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Research Article

DEVELOPMENT AND PHYSICOCHEMICAL QUALITY ASSESSMENT OF SOLAR AND OVEN DRIED SPENT HEN MEAT POWDER INCORPORATED WITH PHYTO-INGREDIENTS

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ABSTRACT

An experiment was planned to develop spent hen meat powder using oven and solar dryer technique by incorporating phytochemicals (10%). The resultant powder was stored under aerobic and vacuum packaging and evaluated for various quality parameters like physico-chemical qualities with monthly interval. Yield of spent hen meat powder was recorded in both the drying methods, whereas significantly lower yield was observed in treated samples compared to control. No significant differences were observed among treatments for hygroscopicity, water hydration capacity, bulk density and solubility, justifying the suitability of the solar drying method. Steady increase of water activity and pH showed a positive correlation between both during storage period in treatments. Incorporation of phyto-ingredients and storage under vacuum packaging had reduced the TBARS values during storage period. Incorporation of phyto-ingredients also improves the colour characteristics of spent hen meat powder. Thus it can be concluded that the solar dryer has added advantage over the oven drying in preparation of spent hen meat power incorporated with phyto-ingredients having better physicochemical and functional properties.

Keywords: Oven drying, pH, Solar drying, Spent hen meat powder, TBARS, Water activity

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Poultry industry with 24 crores of layers (Kotaiah, 2018) records a growth rate of 8% (Desikan and Megarajan, 2014) in India. Effective utilization of layer birds after the end of their productive life is one of the vital requirements of the poultry industry, as 30% of the poultry slaughtered are spent hens (Jose, 2012). Tremendous growth in layer industry is the foundation of augmented availability of spent hen in many folds in the preceding years and will remain so in years to come. Although, spent hen meat is a good protein source but having minimal economic values because of its higher collagen content and toughness.

For commercial meat drying operations in rural settings, improved approaches have been developed using solar drying (Heinz and Hautzinger, 2007). In contrast to sun drying, where the meat is exposed directly to the sun, the solar drying method uses indirect solar radiation. Antioxidants are used in meat and meat products to reduce lipid oxidation. The antioxidants can be synthetic or natural origin and some natural plant extracts contain flavonoids and phenolic compounds having anti-oxidative effects. The demand for natural antioxidants, especially of plant origin has increased in the recent years due to the growing concern about potential toxicological effects of synthetic antioxidants among consumers.

Considering the above, spent hen chicken powder was prepared in a solar dryer which can serve as a good alternative for conversion of low cost layer meat to a high cost value added product with improved physicochemical quality characteristics. Further, addition of indigenous herbs and spices with high antioxidant property might improve the quality of the spent hen meat powder.

MATERIALS AND METHODS

The solar dryer was fabricated with wood which was composed of drying chamber, collector chamber and assemble box. Spent hens of commercial breed were obtained from Regional Poultry Breeding Farm, Kyrdemkulai, Ri Bhoi District, Meghalaya, India. Following ante-mortem examination, spent hens were hygienically slaughtered, dressed and deboned in the laboratory. All separable fat, fascia and connective tissue were trimmed off and meat was minced twice through 6 mm sieve in a meat mincer, packed in low density polyethylene (150 µm thickness) bags, and frozen at -18±2 °C till further use.

After conducting preliminary trials on quality of the finished product by addition of various type of spices and condiments, following spices *viz.* black pepper, cumin, coriander, cinnamon, clove and paprika powder and condiments *viz.* onion, garlic and ginger paste were selected for incorporation. Refined salt (Tata Chemicals Ltd., Mumbai) was procured from local market. After

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conducting preliminary trials and literature survey, as potent antioxidant source fruits and vegetables *viz*. amla (*Phallanthus emblica*), fermented bamboo shoot (*Bamboosa auriculata*), round lemon (*Citrus limon*), green tea (*Camellia sinensis*), and pomegranate (*Punica granatum*) was used in 3:3:1:1:2, respectively as non-meat ingredients for treatment groups.

After thawing of frozen minced meat, lean minced meat was mixed manually with the non meat ingredients chosen *viz.* salt, ice cubes, spices and condiments. After thorough mixing, minced meat was transferred to a clean glass beaker, which was placed in a pressure cooker containing required amount of water. Pressure cooker was closed and cooked for 5 min at 15l bs pressure. Required amount of fruit and vegetables in the form of extracts were added after cooking as shown in the formulation (Table 1).

