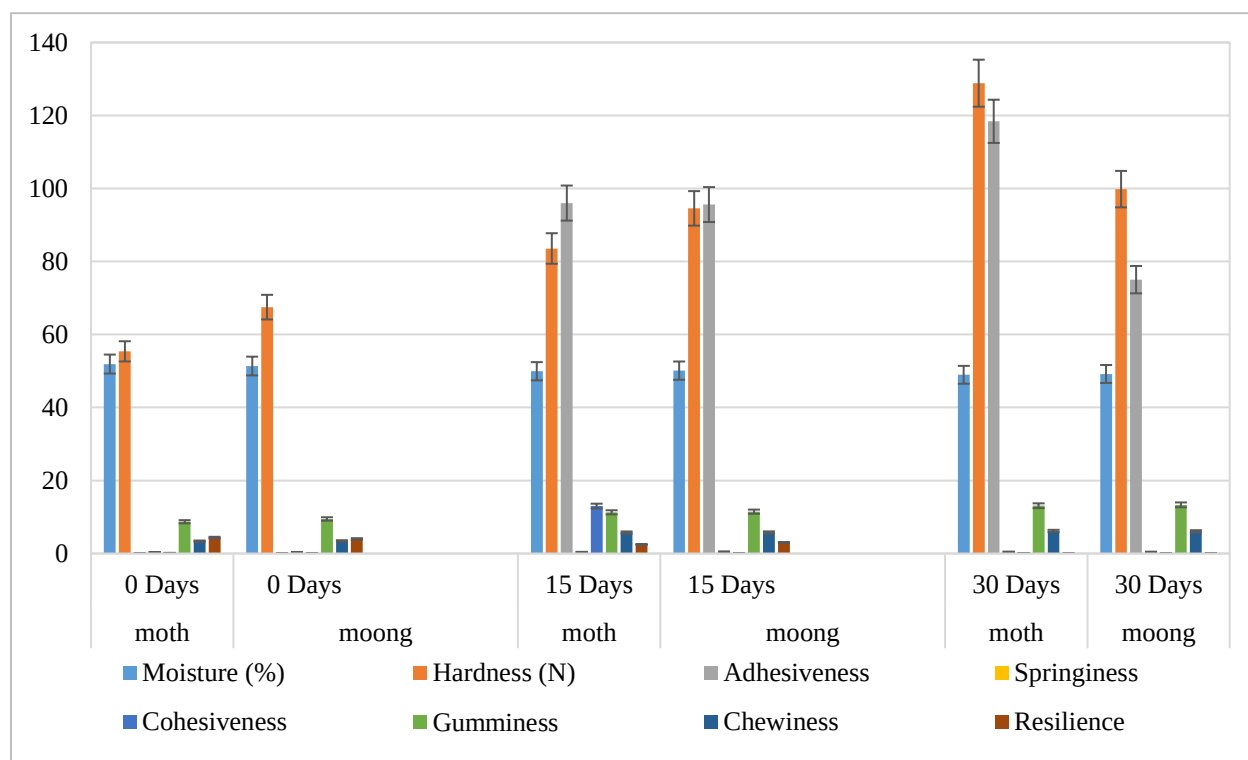


Figure 3. Effect of storage on the textural profile of moth tikki and moong tikki during storage

