Research Article

Production of Value-Added Meat Patties from Spent Hen Meat by Addition of Kiwi and Pineapple Extracts

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Abstract | Adding value to broiler-spent hen meat by enhancing its texture properties using natural tenderizers will not only provide a good affordable source of protein but will also provide economic benefits to the poultry meat industry. Therefore, this study aims to appropriate utilization of this meat to produce less expensive and highly nutritious value-added chicken meat patties. In this context, five groups of spent hen meat patties were formulated as follows: The first and 2nd groups were treated with 5 % and 7 % of kiwi extract, the 3rd and 4th groups were treated with 5 % and 7 % of pineapple extract, meanwhile, the 5th group was treated with a mixture of those extracts (5% kiwi + 5 % pineapple) in addition to the control group. All groups were kept in frozen storage at −18 °C for 3 months and subjected to proximate chemical analysis, measurement of deterioration criteria, and sensory quality. The results revealed that all enzyme-treated samples significantly increase protein content and significantly decrease the fat content, pH, and thiobarbituric acid value with a significant improvement in raw and cooked sensory attributes as compared to their counterpart control samples. Such effect was more pronounced in spent hen meat patties treated with a mixture of kiwi (5%) and pineapple (5%).

Keywords | Spent hen patties, Tenderization, Proximate chemical analysis, Deterioration criteria, Sensory attributes

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INTRODUCTION

Chicken meat has grown much popularity among consumers and its production, marketing, and consumption is increasing to satisfy public demand worldwide. Consumers' acceptability of this meat has increased owing to its low production cost and high nutritional value (Elshebrawy et al., 2022). However, the rapid increase in poultry farming produced a massive availability of spent hen stocks. Meat from the spent hen is highly enriched with a good protein source and omega-3 fatty acids with low cholesterol content (Lee et al., 2003). Conversely, its meat is usually tougher, dry, and less juicy when compared with broiler meat. Its toughness is linked to increasing connective tissue cross-linking of older animals which prohibited its utilization and market value. Therefore, due to the lower acceptability and poor texture of this meat, it is sold at a lower price in the retail market which reflects on the producer's profits (Mendiratta et al., 2004). Furthermore, most spent hen carcasses are slaughtered, rendered, and converted into protein meals for animal feed owing to their higher protein content (Fan and Wu, 2022).

The disposal of spent broiler hens which comprises transport and labor costs is an economic and environmental issue that faces the poultry meat industry (Freeman et al., 2009). Accordingly, using these hens in the production of value-added meat products with high nutritive value could achieve great profitability for both consumers and producers (Kadıoğlu et al., 2019). Challenges in manufacturing different meat products such as patties, sausages, or chicken nuggets from spent hen meat have been reported by Kondaiah and Panda (1992), nonetheless, their popularity is limited due to their firm texture. In this regard, it is essential to develop a suitable technique to improve the less palatable and tough spent hen meat for the production of attractive novel meat products.

Several tenderization methods can be used to improve the texture of the unacceptable tough spent hen meat and among these methods, marination is the most widely applied due to its cost-effective treatment, requires less space, and easy applicable (Arshad et al., 2016). Marination of spent hen meat using natural extracts from fruits such as pineapple and kiwi will increase the opportunities for incorporation of this meat in the manufacture of different meat products particularly to solve the issue related to the great shortage of chicken raw meat materials (Abdel-Naeem et al., 2022a). Pineapple fruit has been reported as a potential source of beneficial bioactive compounds (Ketnawa et al., 2009). It also contains a protein-digesting enzymes group (called cysteine proteinases) which can be used as tenderizing substances in meat. Moreover, kiwi fruit contains a plant thiol protease that has a meat tenderizing effect as well as contains carotenoids and flavonoids which possess great antioxidant activity (Christensen et al., 2009).

Although most of the previous research focused on studying the effect of using different additives such as ginger extract (Hossain et al., 2021), bee honey (Ali et al., 2022), oat flour (Mounika and Sahityarani, 2021), and giloy stem powder (Kumar et al., 2021) on the quality of spent hen meat sausages and patties, to the best of our knowledge, there is limited data on the use of kiwi and pineapple extracts in the processing of spent broiler hen meat patties. Therefore, the main objective of the current study was to assess the effect of using natural extracts of kiwi, pineapple, and their combination on the proximate chemical analysis, deterioration criteria, and sensory attributes of spent broiler hen meat patties.

MATERIALS AND METHODS

Study Design

Three independent experiments at different times (3 samples/ each analytical point) were performed to explore the effect of kiwi (5 and 7 %), pineapple (5 and 7 %) extracts, and their combination (5 % kiwi + 5 % pineapple) on the proximate chemical analysis, deterioration criteria, and sensory attributes of the processed spent hen meat patties.

Enzymes Preparation

Fresh fruits of pineapple and kiwi were obtained from a local market in Cairo, Egypt, peeled, cut, and mixed for 1–2 minutes with an equal amount of distilled water. The pineapple and kiwi slurries were filtered with muslin cloth and their filtrates were collected as fruit extracts which were used as a source of proteolytic enzymes during the production of spent hen meat patties.

Preparation Of Spent Hen Meat Patties Ingredients

Dressed spent hen carcasses (ten numbers and 4 kg each) were obtained from a local spent hen plant in Cairo, Egypt, directly transferred to the lab, and stored for 24 h at 4 °C. After storage, muscles of the breast and thigh were separated from the spent hen carcasses, trimmed from the noticeable connective tissue and fat then cut into small cubes (100 g). Common salt and starch were purchased from a local market in Cairo, Egypt while, phosphate salt and seasonings mix were purchased from Loba Chemie (Mumbai, India).