Cooked meat mix was spread on cleaned stainless steel plates and placed in solar dryer as well as oven dryer (Lab Tech, LBI-15 ºE). The identities of each group were maintained and their weights were recorded. The temperature maintained in the oven dryer was 70 °C but the temperature in solar dryer was 60-70 °C. The drying time allowed in the solar dryer and in oven dryer was 30-35 hours and 20 hours, respectively. Along with the treatments, controls were also prepared parallelly without addition of phyto-ingredients.

Dried meat was ground in a kitchen grinder (Havells, Marathon) till fine powder were obtained and sieved by using a sieve (Mesh size No. 45, Sieve opening 354 µm or 0.354 µm) to remove the coarse material from meat powder.

Meat powder was packed in two methods i.e. vacuum packaging and aerobic packaging. Meat powder was placed inside food grade LDPE bag of 150 µm thickness and sealed with packaging sealer (Make: Golden Eagle, India) for aerobic packaging and with vacuum packaging machine (Sevana) for vacuum packaging. Meat powder packets were kept in room temperature by maintaining their identity intact. Finally, following 8 samples (Fig. 1) were assessed in monthly intervals to determine the shelf-life and other quality parameters.

Sample-A: Solar dried control sample under aerobic packaging

Sample-B: Solar dried control sample under vacuum packaging

Sample-C: Solar dried treatment sample under aerobic packaging

Sample-D: Solar dried treatment sample under vacuum packaging

Sample-E: Oven dried control sample under aerobic packaging

Sample-F: Oven dried control sample under vacuum packaging

Sample-G: Oven dried treatment sample under aerobic packaging

Sample-H: Oven dried treatment sample under vacuum packaging

Yield: The yield of spent hen meat powder was determined by following formula:

$$\text{Meat powder yield (\%)} = \frac{\text{Weight of meat powder}}{\text{Weight of meat mix}} \times 100$$

Water activity: The spent hen meat powder was placed in the sample container up to 1/2 to 3/4th level, placed inside the sample chamber and water activity was recorded by a water activity meter of Aqua Lab (Dew point water activity meter 4TE).

pH: The pH was measured as per the procedure of Pippen *et al.* (1965).

Hygroscopicity: Hygroscopicity of all samples was determined by using the method described by Bhatty (1998).

Water Hydration Capacity: Water hydration capacity of all samples was determined by using the method described by Quinn and Paton (1979).

Bulk density: The bulk density of spent hen meat powder was determined by measuring the weight of the powder and the corresponding volume.

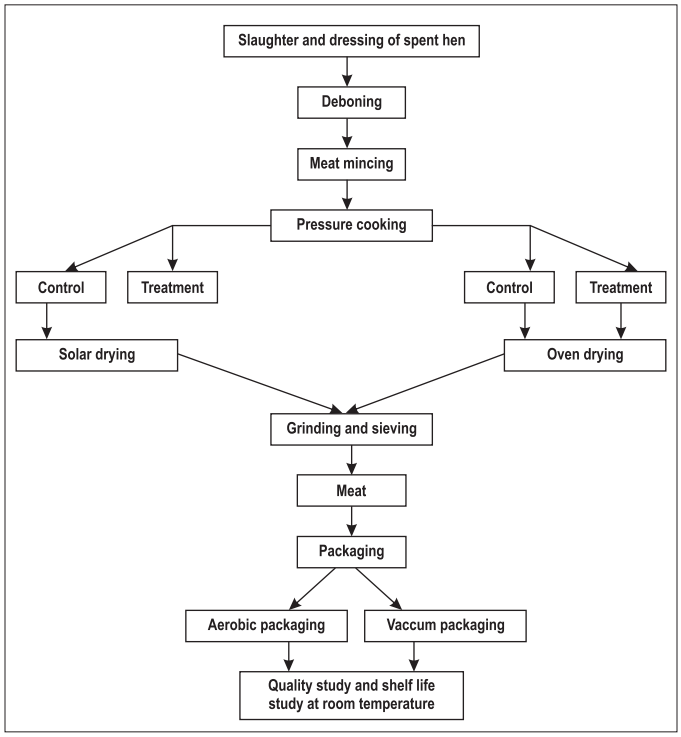

Fig. 1. Flow chart for preparation of spent hen meat powder

Solubility: Solubility of spent hen meat powder was determined using the procedure developed by Eastman and Moore (1984) and as adopted by Cano-Chauca *et al.* (2004).

Thiobarbituric Acid Reactive Substance (TBARS) value: The TBARS value was determined as per the method of Witte *et al.* (1970).

Tyrosine value: The procedure described by Strange *et al.* (1977) was used with slight modifications.

Colour profiles: The colours of spent hen meat powder were determined by using CIE Lmambm system in Cary 100 UV Visible Spectrophotometer. Colour was described as coordinates, e.g. Lm, am and bm where Lm measures relative lightness, am represents relative redness and bm represents relative yellowness. The numerical values received were used for colour analysis and comparison among samples.