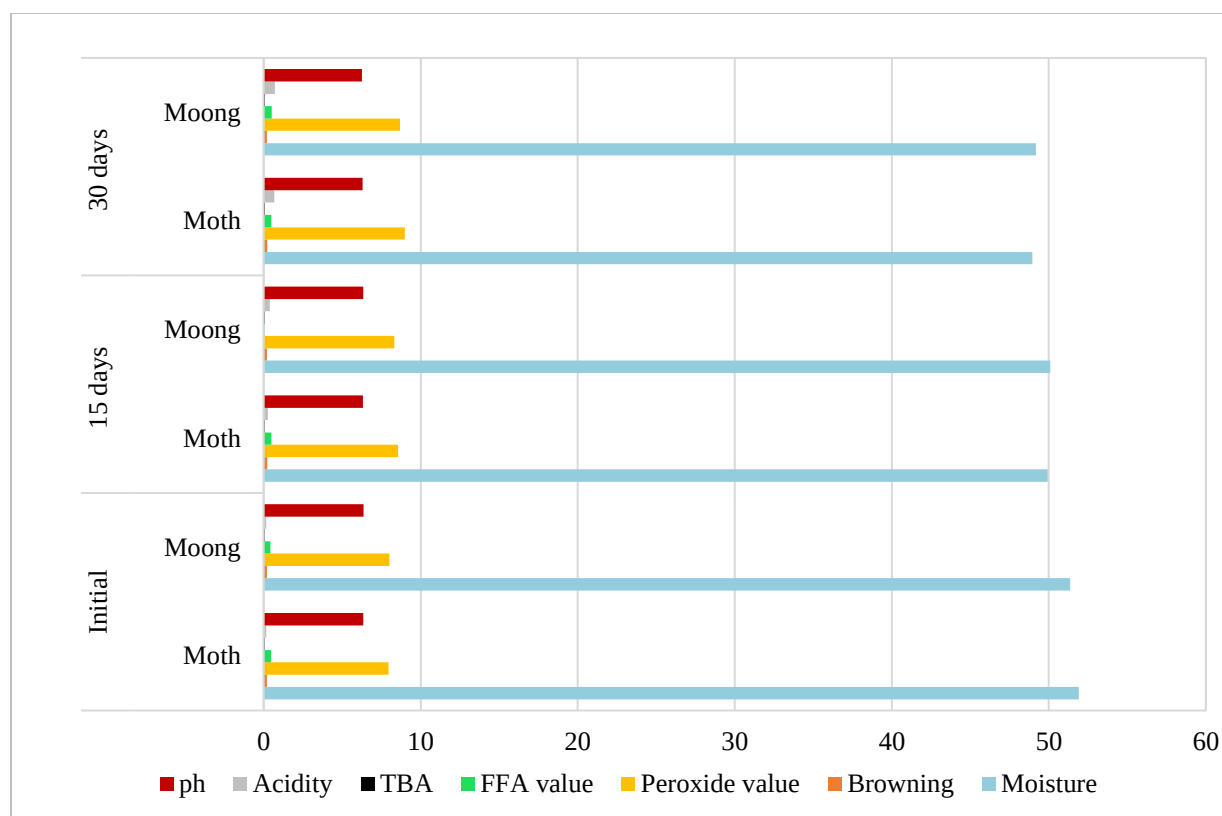


Figure 4. Effect of storage on chemical parameter and sensory quality of legume tikkies

Table 3A. Microbiological changes during shelf-life study of moth tikki

Period	TPC, cfu.g ⁻¹	Spores, cfu.g ⁻¹	Coliforms, cfu.g ⁻¹	Yeasts and molds, cfu.g ⁻¹	OAA
Fresh sample (Control)					
0 d	1.0×10^4	2.0×10^1	Nil	Nil	8.4 ± 0.0
Steam under pressure (15 psi for 20 min)					
0 d	Nil	Nil	Nil	Nil	8.2 ± 0.0
15 d	2.0×10^1	Nil	Nil	Nil	8.0 ± 0.1
30 d	Nil	Nil	Nil	Nil	7.8 ± 0.1
Thermal preservation using hot air (90°C) in a cabinet dryer + sorbic acid (2000 ppm) and citric acid (0.15%)					
0 d	Nil	Nil	Nil	Nil	8.3 ± 0.1
15 d	5.0×10^1	Nil	Nil	2.0×10^1	7.2 ± 0.0
30 d	2.0×10^2	Nil	Nil	Nil	6.5 ± 0.1
Sorbic acid (2000ppm) and Citric acid (0.15%) followed by Pasteurization in water bath (85°C) for 15 minutes					
0 d	Nil	Nil	Nil	Nil	8.3 ± 0.1
15 d	7.0×10^2	Nil	Nil	Nil	7.5 ± 0.0
30 d	8.0×10^2	Nil	Nil	Nil	6.8 ± 0.1