Marination Process

Spent hen meat cubes were immersed into five marinade solutions to obtain five groups as follows: The first and 2nd groups were immersed in 5 % and 7 % of kiwi extract however, the 3rd and 4th groups were immersed in 5 % and 7 % of pineapple extract, meanwhile, the 5th group was immersed in a mixture of those extracts (5% kiwi + 5 % pineapple) in addition to the control group was immersed in water. All groups were kept in the refrigerator for 24 h at 4 °C.

Formulation, Processing, And Storage Of Spent Hen Meat Patties

The marinated and non-marinated spent hen meat (75%) were minced using 4.5-mm a plate grinder (NW 114 E, Seydelmann, Stuttgart, Germany). The minced meat from each group was mixed with 18% of water, 1.5% of salt, 0.3% of polyphosphates, 5% of starch, and 0.2% of seasonings. After that, the mixture of each group was formed into 80 g patties with a thickness of 1.5 cm using a patty former then placed in plastic films and stored for 35 min at −40 °C. The frozen spent hen meat patties were inserted in plastic bags, then kept in freezing storage (−18 °C) for 3 months. The samples were taken from each group for analysis at 0-time (2nd day) and each month for up to 3 months.

Spent Hen Meat Patties Investigations Measurement Of The Proximate Chemical Analysis

Moisture, protein, fat, and ash contents (g/100 g) of spent hen meat patties from each group were measured using the method of AOAC (2000). Moisture contents were determined by drying 3 g of the sample at 100 °C until obtaining two successive fixed weights. In addition, protein content was measured using the Kjeldahl method and a conversion factor of 6.25 to convert nitrogen into crude protein. Moreover, fat content was analyzed using the Soxhlet apparatus, while ash content was analyzed using Muffle Furnace (500 °C for 5 h).

Measurement Of The Deterioration Criteria

The pH, total volatile base nitrogen (TVBN), and thiobarbituric acid (TBA) of spent hen meat patties from each group were measured at 0-time and monthly during frozen storage. For the determination of pH value, five grams from each sample were homogenized for 10–15 s with 20 ml distilled water, then the pH value was measured using a previously adjusted pH meter (Lovibond Senso Direct) with buffers (7.0 and 4.0). Three reading was obtained from each sample and their average was calculated (Abdel-Naeem et al., 2022b). The TBA value was determined using the method described by Du and Ahn (2002) and expressed as milligrams of malondialdehyde per kilogram of the sample. Furthermore, TVBN (mg%) was determined using a macro-Kjeldahl distillation apparatus according to the method outlined by Kearsley et al. (1983).

Sensory Analysis

Sensory examination of raw and cooked spent hen meat patties was performed following the guidelines of the AMSA (1995). Odd numbers of well-trained panelists were selected from Food Hygiene and Control Department at Cairo University, Egypt. The panelists assessed raw spent hen meat patties for appearance, color, odor, consistency, forming, fringe, and overall acceptability, using 9-point numerical scores (9 is highly desirable and 1 is highly undesirable). Nonetheless, for sensory examination of cooked samples, five patties from each group were cooked in a hot air oven (Heraeus D-63,450 Hanau, Germany) at 180 °C and a core temperature of 75 °C. After that, the panelist assessed all groups for appearance, color, flavor, tenderness, juiciness, and overall-acceptability using the same numerical scores of raw samples.

Measurement Of Cooking Loss

Cooked spent hen meat patties from each group were cooled after cooking in a hot air oven, and they were reweighted to determine the cooking loss percentage from the weight, before and after cooking.

Statistical Analysis

All measurements were analyzed using SPSS statistics for windows 17.0 (IBM Corp., Armonk, NY, USA), expressed as mean ± SE, and compared among different groups using one-way analysis of variance (ANOVA). Moreover, the significance was done using the least square difference (LSD) procedure and the differences were considered significant at $P < 0.05$ levels.

RESULTS AND DISCUSSIONS

Proximate Chemical Analysis

The proximate chemical composition of spent hen patties treated with kiwi (5 and 7%), pineapple (5 and 7%), and a mixture of kiwi (5%) and pineapple (5%) is presented in Table 1. There was a significant ($P < 0.05$) increase in moisture content in samples treated with pineapple (5 and 7%), and a mixture of kiwi (5%) and pineapple (5%) when compared with the control sample. In addition, all enzymes treated samples significantly ($P < 0.05$) increase protein content and significantly ($P < 0.05$) decrease the fat content. Moreover, there was a significant ($P < 0.05$) decrease in ash content in samples treated with pineapple (7%), and a mixture of kiwi (5%) and pineapple (5%).

Similar results were recorded by Pooona et al. (2019), who observed a significant increase in protein and moisture content, and a significant reduction in fat content with a non-significant reduction in ash content in spent hen nuggets treated with kiwi. However, AL-Hameed and AL-Jawary (2017) noticed that treatment of spent hen thigh meat with kiwi juice significantly increased moisture content and significantly decreased protein, and fat as compared with the control treatment. In addition, a significant increase in protein and fat with non-significant change in ash was observed in spent hen sausage treated with 2% bee honey (Ali et al., 2022) and 2% ginger extract (Hossain et al., 2021). Furthermore, Sabikun et al. (2021) reported a non-significant change in protein and fat contents in spent hen chicken nuggets treated with 5% milk fat as compared with control samples. The moisture content was significantly increased in spent hen chicken patties treated with egg powders (Kalaikannan et al., 2007) and in spent hen meat tenderized by bitter orange juice, vinegar, salt, and sugar (Al-Hajo, 2009). Conversely, a significant decrease in moisture content was observed in the chicken breast treated with protease enzyme (Rawdkuen et al., 2013). The significant increase in moisture content in pineapple-treated spent hen meat patties owing to the hydrophilic properties of bromelain in pineapple fruit which increase the moisture absorption inside the product (Ketnawa and Rawdkuen, 2011).