Statistical Analysis:

The data were analyzed by SPSS software. 22 by one and two way analysis of variance followed by Tukey's honestly significant difference (HSD) test and Differences were considered significant at $p < 0.05$.

RESULTS AND DISCUSSION

Similar yield (%) of spent hen meat powder was found in both the drying methods with significantly ($p<0.01$) lower yield in treatments as compared to controls, which might be due to replacement of 10% meat with phyto-ingredients in treatment groups (Table 2). Hygroscopicity, water hydration capacity, bulk density and solubility of spent hen meat powder did not differ significantly between control and treatment and in between both the drying methods, indicates no major effects of drying methods and addition of phytoingredients on hygroscopicity, water hydration capacity, bulk density and solubility (Table 2).

The Water activities in spent hen meat powder of both the control and treated group did not differ significantly (Table 3). Steady increase of water activity during storage period in all samples was observed, which might be due to absorption of moisture from the environment, which was in accordance with dehydrated low sodium chicken strips from spent hen meat reported by Dange *et al.* (2014). Non-significant differences were also observed when comparison was made between the aerobic and vacuum packaging methods in both the control and treated groups of both the drying methods.

Similar pH values of the control and treatment were observed between solar and oven drying (Table 4). pH of treatment shows significantly lower values than control in both the drying methods, which might be due to presence of phyto-ingredients which play down chemical breakdown of protein and thus restrict the production of alkaline metabolites. All the samples show a significant ($p<0.01$) increase in mean value of pH during storage period, which might be due to production of certain alkaline metabolites from meat proteins (Sarkar *et al.*, 2020). No significant differences were observed between the mean pH value of aerobic and vacuum packaging throughout the storage period, which indicates that the water activity was low enough to hinder microbial breakdown of protein. Talib and Bouba (2010) also reported that there was slight increase in pH during storage period of cows meat dried by solar and oven dryer. The correlation between water activity and pH was highly positive irrespective of control, treatment, packaging methods and drying methods (Table 5).

Both the drying methods had similar effect on TBARS value of the spent hen meat powder (Table 6). Significantly ($p<0.01$) lower TBARS value of treatment in compare to control was observed from 150th day storage under aerobic and vacuum packaging in both the drying methods, which might be due to antioxidative activity of phyto-ingredients present in treated samples. Rohlik *et al.* (2013) also reported that due to addition of natural antioxidants the TBARS value reduced. Significantly ($p<0.01$) lower TBARS value was also observed in vacuum packaged samples compare to aerobic packaged samples from 150th day storage in control and treatments of both the drying methods, which might be due to hindrance of lipolysis in absence of oxygen in vacuum packaging. Kim *et al.* (2014) also reported increase in TBARS values

Table 1

Formulation for preparation of spent hen meat powder

Ingredients (parts per hundred)	Amount (%)	
	Control	Treatment
Minced chicken	90	80
Non-meat ingredients		
a) Fruits and vegetable as source of antioxidants (Amla, Fermented bamboo shoot, Round lemon, Green tea and Pomegranate)	0	10
b) Salt	2	2
c) Spices (Black pepper, Cumin, Coriander, Cinnamon, Clove, Paprika powder)	1	1
d) Condiments (Garlic:Ginger:Onion=1:1:2)	4	4
e) Ice cubes	3	3

Table 2

Physico-chemical characteristics of spent hen meat powder (Mean±SE)

Parameters	Solar Dried		Oven Dried	
	Control	Treatment	Control	Treatment
Yield (%)	23.66 ± 0.14^{A}	21.14 ± 0.14^{B}	23.63 ± 0.17^{A}	21.05 ± 0.14^{B}
Hygroscopicity (%)	26.65 ± 0.27^{A}	26.53 ± 0.26^{A}	26.89 ± 0.06^{A}	26.76 ± 0.15^{A}
Water Hydration Capacity (ml/g)	1.52 ± 0.04^{A}	1.54 ± 0.03^{A}	1.41 ± 0.11^{A}	1.44 ± 0.09^{A}
Bulk Density (g/ml)	0.41 ± 0.01^{A}	0.41 ± 0.01^{A}	0.40 ± 0.01^{A}	0.40 ± 0.01^{A}
Solubility (%)	36.51 ± 3.14^{A}	37.54 ± 3.27^{A}	36.47 ± 2.87^{A}	37.48 ± 3.57^{A}

Means having different superscripts in the row (capital letter) differ significantly (P<0.01). SE=Standard Error, N=5

Table 3

Water activity of spent hen meat powder during storage periods (Mean±SE)