Table 3B. Microbiological changes during shelf-life study of moong tikkies

Period	TPC, cfu.g ⁻¹	Spores, cfu.g ⁻¹	Coliforms, cfu.g ⁻¹	Yeasts and molds, cfu.g ⁻¹	OAA
Fresh sample (Control)					
0 days	3.0×10^2	1.0×10^1	Nil	Nil	8.6±0.1
Steam under pressure (15 psi for 20 min)					
0 days	Nil	Nil	Nil	Nil	8.1±0.0
15 days	1.0×10^1	Nil	Nil	Nil	7.8±0.1
30 days	Nil	Nil	Nil	Nil	7.6±0.1
Thermal preservation using hot air (90°C) in a cabinet Dryer + Sorbic acid (2000ppm) and Citric Acid (0.15%)					
0 days	Nil	Nil	Nil	Nil	8.4±0.1
15 days	1.0×10^4	2.0×10^1	Nil	Nil	7.4±0.0
30 days	8.0×10^1	Nil	Nil	Nil	6.0±0.1
Sorbic acid (2000ppm) and Citric acid (0.15%) followed by Pasteurization in water bath (85°C) for 15 minutes					
0 days	Nil	Nil	Nil	Nil	8.4±0.0
15 days	7.0×10^2	Nil	Nil	Nil	7.2±0.0
30 days	8.0×10^2	Nil	Nil	Nil	6.0±0.1

Microbiological changes during shelf-life study of moth and moong tikkies. The microbiological analysis of the tikkies was carried out periodically to ascertain their safe consumption. Microbial analysis for total plate

counts, spore count, presence of coliforms, and contamination by yeast and moulds were recorded. The results are compiled in (Table. 3A and 3B).

Table 4. Effect of different preservation methods on the fatty acid profile of refined sunflower oil: A. Control system, B. Moth tikkies, C. Moong tikkies (GC analysis)

Sample	Palmitic acid, % (C16:0)	Stearic acid, % (C18:0)	Oleic acid, % (C18:1)	Linoleic acid, % (C18:2)
A. Refined sunflower oil (Control system)				
	6.96±0.11	3.52±0.08	32.43±0.56	57.09±0.11
B. Moth tikki				
Control	7.55±0.10	3.94±0.00	31.32±0.44	57.28±0.22
Pasteurised	8.41±0.05	3.97±0.01	31.87±0.32	55.75±0.41
Cabinet	8.15±0.04	3.70±0.05	32.16±0.25	56.00±0.11
Autoclave	6.89±0.10	3.04±0.01	28.30±0.11	54.48±0.21
C. Moong tikki				
Control	6.81±0.10	3.90±0.05	29.98±0.14	55.25±0.11
Pasteurised	6.58±0.02	3.94±0.01	30.60±0.65	58.89±0.21
Cabinet	6.87±0.09	3.68±0.00	29.67±0.11	59.78±0.51
Autoclave	5.93±0.04	4.28±0.01	30.16±0.54	61.64±0.25

Moong and moth tikkies have undergone treatment of steam under pressure and were stable for more than 30 d at ambient temperature conditions. In contrast, other batches exposed to hot air and water bath pasteurisation were found to have some microbial load. The sample treated with steam under pressure was microbiologically shown the nil count for all viable and dormant stages of contamination and scored acceptable score on sensory analysis also; on the other hand, the samples of other preservation treatments resulted in a slight after-bitter taste observed by most of the panellists which negatively affected the sensory scores and were not considered for further physicochemical analysis during storage. However, hot air-treated and pasteurised samples showed well-comparable textural and related aesthetic attributes. Still, the overall acceptability of the samples was reduced owing to the bitter aftertaste may be due to the presence of sorbic acid (Vanitha et al. 2015). Observed an increase in TPC during storage in fish burgers. As per FSSAI appendix b-thermally processed vegetable products with exposure temperature less than 100°C required yeast and mold count max 50.g⁻¹. Whereas retort product should not possess any yeast and mould count. The E. coli count was absent in 25 g of the sample. A moth and moong tikki product satisfying regulatory compliances (Safety 2011).