It was noteworthy that the proximate chemical analysis was affected by the species and breed. For instance, Biswas et al. (2006) compared the quality of chicken and duck patties prepared from broiler, spent hen, and duck. The authors recorded that patties prepared from broiler meat showed

Table 1: Proximate chemical analysis of spent hen patties treated with kiwi (5 and 7%), pineapple (5 and 7%), and a mixture of kiwi (5%) and pineapple (5%).

	Moisture (g%)	Protein (g%)	Fat (g%)	Ash (g%)
Control	69.54^{c} ± 0.06	15.53^{d} ± 0.26	12.62^{a} ± 0.19	2.28^{ab} ± 0.05
Kiwi 5%	69.77^{bc} ± 0.18	17.73^{c} ± 0.21	10.04^{b} ± 0.02	2.44^{a} ± 0.01
Kiwi 7%	69.60^{bc} ± 0.14	18.27^{b} ± 0.09	9.64^{bc} ± 0.31	2.46^{a} ± 0.03
Pineapple 5%	70.06^{ab} ± 0.16	18.53^{ab} ± 0.22	9.45^{cd} ± 0.26	1.95^{bc}± 0.15
Pineapple 7%	70.41^{a} ± 0.13	19.17^{a} ± 0.26	9.00^{d} ± 0.01	1.42^{c} ± 0.12
Kiwi 5% & Pineapple 5%	70.30^{a} ± 0.12	18.74^{ab} ± 0.24	9.07^{cd} ± 0.08	1.63^{c} ± 0.17

$^{a–d}$ Means with different superscripts within the same column significantly (P < 0.05 or P < 0.01) different

Values represent the mean ± SE.

significantly the highest moisture content, while the significantly higher fat content was recorded in duck patties. Likewise, Indumathi et al. (2019) found that sausages made from spent broiler hen meat had significantly superior proximate analysis than sausages made from broiler meat. Additionally, Loetscher et al. (2014) observed that fat content was lower in sausages prepared from the meat of Institut de Sélection Animale warren spent hens than those from Dekalb White spent hen.

Deterioration Criteria

The obtained results revealed that all enzymes treated-spent hen patties induced significant (P < 0.05) reduction in pH value as compared with control samples. Among all treated samples, spent hen patties treated with kiwi 7% had the lowest pH value (Table 2). A similar pH drop in kiwi treated sample, in this study, was observed in spent hen nuggets marinated with kiwi (Pooona et al., 2019) and in pork loin muscle treated with kiwi fruit juice (Liu et al., 2011). This was explained by the acidic pH of kiwi fruit (Fernández-Sestelo et al., 2013). However, AL-Hameed and AL-Jawary (2017) recorded a non-significant decrease in pH value of 50% kiwi-treated spent hens meat. Furthermore, the significant decrease in pH value in the pineapple-treated sample, in the current study, is in harmony with Hussain et al. (2022), who observed a significant decrease in pH value in broiler breast meat macerated with 100% pineapple core extract for 35 min. Moreover, Kadıoğlu et al. (2019) noticed a significant decrease in the pH of pineapple fruit treated spent hens with increasing marination time. Such finding is owing to the proteolytic activity of bromelain enzyme in pineapple fruit with subsequent release of amino acids. This observation was supported by Ketnawa and Rawduken (2011), who found that bromelain makes hydrolyses for the muscle protein and leads to the release of amino acids which results in a decrease in the meat's pH.

Treatment of spent hen patties with kiwi (7%), pineapple (5 and 7%), and a mixture of kiwi (5%) and pineapple (5%) resulted in a significant (P < 0.05) increase in TVBN at zero time of examination and during the entire frozen storage (Table 3). However, treatment of spent hen patties with kiwi (5%) induced a significant (P < 0.05) increase in TVBN at only the end of the storage period (Table 3). Such observation is due to the degradation of protein into volatile nitrogen compounds with subsequent increase in TVBN by the action of the proteolytic enzymes in kiwi and pineapple fruits. This was confirmed by Zhang et al. (2011), who found that TVBN is formed by the degradation of protein into volatile bases through the action of endogenous enzymes. Furthermore, the TVBN value of all enzyme-treated spent hen meat patties as well as control samples was increased with an increase in the storage time (Table 3). This was in harmony with that reported in kiwi-treated beef stored at 4 °C for 7 days (Jiao et al., 2020). Our results revealed that all enzyme-treated spent hen patties exerted a significant (P < 0.05) decrease in TBA value when compared with control samples and such effect was more pronounced in samples treated with kiwi (5% and 7%) as well as samples treated with a mixture of kiwi (5%) and pineapple (5%; Table 4). It is also clear that pH value, TVBN and TBA values increased with increasing the storage period as such effects were more pronounced in the control untreated spent hen patties (Tables 2, 3, and 4). Similar to the obtained results, Pooona et al. (2019) observed a significant reduction in TBA of spent hen meat nuggets treated with kiwi which is related to its antioxidant properties. Moreover, Abdel-Wahab et al. (2020) found that kiwi reduces lipid and protein oxidation of the marinated fish and they attributed this effect to its content of bioactive compounds which have great antioxidant activity. In the same regard, D'evoli et al. (2015) noticed that kiwi fruit is a good source of numerous natural antioxidant bioactive compounds such as ascorbic acid, carotenoids, and phenolics. A lower TBA value in pineapple-treated spent hen meat than the control sample was reported by Kantale et al. (2019) owing to the natural antioxidant effect of polyphenols and flavonoids in pineapple peel. Additionally, a significant reduction in TBA value was reported in spent hen sausages treated with bee honey (Ali et al., 2022), spent hen sausages treated with the ginger extract (Hossain et al., 2021), trans-cinnamaldehyde treated meat patties (Naveena et al., 2014), and dried yolk and albumen

Table 2: pH values of spent hen patties treated with kiwi (5 and 7%), pineapple (5 and 7%), and a mixture of kiwi (5%) and pineapple (5%) during frozen (−18 °C) storage for 3 months.