Storage period (day)	Drying methods							
	Solar Dried				Oven Dried			
	Control		Treatment		Control		Treatment	
	A	B	C	D	E	F	G	H
0	$_{d}0.41\pm0.05^{A}$	$_{c}0.41\pm0.05^{A}$	$_{d}0.41\pm0.04^{A}$	$_{b}0.41\pm0.04^{A}$	$_{d}0.39\pm0.04^{A}$	$_{c}0.39\pm0.04^{A}$	$_{e}0.39\pm0.05^{A}$	$_{d}0.39\pm0.05^{A}$
30	$_{cd}0.45\pm0.03^{A}$	$_{bc}0.44\pm0.04^{A}$	$_{cd}0.45\pm0.04^{A}$	$_{ab}0.45\pm0.04^{A}$	$_{cd}0.44\pm0.01^{A}$	$_{bc}0.42\pm0.02^{A}$	$_{de}0.42\pm0.03^{A}$	$_{cd}0.41\pm0.04^{A}$
60	$_{cd}0.46\pm0.03^{A}$	$_{abc}0.45\pm0.04^{A}$	$_{bcd}0.47\pm0.04^{A}$	$_{ab}0.46\pm0.04^{A}$	$_{cd}0.45\pm0.02^{A}$	$_{bc}0.43\pm0.02^{A}$	$_{cde}0.45\pm0.04^{A}$	$_{bcd}0.43\pm0.04^{A}$
90	$_{bcd}0.47\pm0.03^{A}$	$_{abc}0.46\pm0.03^{A}$	$_{bc}0.49\pm0.04^{A}$	$_{ab}0.47\pm0.04^{A}$	$_{bc}0.47\pm0.01^{A}$	$_{abc}0.45\pm0.02^{A}$	$_{bcd}0.48\pm0.02^{A}$	$_{abcd}0.46\pm0.02^{A}$
120	$_{ab}c0.51\pm0.02^{A}$	$_{ab}0.49\pm0.03^{A}$	$_{ab}0.53\pm0.02^{A}$	$_{a}0.49\pm0.03^{A}$	$_{abc}0.51\pm0.02^{A}$	$_{ab}0.47\pm0.02^{A}$	$_{abc}0.51\pm0.02^{A}$	$_{abc}0.47\pm0.03^{A}$
150	$_{ab}0.54\pm0.02^{A}$	$_{ab}0.50\pm0.03^{A}$	$_{ab}0.54\pm0.02^{A}$	$_{a}0.50\pm0.03^{A}$	$_{ab}0.53\pm0.02^{A}$	$_{ab}0.49\pm0.02^{A}$	$_{ab}0.54\pm0.02^{A}$	$_{ab}0.50\pm0.02^{A}$
180	$_{a}0.57\pm0.01^{A}$	$_{a}0.52\pm0.02^{A}$	$_{a}0.57\pm0.02^{A}$	$_{a}0.52\pm0.03^{A}$	$_{a}0.57\pm0.01^{A}$	$_{a}0.51\pm0.02^{A}$	$_{a}0.57\pm0.01^{A}$	$_{a}0.51\pm0.02^{A}$

Means having different subscripts in the column (small letter) differ significantly (P<0.01). Means having different superscripts in the row (capital letter) differ significantly (P<0.01). SE=Standard Error, N=5

Table 4

Effect of drying and packaging methods on pH of spent hen meat powder during storage periods (Mean±SE)