Fatty acid profile of legume tikkies analysed by gas chromatogram. The data obtained in terms of primary fatty acids present in the frying medium (refined sunflower oil) used during processing palmitic acid C16:0, stearic acid C18:0, oleic acid C18:1 and linoleic acid C18:2 (Table 4). There was a significant difference in the fatty acid content of the samples under different preservation treatments. The change in fatty acid composition can be related to the formation of peroxide value and FFA during storage. Changes in fatty acid increase POV during iced storage were investigated (Sae-leaw and Benjakul 2014).

Conclusions

The process for the preparation of legume-based Tikkies (Moong bean and Moth) was optimized concerning organoleptic acceptability. It was difficult to prepare a Tikki having legume fraction more than 60%, hence different concentrations of

legumes viz. 60, 65, 70, 75, and 80% was tried along with other ingredients. Batch having 70% Moth and 10% potato was noted to be most acceptable concerning aesthetic attributes as desired in any Tikki or similar products. Preservation methods have a significant effect on various quality parameters affecting the sensory acceptability of Tikki. Moong and Moth Tikkies have undergone various preservation thermal treatments for shelf life of 30 days. Currently only vegetable and potato based tikkies available in the market with protein content approximately 2 to 4%. Moth and moong based tikki not only served purpose of culinary but also protein nutrition to society as well as special groups like sports person, teenagers, and soldiers. Such products do have their equal usability to the Armed Forces working at a hostile environment to meet their immediate requirement of nutritious and tasty food at their backpack.

References

- Ackman R.G. The analysis of fatty acids and related materials by gas-liquid chromatography. *Progress in the Chemistry of Fats and Other Lipids*, (1972). 12(C): 165-284.
[https://doi.org/10.1016/0079-6832\(72\)90003-1](https://doi.org/10.1016/0079-6832(72)90003-1)
- Bai J., Lee J., Lee S., Kim S., Choi M., Cho Y. Changes in Quality Characteristics of Pork Patties Containing Antioxidative Fish Skin Peptide or Fish Skin Peptide-loaded Nanoliposomes during Refrigerated Storage. *Food Science of Animal Resources*, 2017, 37(5): 752-763
<https://doi.org/10.5851/2Fkosfa.2017.37.5.752>
- Biswas A.K., Chatli, M. K., Sahoo, J. (2014). Shelf-life extension of chicken patties with the application of multiple hurdles and modified atmospheres packaging. *Indian Journal of Animal Sciences*, 84(10): 1121-1126. Available at:
<https://epubs.icar.org.in/index.php/IJAnS/article/view/44319/19527>
- Borch D., Juul-hindsgaul N., Veller M., Astrup A., Jaskolowski J., Raben A. Potatoes and risk of obesity, type 2 diabetes, and cardiovascular disease in apparently healthy adults. *The American Journal of Clinical Nutrition*, 2016, 104(1): 489-498.
<https://doi.org/10.3945/ajcn.116.132332>
- Goldberg B., Stern A. The role of the superoxide anion as a toxic species in the erythrocyte. *Archives of Biochemistry and Biophysics*, 1977, 178(1): 218-225.
[https://doi.org/10.1016/0003-9861\(77\)90187-4](https://doi.org/10.1016/0003-9861(77)90187-4)