Treatments	Storage period (months)			
	0-time	1st month	2nd month	3rd month
Control	$6.13^{a} \pm 0.03$	$6.24^{a} \pm 0.01$	$6.34^{a} \pm 0.01$	$6.39^{a} \pm 0.01$
Kiwi 5%	$5.73^{d} \pm 0.06$	$5.91^{d} \pm 0.04$	$6.14^{d} \pm 0.01$	$6.21^{d} \pm 0.01$
Kiwi 7%	$5.48^{e} \pm 0.01$	$5.73^{e} \pm 0.05$	$5.88^{e} \pm 0.02$	$6.13^{e} \pm 0.00$
Pineapple 5%	$6.01^{b} \pm 0.04$	$6.08^{bc} \pm 0.00$	$6.19^{c} \pm 0.00$	$6.22^{cd} \pm 0.01$
Pineapple 7%	$6.00^{b} \pm 0.02$	$6.06^{c} \pm 0.02$	$6.18^{c} \pm 0.00$	$6.24^{bc} \pm 0.02$
Kiwi 5% & Pineapple 5%	$5.87^{c} \pm 0.03$	$6.08^{bc} \pm 0.01$	$6.22^{b} \pm 0.01$	$6.26^{b} \pm 0.01$

a–e Means with different superscripts within the same column significantly ($P < 0.05$ or $P < 0.01$) different
Values represent the mean ± SE

Table 3: Total volatile base nitrogen (mg%) values of spent hen patties treated with kiwi (5 and 7%), pineapple (5 and 7%), and a mixture of kiwi (5%) and pineapple (5%) during frozen (−18 °C) storage for 3 months.

Treatments	Storage period (months)			
	0-time	1st month	2nd month	3rd month
Control	$2.62^{d} \pm 0.14$	$3.86^{d} \pm 0.19$	$6.51^{b} \pm 0.20$	$12.08^{b} \pm 0.33$
Kiwi 5%	$2.94^{cd} \pm 0.04$	$3.77^{cd} \pm 0.60$	$7.32^{ab} \pm 0.30$	$14.08^{a} \pm 0.96$
Kiwi 7%	$3.25^{bc} \pm 0.16$	$4.63^{bc} \pm 0.31$	$7.58^{a} \pm 0.26$	$14.33^{a} \pm 0.88$
Pineapple 5%	$3.89^{a} \pm 0.05$	$5.40^{ab} \pm 0.16$	$7.83^{a} \pm 0.43$	$14.18^{a} \pm 0.09$
Pineapple 7%	$3.95^{a} \pm 0.03$	$5.81^{a} \pm 0.04$	$7.84^{a} \pm 0.12$	$14.60^{a} \pm 0.28$
Kiwi 5% & Pineapple 5%	$3.40^{b} \pm 0.21$	$5.16^{ab} \pm 0.01$	$7.51^{a} \pm 0.22$	$14.18^{a} \pm 0.60$

a–d Means with different superscripts within the same column significantly ($P < 0.05$ or $P < 0.01$) different
Values represent the mean ± SE

Table 4: Thiobarbituric acid (mg/kg) values of spent hen patties treated with kiwi (5 and 7%), pineapple (5 and 7%), and a mixture of kiwi (5%) and pineapple (5%) during frozen (−18 °C) storage for 3 months.

Treatments	Storage period (months)			
	0-time	1st month	2nd month	3rd month
Control	$0.26^{a} \pm 0.02$	$0.38^{a} \pm 0.04$	$0.75^{a} \pm 0.01$	$0.88^{a} \pm 0.01$
Kiwi 5%	$0.10^{bcd} \pm 0.01$	$0.14^{c} \pm 0.01$	$0.27^{c} \pm 0.01$	$0.36^{c} \pm 0.01$
Kiwi 7%	$0.08^{cd} \pm 0.02$	$0.13^{c} \pm 0.01$	$0.22^{d} \pm 0.00$	$0.33^{cd} \pm 0.01$
Pineapple 5%	$0.15^{b} \pm 0.01$	$0.26^{b} \pm 0.01$	$0.34^{b} \pm 0.01$	$0.45^{b} \pm 0.02$
Pineapple 7%	$0.13^{bc} \pm 0.01$	$0.23^{b} \pm 0.01$	$0.30^{bc} \pm 0.02$	$0.42^{b} \pm 0.02$
Kiwi 5% & Pineapple 5%	$0.07^{d} \pm 0.00$	$0.13^{c} \pm 0.01$	$0.19^{d} \pm 0.02$	$0.29^{d} \pm 0.01$

a–d Means with different superscripts within the same column significantly ($P < 0.05$ or $P < 0.01$) different
Values represent the mean ± SE

treated spent hens meat patties (Kalaikannan et al., 2007). Conversely, the addition of milk fat (8-10%) did not significantly affect the oxidative stability of spent hen meat during storage (Sabikun et al., 2021). The quality of chicken and duck patties processed from broiler, spent hen, and the duck was compared by Biswas et al. (2006) and they recorded higher TBA values in duck patties than spent hen and broiler. Such observation is owing to a higher fat content in duck meat as compared to chicken meat with subsequent oxidation in the concerned patties (Rao and Reddy, 2000).