Storage period (day)	Drying methods							
	Solar Dried				Oven Dried			
	Control		Treatment		Control		Treatment	
	Aerobic Packaging (A)	Vacuum Packaging (B)	Aerobic Packaging (C)	Vacuum Packaging (D)	Aerobic Packaging (E)	Vacuum Packaging (F)	Aerobic Packaging (G)	Vacuum Packaging (H)
0	$_{c}5.73\pm0.12^{A}$	$_{b}5.73\pm0.12^{A}$	$_{c}5.25\pm0.15^{AB}$	$_{c}5.25\pm0.15^{AB}$	$_{b}5.67\pm0.15^{AB}$	$_{b}5.67\pm0.15^{AB}$	$_{c}5.23\pm0.23^{B}$	$_{c}5.23\pm0.23^{B}$
30	$_{c}5.90\pm0.19^{A}$	$_{b}5.90\pm0.19^{A}$	$_{bc}5.43\pm0.21^{AB}$	$_{bc}5.39\pm0.23^{B}$	$_{b}5.80\pm0.13^{AB}$	$_{b}5.85\pm0.14^{AB}$	$_{bc}5.49\pm0.28^{AB}$	$_{bc}5.48\pm0.25^{AB}$
60	$_{c}5.92\pm0.18^{A}$	$_{b}5.91\pm0.17^{AB}$	$_{bc}5.45\pm0.24^{AB}$	$_{bc}5.42\pm0.27^{B}$	$_{b}5.82\pm0.09^{AB}$	$_{b}5.89\pm0.09^{AB}$	$_{bc}5.51\pm0.24^{AB}$	$_{bc}5.50\pm0.25^{AB}$
90	$_{c}5.93\pm0.17^{A}$	$_{b}5.91\pm0.14^{A}$	$_{bc}5.52\pm0.29^{A}$	$_{bc}5.46\pm0.30^{A}$	$_{b}5.82\pm0.09^{A}$	$_{b}5.89\pm0.04^{A}$	$_{abc}5.64\pm0.11^{A}$	$_{abc}5.52\pm0.12^{A}$
120	$_{bc}5.99\pm0.12^{A}$	$_{b}5.93\pm0.13^{AB}$	$_{bc}5.55\pm0.29^{AB}$	$_{bc}5.49\pm0.35^{B}$	$_{b}5.92\pm0.08^{AB}$	$_{b}5.90\pm0.04^{AB}$	$_{abc}5.67\pm0.10^{AB}$	$_{abc}5.57\pm0.12^{AB}$
150	$_{ab}6.72\pm0.13^{A}$	$_{a}6.65\pm0.14^{A}$	$_{ab}5.92\pm0.25^{BC}$	$_{ab}5.79\pm0.23^{C}$	$_{a}6.45\pm0.18^{A}$	$_{a}6.40\pm0.15^{AB}$	$_{ab}5.88\pm0.11^{C}$	$_{ab}5.79\pm0.13^{C}$
180	$_{a}6.83\pm0.13^{A}$	$_{a}6.78\pm0.15^{A}$	$_{a}6.14\pm0.22^{BC}$	$_{a}6.04\pm0.18^{C}$	$_{a}6.71\pm0.16^{A}$	$_{a}6.61\pm0.15^{AB}$	$_{a}6.13\pm0.12^{BC}$	$_{a}6.01\pm0.14^{C}$

Means having different subscripts in the column (small letter) differ significantly (P<0.01). Means having different superscripts in the row (capital letter) differ significantly (P<0.01). SE=Standard Error, N=5

during storage period of dry cured pork. Use of phytoingredients containing antioxidants is valuable in intercepting free radical in order to decrease rancidification.

The mean tyrosine value (mg/100 gm) was found to be in lower range in Solar drying than that of oven drying method, however no significant difference was observed

Table 5

Correlation between water activity (a_w) and pH of spent hen meat powder)

Parameter	Drying methods							
	Solar Dried				Oven Dried			
	Control		Treatment		Control		Treatment	
	Aerobic Packaging (A)	Vacuum Packaging (B)	Aerobic Packaging (C)	Vacuum Packaging (D)	Aerobic Packaging (E)	Vacuum Packaging (F)	Aerobic Packaging (G)	Vacuum Packaging (H)
Correlation coefficient between a_w and pH	0.920 (**)	0.852 (**)	0.911 (**)	0.908 (**)	0.901 (**)	0.902 (**)	0.979 (**)	0.923 (**)

** Correlation is significant at the 0.01 level (2-tailed)

Table 6

TBARS value (mg malonaldehyde/kg) of spent hen meat powder during storage periods (Mean±SE)