- Harrigan W.F., McCance M.E. *Laboratory Methods in Food and Dairy Microbiology*. (First Edition). Academic Press Inc. Limited, London, New York, San Francisco. 1976, 452 pages. Print ISBN: 978-0123260406
- Jiao M., Zhao M., Lin L., Wang Y. Lonicera japonica Thunb. extract improves the quality of cold-stored porcine patty through inhibition of lipid and myofibrillar protein oxidation. *International Journal of Food Science and Technology*, 2018, 53(4): 986-993. <https://doi.org/10.1111/ijfs.13673>
- Khan M.A., Mahesh C., Semwal A.D., Sharma G.K., Srihari S.P., Jayaprahash C., Srihari K.A. Studies on the shelf-life enhancement of potato stuffed paratha using thermal processing. *Journal of Food Science and Technology*, 2014, 51(9): 2190-2196. <https://doi.org/10.1007/s13197-014-1269-y>
- Khan M.A., Semwal A.D., Sharma G.K., Mahesh C., Nataraj S., Srihari K.A., Bawa A.S. Development and evaluation of long shelf-life ambient stable chapatias without the use of chemical preservatives. *Journal of Food Processing and Technology*, 2011, 2(1): 107. <https://doi.org/10.4172/2157-7110.1000107>
- Krishnan J.G., Padmaja G., Moorthy S.N., Suja G., Sajeev M.S. Effect of pre-soaking treatments on the nutritional profile and browning index of sweet potato and yam flours. *Innovative Food Science and Emerging Technologies*, 2010, 11(2): 387-393. <https://doi.org/10.1016/j.ifset.2010.01.010>
- Lonnie M., Hooker E., Brunstrom J.M., Corfe B.M., Green M.A., Watson A.W., Williams E.A., Stevenson E.J., Penson S., Johnstone A.M. Protein for life: Review of optimal protein intake, sustainable dietary sources and the effect on appetite in ageing adults. *Nutrients*, 2018, 10(3): 1-18. <https://doi.org/10.3390/nu10030360>
- Mishal S., Kanchan S., Bhushette P.R., Sonawane S.K. Development of Plant based meat analogue. *Food Science and Applied Biotechnology*, 2022, 5(1): 45-53. <https://doi.org/10.30721/FSAB2022.V5.I1.169>
- Masson-Delmotte V., Zhai P., Pörtner H.-O., Roberts D., Skea J., Buendía E.C., Shukla P.R. Intergovernmental Panel on Climate Change. In: *Information Climate Change 2013 – The Physical Science Basis* (Working Group I Ed.). Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press. 2014, pp. 1 - 30, Online ISBN: 978-1-1074-1532-4, <https://doi.org/10.1017/CBO9781107415324.004>
- Pankaj S.K. Thermal Processing of Food. In: *Advances in Food Biotechnology* (V. Ravishankar Rai Ed.). John Wiley & Sons Ltd. 2015, pp. 681-692, Print ISBN: 978-1-118-86455-5, Online ISBN: 978-1-1188-6446-3, <https://doi.org/10.1002/9781118864463.ch40>
- Patel D., Rathod R. Ready to eat Food Perception, Food Preferences and Food Choice: A Theoretical Discussion. *World Wide Journal of Multidisciplinary Research and Development*, 2017, 3(8): 198-205. Available at: <http://www.jmr.com/upload/ready-to-eat-food-perception-food-preferences-and-food-choice-a-theoretical-discussion.pdf>
- Sae-leaw T., Benjakul S. Fatty acid composition, lipid oxidation, and fishy odour development in seabass (*Lates calcarifer*) skin during iced storage. *European Journal of Lipid Science and Technology*, 2014a, 116(7): 885-894. <https://doi.org/10.1002/ejlt.201300381>
- Safety F. Notification F.No. 2-15015/30/2010 Food Products Standards and Food Additives. In: *The Food Safety and Standards Authority of India (FSSAI)*, Ministry of Health and Family Welfare, New Delhi, 2011, pp. 287-529, Availabe at: <https://fssai.gov.in/cms/food-safety-and-standards-regulations.php>
- Vanitha M., Dhanapal K., Vidya Sagar Reddy G. Quality changes in fish burger from Catla (*Catla Catla*) during refrigerated storage. *Journal of Food Science and Technology*, 2015, 52(3): 1766-1771. <https://doi.org/10.1007/s13197-013-1161-1>
- Young L.S. Applications of texture analysis to dough and bread. In: *Breadmaking: Improving Quality, Second Edition* (S.P. Cauvain Ed). Woodhead Publishing Limited. 2012a, pp. 156-167. Print ISBN: 978-0-85709-060-7 <https://doi.org/10.1533/9780857095695.3.562>