Sensory Quality

The sensory scores of raw and cooked spent hen meat patties treated with 5 and 7% of each kiwi and pineapple and a mixture of them (5% kiwi + 5% pineapple) are presented in Table 5-6. All enzyme treated-samples induced a significant improvement in all raw and cooked sensory attributes as compared to their counterpart control samples and this finding was more pronounced in spent hen patties treated with a mixture of kiwi (5%) and pineapple (5%). Nevertheless, lower consumer acceptability was observed in 7% pineapple-treated samples and this may be due to

Table 5: Sensory analysis of raw spent hen patties treated with kiwi (5 and 7%), pineapple (5 and 7%), and a mixture of kiwi (5%) and pineapple (5%) during frozen (−18 °C) storage for 3 months.

Treatments	Storage period (months)			
	0-time	**1st month**	**2nd month**	**3rd month**
	Appearance			
Control	$6.67^{b} \pm 0.33$	$5.33^{c} \pm 0.67$	$4.67^{c} \pm 0.33$	$4.00^{c} \pm 0.00$
Kiwi 5%	$8.67^{a} \pm 0.33$	$8.00^{a} \pm 0.00$	$7.67^{a} \pm 0.33$	$7.33^{a} \pm 0.33$
Kiwi 7%	$8.33^{a} \pm 0.33$	$8.00^{a} \pm 0.00$	$7.67^{a} \pm 0.33$	$7.33^{a} \pm 0.33$
Pineapple 5%	$7.33^{b} \pm 0.33$	$7.00^{ab} \pm 0.00$	$6.33^{b} \pm 0.33$	$6.00^{b} \pm 0.58$
Pineapple 7%	$7.00^{b} \pm 0.00$	$6.67^{b} \pm 0.33$	$6.00^{b} \pm 0.00$	$5.67^{b} \pm 0.33$
Kiwi 5% & Pineapple 5%	$8.67^{a} \pm 0.33$	$8.33^{a} \pm 0.33$	$7.67^{a} \pm 0.33$	$7.33^{a} \pm 0.33$
	Color			
Control	$5.67^{c} \pm 0.33$	$4.33^{c} \pm 0.33$	$3.67^{c} \pm 0.33$	$2.67^{d} \pm 0.33$
Kiwi 5%	$8.33^{a} \pm 0.33$	$7.67^{ab} \pm 0.33$	$7.33^{ab} \pm 0.33$	$7.00^{ab} \pm 0.58$
Kiwi 7%	$8.00^{ab} \pm 0.00$	$7.67^{ab} \pm 0.33$	$7.67^{a} \pm 0.33$	$7.33^{a} \pm 0.33$
Pineapple 5%	$7.33^{b} \pm 0.33$	$7.00^{b} \pm 0.00$	$6.33^{b} \pm 0.33$	$5.67^{c} \pm 0.33$
Pineapple 7%	$7.33^{b} \pm 0.33$	$7.00^{b} \pm 0.00$	$6.33^{b} \pm 0.33$	$6.00^{bc} \pm 0.00$
Kiwi 5% & Pineapple 5%	$8.67^{a} \pm 0.33$	$8.33^{a} \pm 0.33$	$8.33^{a} \pm 0.33$	$8.00^{a} \pm 0.00$
	Odor			
Control	$4.33^{b} \pm 0.33$	$3.67^{b} \pm 0.33$	$3.00^{b} \pm 0.58$	$2.67^{b} \pm 0.33$
Kiwi 5%	$8.33^{a} \pm 0.33$	$8.00^{a} \pm 0.00$	$7.67^{a} \pm 0.33$	$7.33^{a} \pm 0.33$
Kiwi 7%	$8.67^{a} \pm 0.33$	$8.33^{a} \pm 0.33$	$8.00^{a} \pm 0.58$	$7.67^{a} \pm 0.33$
Pineapple 5%	$8.33^{a} \pm 0.33$	$8.00^{a} \pm 0.00$	$7.33^{a} \pm 0.33$	$7.00^{a} \pm 0.58$
Pineapple 7%	$8.33^{a} \pm 0.33$	$8.33^{a} \pm 0.33$	$8.00^{a} \pm 0.00$	$7.67^{a} \pm 0.33$
Kiwi 5% & Pineapple 5%	$9.00^{a} \pm 0.00$	$8.33^{a} \pm 0.33$	$8.33^{a} \pm 0.33$	$8.00^{a} \pm 0.58$
	Consistency			
Control	$4.33^{c} \pm 0.33$	$3.33^{c} \pm 0.33$	$3.00^{d} \pm 0.00$	$2.33^{c} \pm 0.33$
Kiwi 5%	$8.33^{ab} \pm 0.33$	$8.00^{a} \pm 0.20$	$7.67^{ab} \pm 0.33$	$7.33^{ab} \pm 0.33$
Kiwi 7%	$8.67^{a} \pm 0.33$	$8.33^{a} \pm 0.33$	$8.33^{a} \pm 0.33$	$8.00^{a} \pm 0.58$
Pineapple 5%	$8.00^{ab} \pm 0.33$	$7.33^{b} \pm 0.33$	$7.00^{bc} \pm 0.00$	$6.67^{b} \pm 0.33$
Pineapple 7%	$7.67^{b} \pm 0.33$	$7.00^{b} \pm 0.00$	$6.67^{c} \pm 0.33$	$6.33^{b} \pm 0.33$
Kiwi 5% & Pineapple 5%	$8.67^{a} \pm 0.33$	$8.33^{a} \pm 0.33$	$8.33^{a} \pm 0.33$	$8.00^{a} \pm 0.58$
	Forming			
Control	$7.67^{bc} \pm 0.33$	$7.00^{ab} \pm 0.00$	$6.33^{c} \pm 0.33$	$6.00^{b} \pm 0.58$
Kiwi 5%	$8.33^{ab} \pm 0.33$	$8.00^{a} \pm 0.58$	$7.67^{ab} \pm 0.33$	$7.33^{a} \pm 0.33$
Kiwi 7%	$8.33^{ab} \pm 0.33$	$7.67^{ab} \pm 0.33$	$7.67^{ab} \pm 0.33$	$7.33^{a} \pm 0.33$
Pineapple 5%	$7.33^{c} \pm 0.33$	$7.00^{ab} \pm 0.58$	$6.67^{bc} \pm 0.33$	$6.67^{ab} \pm 0.33$
Pineapple 7%	$7.00^{c} \pm 0.00$	$6.67^{b} \pm 0.33$	$6.00^{c} \pm 0.58$	$6.00^{b} \pm 0.00$
Kiwi 5% & Pineapple 5%	$8.67^{a} \pm 0.33$	$8.00^{a} \pm 0.00$	$8.00^{a} \pm 0.00$	$7.67^{a} \pm 0.33$
	Fringe			
Control	$7.00^{c} \pm 0.00$	$6.67^{b} \pm 0.33$	$5.67^{b} \pm 0.33$	$5.33^{b} \pm 0.33$
Kiwi 5%	$8.00^{b} \pm 0.00$	$7.67^{a} \pm 0.33$	$7.67^{a} \pm 0.33$	$7.33^{a} \pm 0.33$
Kiwi 7%	$8.00^{b} \pm 0.00$	$7.67^{a} \pm 0.33$	$7.33^{a} \pm 0.33$	$7.33^{a} \pm 0.33$
Pineapple 5%	$6.67^{c} \pm 0.33$	$6.33^{b} \pm 0.33$	$6.33^{b} \pm 0.33$	$6.00^{b} \pm 0.58$
Pineapple 7%	$6.67^{c} \pm 0.33$	$6.00^{b} \pm 0.00$	$6.00^{b} \pm 0.00$	$5.67^{b} \pm 0.33$
Kiwi 5% & Pineapple 5%	$9.00^{a} \pm 0.00$	$8.33^{a} \pm 0.33$	$8.00^{a} \pm 0.00$	$7.33^{a} \pm 0.33$
	Overall-acceptability			