Storage period (day)	Drying methods							
	Solar Dried				Oven Dried			
	Control		Treatment		Control		Treatment	
	Aerobic Packaging (A)	Vacuum Packaging (B)	Aerobic Packaging (C)	Vacuum Packaging (D)	Aerobic Packaging (E)	Vacuum Packaging (F)	Aerobic Packaging (G)	Vacuum Packaging (H)
0	$_{c}0.38\pm0.03^{A}$	$_{c}0.38\pm0.03^{A}$	$_{c}0.35\pm0.03^{A}$	$_{b}0.35\pm0.03^{A}$	$_{c}0.41\pm0.04^{A}$	$_{c}0.41\pm0.04^{A}$	$_{c}0.35\pm0.03^{A}$	$_{b}0.35\pm0.03^{A}$
30	$_{c}0.40\pm0.05^{A}$	$_{bc}0.39\pm0.05^{A}$	$_{c}0.37\pm0.06^{A}$	$_{b}0.35\pm0.06^{A}$	$_{c}0.42\pm0.04^{A}$	$_{c}0.41\pm0.05^{A}$	$_{c}0.39\pm0.04^{A}$	$_{b}0.35\pm0.04^{A}$
60	$_{c}0.42\pm0.07^{A}$	$_{bc}0.39\pm0.07^{A}$	$_{c}0.37\pm0.03^{A}$	$_{b}0.36\pm0.03^{A}$	$_{c}0.44\pm0.05^{A}$	$_{bc}0.42\pm0.06^{A}$	$_{c}0.40\pm0.04^{A}$	$_{b}0.36\pm0.04^{A}$
90	$_{c}0.47\pm0.10^{A}$	$_{bc}0.40\pm0.07^{A}$	$_{bc}0.40\pm0.07^{A}$	$_{b}0.37\pm0.07^{A}$	$_{c}0.48\pm0.05^{A}$	$_{c}0.41\pm0.03^{A}$	$_{c}0.41\pm0.05^{A}$	$_{b}0.37\pm0.04^{A}$
120	$_{c}0.60\pm0.10A^{B}$	$_{bc}0.45\pm0.07^{AB}$	$_{bc}0.45\pm0.08^{AB}$	$_{b}0.39\pm0.07^{B}$	$_{c}0.62\pm0.06^{A}$	$_{bc}0.46\pm0.04^{AB}$	$_{bc}0.46\pm0.05^{AB}$	$_{b}0.39\pm0.04^{B}$
150	$_{b}0.91\pm0.11^{A}$	$_{b}0.61\pm0.09^{BC}$	$_{b}0.62\pm0.10^{BC}$	$_{b}0.48\pm0.09^{C}$	$_{b}0.94\pm0.10^{A}$	$_{b}0.64\pm0.08^{BC}$	$_{b}0.65\pm0.09^{BC}$	$_{b}0.48\pm0.05^{C}$
180	$_{a}2.01\pm0.25^{A}$	$_{a}1.06\pm0.13^{BC}$	$_{a}1.05\pm0.12^{BC}$	$_{a}0.73\pm0.11^{D}$	$_{a}2.04\pm0.21^{A}$	$_{a}1.22\pm0.13^{B}$	$_{a}1.14\pm0.12^{B}$	$_{a}0.87\pm0.08^{CD}$

Means having different subscripts in the column (small letter) differ significantly (P<0.01). Means having different superscripts in the row (capital letter) differ significantly (P<0.01). SE=Standard Error, N=5

Table 7

Tyrosine value (mg tyrosine/100g) of spent hen meat powder during storage periods (Mean±SE)

Storage period (day)	Drying methods							
	Solar Dried				Oven Dried			
	Control		Treatment		Control		Treatment	
	Aerobic Packaging (A)	Vacuum Packaging (B)	Aerobic Packaging (C)	Vacuum Packaging (D)	Aerobic Packaging (E)	Vacuum Packaging (F)	Aerobic Packaging (G)	Vacuum Packaging (H)
0	83.41 ± 3.47^{B}	83.41 ± 3.47^{B}	84.07 ± 1.05^{AB}	84.07 ± 1.05^{AB}	88.39 ± 2.21^{AB}	88.39 ± 2.21^{AB}	90.08 ± 2.07^{A}	90.08 ± 2.07^{A}
30	85.14 ± 2.71^{A}	85.13 ± 2.94^{A}	85.37 ± 2.06^{A}	85.22 ± 1.82^{A}	90.86 ± 1.52^{A}	90.16 ± 2.87^{A}	90.26 ± 2.11^{A}	90.01 ± 3.02^{A}
60	85.53 ± 2.06^{A}	85.48 ± 1.63^{A}	85.76 ± 2.27^{A}	85.56 ± 1.68^{A}	90.99 ± 0.43^{A}	90.63 ± 2.78^{A}	92.69 ± 1.94^{A}	92.12 ± 2.01^{A}
90	85.66 ± 2.21^{C}	85.54 ± 1.96^{C}	85.83 ± 3.44^{BC}	85.58 ± 3.11^{C}	91.03 ± 2.14^{ABC}	90.70 ± 2.67^{ABC}	92.75 ± 1.47^{A}	92.18 ± 2.06^{AB}
120	85.81 ± 3.77^{C}	85.59 ± 1.99^{C}	85.90 ± 0.52^{BC}	85.58 ± 3.07^{C}	90.91 ± 1.08^{ABC}	90.77 ± 2.69^{ABC}	92.85 ± 1.47^{A}	92.24 ± 2.05^{AB}
150	85.93 ± 3.76^{BC}	85.69 ± 1.99^{C}	86.00 ± 0.52^{BC}	85.65 ± 3.07^{C}	91.05 ± 1.05^{ABC}	90.87 ± 2.69^{ABC}	92.95 ± 1.47^{A}	92.31 ± 2.05^{AB}
180	86.00 ± 3.73^{BC}	85.73 ± 1.99^{C}	86.06 ± 0.51^{BC}	85.71 ± 3.06^{C}	91.10 ± 1.04^{ABC}	90.92 ± 2.66^{ABC}	93.01 ± 1.44^{A}	92.36 ± 2.02^{AB}