Control	5.00^{c} ± 0.58	4.00^{d} ± 0.58	3.67^{d} ± 0.67	3.33^{d} ± 0.33
Kiwi 5%	8.33^{ab} ± 0.33	7.67^{ab} ± 0.33	7.33^{ab} ± 0.33	7.00^{ab} ± 0.00
Kiwi 7%	8.00^{ab} ± 0.58	8.00^{ab} ± 0.58	7.67^{ab} ± 0.33	7.33^{a} ± 0.33
Pineapple 5%	7.67^{ab} ± 0.33	7.00^{bc} ± 0.00	6.67^{bc} ± 0.33	6.33^{b} ± 0.33
Pineapple 7%	7.00^{b} ± 0.58	6.00^{c} ± 0.00	5.67^{c} ± 0.33	5.33^{c} ± 0.33
Kiwi 5% & Pineapple 5%	8.67^{a} ± 0.33	8.33^{a} ± 0.33	8.00^{a} ± 0.00	7.67^{a} ± 0.33

$^{a-d}$ Means with different superscripts within the same column significantly ($P < 0.05$) different
Values represent the mean ± SE

Table 6: Sensory analysis of cooked spent hen patties treated with kiwi (5 and 7%), pineapple (5 and 7%), and a mixture of kiwi (5%) and pineapple (5%) during frozen (−18 °C) storage for 3 months.

Treatments	**Storage period (months)**			
	0-time	**1st month**	**2nd month**	**3rd month**
	Appearance			
Control	6.33^{c} ± 0.33	5.00^{c} ± 0.58	4.33^{c} ± 0.33	3.67^{c} ± 0.33
Kiwi 5%	9.00^{a} ± 0.00	8.33^{a} ± 0.33	8.00^{a} ± 0.58	7.67^{a} ± 0.33
Kiwi 7%	8.67^{a} ± 0.33	8.33^{a} ± 0.33	8.00^{a} ± 0.58	7.67^{a} ± 0.33
Pineapple 5%	7.67^{b} ± 0.33	7.33^{ab} ± 0.33	6.67^{ab} ± 0.33	6.33^{b} ± 0.33
Pineapple 7%	7.33^{b} ± 0.33	7.00^{b} ± 0.00	6.33^{b} ± 0.33	6.00^{b} ± 0.00
Kiwi 5% & Pineapple 5%	9.00^{a} ± 0.00	8.33^{a} ± 0.33	8.00^{a} ± 0.58	7.67^{a} ± 0.33
	Color			
Control	6.00^{c} ± 0.00	4.67^{b} ± 0.33	4.00^{c} ± 0.00	3.33^{c} ± 0.33
Kiwi 5%	8.67^{a} ± 0.33	8.00^{a} ± 0.00	7.67^{a} ± 0.33	7.33^{a} ± 0.33
Kiwi 7%	8.33^{ab} ± 0.33	8.00^{a} ± 0.00	8.00^{a} ± 0.00	7.67^{a} ± 0.33
Pineapple 5%	7.67^{b} ± 0.33	7.33^{a} ± 0.33	6.67^{b} ± 0.33	6.00^{b} ± 0.00
Pineapple 7%	7.67^{b} ± 0.33	7.33^{a} ± 0.33	6.67^{b} ± 0.33	6.00^{b} ± 0.00
Kiwi 5% & Pineapple 5%	8.33^{ab} ± 0.33	8.00^{a} ± 0.00	8.00^{a} ± 0.00	7.67^{a} ± 0.33
	Flavor			
Control	4.67^{b} ± 0.33	3.33^{b} ± 0.33	2.67^{b} ± 0.33	2.33^{b} ± 0.33
Kiwi 5%	8.67^{a} ± 0.33	8.33^{a} ± 0.33	8.00^{a} ± 0.00	7.67^{a} ± 0.33
Kiwi 7%	8.67^{a} ± 0.33	8.67^{a} ± 0.33	8.33^{a} ± 0.33	8.00^{a} ± 0.58
Pineapple 5%	8.67^{a} ± 0.33	8.33^{a} ± 0.33	7.67^{a} ± 0.33	7.33^{a} ± 0.33
Pineapple 7%	8.67^{a} ± 0.33	8.67^{a} ± 0.33	8.33^{a} ± 0.33	8.00^{a} ± 0.58
Kiwi 5% & Pineapple 5%	8.67^{a} ± 0.33	8.67^{a} ± 0.33	8.33^{a} ± 0.33	8.33^{a} ± 0.33
	Tenderness			
Control	4.67^{c} ± 0.33	3.67^{c} ± 0.33	3.33^{d} ± 0.33	2.33^{d} ± 0.33
Kiwi 5%	8.67^{ab} ± 0.33	8.33^{ab} ± 0.33	8.00^{ab} ± 0.00	7.67^{ab} ± 0.33
Kiwi 7%	9.00^{a} ± 0.00	8.67^{a} ± 0.33	8.67^{a} ± 0.33	8.33^{a} ± 0.33
Pineapple 5%	8.33^{ab} ± 0.33	7.67^{ab} ± 0.33	7.33^{bc} ± 0.33	7.00^{bc} ± 0.00
Pineapple 7%	8.00^{b} ± 0.00	7.33^{b} ± 0.33	7.00^{c} ± 0.00	6.67^{c} ± 0.33
Kiwi 5% & Pineapple 5%	9.00^{a} ± 0.00	8.67^{a} ± 0.33	8.67^{a} ± 0.33	8.33^{a} ± 0.33
	Juiciness			
Control	4.33^{c} ± 0.33	3.33^{e} ± 0.33	3.00^{d} ± 0.00	2.67^{d} ± 0.33
Kiwi 5%	8.33^{a} ± 0.33	8.00^{bc} ± 0.00	7.67^{ab} ± 0.33	7.33^{ab} ± 0.33
Kiwi 7%	9.00^{a} ± 0.33	8.67^{ab} ± 0.33	8.00^{a} ± 0.58	8.00^{a} ± 0.58
Pineapple 5%	7.67^{b} ± 0.33	7.33^{cd} ± 0.33	6.67^{bc} ± 0.33	6.33^{bc} ± 0.33
Pineapple 7%	7.33^{b} ± 0.33	6.67^{d} ± 0.33	6.33^{c} ± 0.33	6.00^{c} ± 0.00

Kiwi 5% & Pineapple 5%	$9.00^{a} \pm 0.33$	$9.00^{a} \pm 0.00$	$8.67^{a} \pm 0.33$	$8.33^{a} \pm 0.33$
	Overall-acceptability			
Control	$4.67^{c} \pm 0.33$	$3.67^{d} \pm 0.33$	$3.33^{d} \pm 0.33$	$3.00^{d} \pm 0.00$
Kiwi 5%	$8.67^{a} \pm 0.33$	$8.00^{ab} \pm 0.00$	$7.67^{ab} \pm 0.33$	$7.33^{ab} \pm 0.33$
Kiwi 7%	$8.67^{a} \pm 0.33$	$8.33^{ab} \pm 0.33$	$8.00^{ab} \pm 0.00$	$7.67^{ab} \pm 0.33$
Pineapple 5%	$8.33^{ab} \pm 0.33$	$7.67^{b} \pm 0.33$	$7.33^{b} \pm 0.33$	$7.00^{b} \pm 0.00$
Pineapple 7%	$7.67^{b} \pm 0.33$	$6.67^{c} \pm 0.33$	$6.00^{c} \pm 0.00$	$5.67^{c} \pm 0.33$
Kiwi 5% & Pineapple 5%	$9.00^{a} \pm 0.00$	$8.67^{a} \pm 0.33$	$8.33^{a} \pm 0.33$	$8.00^{a} \pm 0.00$

[a–e]Means with different superscripts within the same row for each parameter are significantly ($P < 0.05$) different.
Values represent the mean of 3 independent replicates± SE

Table 7: Cooking loss percentage of spent hen patties treated with kiwi (5 and 7%), pineapple (5 and 7%), and a mixture of kiwi (5%) and pineapple (5%) during frozen (−18 °C) storage for 3 months.