Means having different superscripts in the row (capital letter) differ significantly (P<0.01). SE=Standard Error, N=5

between these two drying methods (Table 7). Storage period had non-significant increasing trend on tyrosine value of spent hen meat powder in both control and treated samples under both drying and packaging methods indicates mild proteolysis during storage period, which could be minimize by vacuum packaging. Dange *et al.* (2014) also reported a consistent trend of increase in tyrosine value during entire storage period in dehydrated low sodium chicken strips from spent hen meat.

During storage period, the L* value increased

Table 8

Lightness/ darkness (l*) of spent hen meat powder during storage periods (Mean±SE)

Storage period (day)	Drying methods							
	Solar Dried				Oven Dried			
	Control		Treatment		Control		Treatment	
	Aerobic Packaging (A)	Vacuum Packaging (B)	Aerobic Packaging (C)	Vacuum Packaging (D)	Aerobic Packaging (E)	Vacuum Packaging (F)	Aerobic Packaging (G)	Vacuum Packaging (H)
0	$_{b}$89.25±0.84	$_{b}$89.25±0.84	$_{a}$89.03±1.91	$_{a}$89.03±1.91	$_{c}$89.13±1.99	$_{b}$89.13±1.99	$_{a}$89.08±1.75	$_{a}$89.08±1.75
30	$_{ab}$90.54±1.77	$_{ab}$90.15±2.25	$_{a}$89.13±2.39	$_{a}$89.11±1.53	$_{bc}$90.46±1.93	$_{ab}$90.16±2.12	$_{a}$89.14±2.26	$_{a}$89.13±1.56
60	$_{ab}$91.74±1.23	$_{ab}$90.87±1.35	$_{a}$89.92±2.30	$_{a}$89.91±1.43	$_{abc}$91.66±1.18	$_{ab}$90.72±0.95	$_{a}$89.85±1.32	$_{a}$89.86±1.07
90	$_{ab}$91.90±0.97	$_{ab}$91.54±1.15	$_{a}$90.43±2.35	$_{a}$90.23±1.19	$_{abc}$91.84±1.03	$_{ab}$90.81±0.28	$_{a}$90.28±1.46	$_{a}$90.25±0.39
120	$_{ab}$92.10±0.78	$_{ab}$91.76±1.05	$_{a}$90.63±2.15	$_{a}$90.43±1.01	$_{abc}$92.24±0.67	$_{ab}$90.81±0.28	$_{a}$90.50±1.44	$_{a}$90.35±0.42
150	$_{ab}$92.91±0.24	$_{ab}$92.16±0.69	$_{a}$91.23±0.63	$_{a}$90.86±0.69	$_{ab}$92.98±0.36	$_{ab}$92.25±0.75	$_{a}$91.30±0.67	$_{a}$90.95±0.69
180	$_{a}$94.11±0.72	$_{a}$92.96±0.66	$_{a}$92.03±0.51	$_{a}$91.26±0.50	$_{a}$94.18±0.23	$_{a}$93.05±0.83	$_{a}$92.10±0.52	$_{a}$91.35±0.44

Means having different subscripts in the column (small letter) differ significantly (P<0.01). SE=Standard Error, N=5

Table 9

Redness/greenness (a*) of spent hen meat powder during storage periods (Mean±SE)

Storage period (day)	Drying methods							
	Solar Dried				Oven Dried			
	Control		Treatment		Control		Treatment	
	Aerobic Packaging (A)	Vacuum Packaging (B)	Aerobic Packaging (C)	Vacuum Packaging (D)	Aerobic Packaging (E)	Vacuum Packaging (F)	Aerobic Packaging (G)	Vacuum Packaging (H)
0	$_{a}$4.32±1.34	$_{a}$4.32 ±1.34	$_{a}$5.08±1.55	$_{a}$5.08±1.55	$_{a}$4.27±0.11	$_{a}$4.27±0.11	$_{a}$4.97±1.20	$_{a}$4.97±1.20
30	$_{a}$3.65±0.65	$_{a}$3.72±0.54	$_{ab}$4.41±0.68	$_{a}$4.71±0.82	$_{a}$3.63±0.63	$_{a}$3.71±0.92	$_{a}$4.40±0.57	$_{a}$4.68±0.82
60	$_{a}$3.51±0.62	$_{a}$3.66±0.45	$_{ab}$4.08±0.51	$_{a}$4.25±0.69	$_{a}$3.52±0.61	$_{a}$3.63±0.73	$_{a}$4.09±0.58	$_{a}$4.21±0.70
90	$_{a}$3.23±0.43	$_{a}$3.37±0.41	$_{ab}$3.75±0.60	$_{a}$3.95±0.77	$_{a}$3.23±0.41	$_{a}$3.32±0.43	$_{a}$3.74±0.70	$_{a}$3.92±0.77
120	$_{a}$3.03±0.23	$_{a}$3.17±0.26	$_{ab}$3.55±0.42	$_{a}$3.75±0.58	$_{a}$3.03±0.21	$_{a}$3.12±0.23	$_{a}$3.54±0.52	$_{a}$3.72±0.58
150	$_{a}$2.83±0.36	$_{a}$2.97±0.40	$_{ab}$3.35±0.47	$_{a}$3.55±0.64	$_{a}$2.83±0.32	$_{a}$2.92±0.37	$_{a}$3.34±0.65	$_{a}$3.52±0.62
180	$_{a}$2.45±0.28	$_{a}$2.57±0.40	$_{b}$3.07±0.36	$_{a}$3.35±0.73	$_{a}$2.43±0.24	$_{a}$2.52±0.25	$_{a}$3.04±0.52	$_{a}$3.32±0.72

Means having different subscripts in the column (small letter) differ significantly (P<0.01). SE=Standard Error, N=5

Table 10

Yellowness/blueness (b*) of spent hen meat powder during storage periods (Mean±SE)

Storage period (day)	Drying methods							
	Solar Dried				Oven Dried			
	Control		Treatment		Control		Treatment	
	Aerobic Packaging (A)	Vacuum Packaging (B)	Aerobic Packaging (C)	Vacuum Packaging (D)	Aerobic Packaging (E)	Vacuum Packaging (F)	Aerobic Packaging (G)	Vacuum Packaging (H)
0	12.19±1.06	12.19±1.06	11.73±1.16	11.73±1.16	12.22±1.35	12.22±1.35	11.82±1.15	11.82±1.15
30	12.34±0.97	12.30±1.03	11.84±1.14	11.82±1.13	12.35±0.92	12.29±0.90	11.85±1.22	11.83±1.02
60	12.46±0.97	12.44±1.21	11.95±1.23	11.92±1.29	12.47±1.12	12.44±1.25	11.96±1.46	11.97±1.25
90	12.58±1.02	12.55±1.03	12.12±0.97	12.02±1.16	12.64±0.98	12.57±0.97	12.14±1.28	12.04±1.10
120	12.78±0.84	12.73±0.86	12.22±0.88	12.12±1.06	12.84±0.79	12.75±0.80	12.25±1.18	12.14±1.00
150	13.18±0.78	13.05±0.85	12.38±0.86	12.22±1.04	13.24±0.71	13.11±0.85	12.41±1.16	12.27±0.99
180	13.98±0.87	13.83±0.85	12.88±0.66	12.76±0.78	14.04±0.72	13.81±0.81	12.91±0.92	12.98±0.86

SE=Standard Error, N=5

marginally indicating colour of the products turn into more lighter (Table 8). Treatments of both drying methods show non-significant differences of lightness during storage period of 180 days, indicating hindrance of lipolysis due to presence of anti-oxidative substance in phyto-ingredients. Gramatina *et al.* (2014) also reported increase in Lm value during storage of venison jerky.

Redness which is used as an indicator of colour stability in meat and meat products showed minor fading with increasing storage period in both the packaging systems (Table 9). This might be due to increase in water activity in the samples during storage period which result into increased reflectance of the products and there is fading of colour of the dry products. Gramatina *et al.* (2014) also reported similar results of decreasing trend in redness during storage of venison jerky.

The drying and packaging methods and incorporation of phyto-ingredients did not influenced b* value of spent hen meat powder (Table 10). The non-significant increasing trend in b* values during storage could be related to oxidation of pigment and unsaturated fat content. The treated groups had lower b* values which might be due to presence of phyto-ingredients containing antioxidants. Cilla *et al.* (2006) also reported increasing trends in yellowness in MAP samples which is related to increased pigment oxidation during storage. Similar findings were also reported by Gramatina *et al.* (2014) who observed increase in yellowness during storage of venison jerky.

CONCLUSION

Spent hen meat powder could be developed incorporating with phyto-ingredients which exhibit good physicochemical, functional properties with better shelf stability. The solar dryer can be used over oven dryer for preparation of spent hen meat powder economically with similar product quality. Vacuum packaging is better than aerobic packaging to preserve qualities of end product.

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