Treatments	Storage period (months)			
	0-time	1st month	2nd month	3rd month
Control	$13.85^{c} \pm 0.67$	$17.25^{d} \pm 0.21$	$20.11^{e} \pm 0.35$	$27.96^{d} \pm 0.41$
Kiwi 5%	$14.18^{bc} \pm 0.67$	$19.47^{c} \pm 0.30$	$23.75^{d} \pm 0.57$	$31.53^{c} \pm 0.37$
Kiwi 7%	$15.51^{bc} \pm 0.34$	$22.47^{b} \pm 0.91$	$25.08^{cd} \pm 0.30$	$33.86^{b} \pm 0.52$
Pineapple 5%	$20.67^{a} \pm 0.72$	$26.14^{a} \pm 0.49$	$27.08^{b} \pm 0.30$	$36.26^{a} \pm 0.31$
Pineapple 7%	$22.34^{a} \pm 1.05$	$27.35^{a} \pm 0.60$	$28.68^{a} \pm 0.49$	$37.04^{a} \pm 0.27$
Kiwi 5% & Pineapple 5%	$16.18^{b} \pm 0.26$	$23.14^{b} \pm 0.69$	$25.75^{bc} \pm 0.53$	$34.53^{b} \pm 0.27$

[a–e] Means with different superscripts within the same column significantly ($P < 0.05$) different
Values represent the mean ± SE

over-tenderization induced by using a higher concentration of pineapple (7%) with a consequent decrease in the forming score and formation of fringe.

Similar findings are reported in pineapple fruit-treated spent hen meat (Kang et al., 2012; Kadıoğlu et al., 2019) and kiwifruit-treated spent hen meat (Sharma and Vaidya, 2018). Furthermore, our results are also in good agreement with that reported in spent hen meat products. For instance, the incorporation of kiwifruit extract in spent hen chicken nuggets (Pooona et al., 2019) and spent hen chicken emulsion (Singh et al., 2021) resulted in significant improvement in their sensory score. In addition, a significant improvement in the sensory attributes of pork dry sausage treated with pineapple and kiwi fruits was reported by Żochowska-Kujawska et al. (2013). It is noteworthy that the significant improvement in the juiciness scores of kiwi and pineapple-treated samples may be attributed to the lower pH value (Table 2). Likewise, the significant improvement in their tenderness scores is owing to the proteolytic effect of bromelain in pineapple and actinidin enzymes in kiwi fruits. Moreover, the significant improvement in the flavor score in kiwi and pineapple-treated samples may be due to the formation of peptides and amino which are precursors of flavor compounds as a consequence of the proteolytic activity of bromelain and actinidin enzymes. Such observation was also confirmed by Demeyer et al. (1995) and Fadda et al. (2001), who reported that the proteolysis process improves the flavor score due to the formation of low molecular weight compounds such as peptides and amino.

Cooking Loss%

Our findings, in the current study, showed that there was a significant ($P < 0.05$) increase in cooking loss% in spent hen patties treated with kiwi (5% and 7%) starting from the first month of freezing storage and in spent hen patties treated with pineapple (5 and 7%), and a mixture of kiwi (5%) and pineapple (5%) at zero time of examination and during the entire store period (Table 7).

The obtained results are in consistent with Kadıoğlu et al. (2019), who noticed that treatment of spent hen meat with pineapple significantly increases cooking loss%. Moreover, Singh et al. (2018) found that treatment of chicken and beef meats with bromelain enzyme extracted from pineapple wastes significantly increases cooking loss value, and such value increase more with the increase of bromelain enzyme percentage. In the same regard, Ketnawa and Rawdkuen (2011) investigated the tenderizing effects of bromelain extract on the cooking yields of chicken and beef and noticed a significant decrease in the cooking yield% particularly when the concentration of bromelain enzyme increased. Nonetheless, Rawdkuen et al. (2013) observed a non-significant change in cooking yield% of the chicken breast samples treated with protease extracted from Calotropis Procera latex. Furthermore, a non-significant difference in the cooking loss% was recorded in spent hen sausages treated with bee honey (Ali et al., 2022), spent hen sausages treated with the ginger extract (Hossain et al., 2021), and spent hen meat patties treated with trans-cinnamaldehyde (Naveena et al., 2014). The significant increase in the cooking loss% in all treated spent hen patties samples, in this study, is attributed to the proteolytic effect of bromelain in pineapple and actinidin enzymes in kiwi fruits as well as their lower pH value that prompts protein denaturation and decreases their ability to hold the water.

CONCLUSIONS

Spent hen meat is a valuable source of protein however; the most significant issue associated with this meat is its extreme toughness owing to increasing connective tissue cross-linking with age which prohibited its utilization and market value. Therefore, kiwi and pineapple extracts were used for the tenderization of such meat and after that used for the production of spent hen meat patties. The results demonstrated that all enzyme-treated samples significantly improve the nutritional quality, lipid stability, and sensory attributes of the processed meat patties, particularly in samples treated with a mixture of kiwi (5%) and pineapple (5%). In conclusion, kiwi and pineapple extracts can be utilized by poultry meat processors to enhance consumer acceptance of this meat and to increase its suitability as a raw material for further meat processing.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

NOVELTY STATEMENT

Solving the issue related to the unacceptable texture of broiler-spent hen meat using natural tenderizers such as kiwi and pineapple extracts will not only provide a good affordable source of protein but also will provide economic benefits to the poultry meat industry. However, most of the previous research focused on studying the effect of using other additives such as ginger extract, bee honey, oat flour, and giloy stem powder on the quality of spent hen meat products and there is limited data on the use of kiwi and pineapple extracts in the processing of spent broiler hen meat patties. Therefore, this is the first study that was conducted to assess the effect of using natural extracts of kiwi, pineapple, and their combination on the proximate chemical analysis, deterioration criteria, and sensory attributes of spent broiler hen meat patties. From the obtained results, it is noteworthy that the incorporation of kiwi and pineapple extracts into spent hen meat patties adds value to such product, and improves its nutritional quality, oxidative stability as well as sensory quality.

AUTHOR'S CONTRIBUTION

All authors shared the same effort during performing this study

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