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Research Article

QUALITY IMPROVEMENT OF POULTRY SLAUGHTER HOUSE BYPRODUCTS BASED PET FOOD WITH INCORPORATION OF FIBER-RICH VEGETABLE POWDER

Rishav Kumar[1*], Meena Goswami[1], Vikas Pathak[1], Arun Kumar Verma[2], Rajkumar V[2]

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ABSTRACT: The present study was conducted to evaluate the effect of fiber-rich vegetables on the quality characteristics of poultry slaughterhouse byproducts incorporated in pet food. Poultry byproducts incorporated in pet food were treated with different fiber-rich vegetables, *viz.* carrot and French beans powder separately at three suitable concentrations *i.e.* 5%, 10%, and 15% replacing freshly grated cruciferous vegetables and baked in a hot air oven at 150^{0}C for 20-25 minutes. Carrot powder @10% (CR) and French bean powder @10% (FB) were found optimum based on the palatability test. Finally, CR and FB were compared with control (BP) pet food for various physico-chemical properties and palatability tests. The pH values of BP and CR were significantly ($p<0.05$) higher than FB, whereas the baking yield values of CR were significantly ($p<0.05$) higher than BP and FB. Moisture, ash content, and water activity values of CR and FB were significantly ($p<0.05$) higher, and protein, as well as fat content, were significantly ($p<0.05$) lower than BP. There were no significant differences in springiness, cohesiveness, and resilience values between control and treatments. Hardness values of BP were significantly ($p<0.05$) higher whereas gumminess and chewiness values were significantly ($p<0.05$) lower than CR and FB. There was no significant difference in any textural parameter between CR and FB. Lightness and yellowness values of CR were significantly ($p<0.05$) higher whereas redness values of FB were significantly ($p<0.05$) lower than BP and other treatments. The scores of all palatability attributes of FB were significantly ($p<0.05$) lower than BP and CR, whereas no significant difference was observed between BP and CR. Therefore, Poultry byproducts incorporated with pet food with 10% carrot powder were selected as the best treatment.

Key words: Poultry slaughterhouse byproducts, Fiber enrichment, Carrot powder, French bean powder, Palatability test.

INTRODUCTION

Slaughter Byproducts obtained from poultry ranges from 30 to 40% of live weight depending upon species, breed, and dressing of carcass. The value of unprocessed raw byproducts ranges from 10 to 20 % of the total value of the animal while the output returns from processed byproducts would be equal to the value of meat derived from the animal (Jayathilakan *et al.* 2012). Poultry processing industries have a large number of byproducts having a high nutritional quality that can be used in animal pet foods, particularly for dogs and cats to minimize the cost of production while maximizing the profit by producing high value-added products. Poultry slaughterhouse by-products like lungs, heart, kidney, spleen, head, feet, and intestines have high nutritive value and take part in the diet formulation of different animal pet foods (Toldra and Reig 2011). Pets play an important role in day-to-day life and have become family members both in urban and rural areas.

Ingredients in pet food may vary depending on the type of animal, age, species, breed, weather, etc. Pet food is usually prepared by combining plant and animal products. Hence, the pet food industry is considered a continuous part of slaughter, human food, and other agricultural processing industries and is flourishing at a very high pace currently. Innovation and new product development continue to drive the growth of the pet food market. A dynamic economy and increased disposable income are

[1]*Department of Livestock Products Technology,* [2] *Department of Veterinary and Animal Husbandry Extension, College of Veterinary Sciences and Animal Husbandry, DUVASU, Mathura-281001 UP, India.*
[2]*Division of Goat Products Technology Laboratory, Central Institute for Research on Goats, Makhdoom, Farah-281122, Mathura, UP, India.*
[*]*Corresponding author. e mail: rishavvet42@gmail.com*

vital to the pet food market development. Pet food researchers have an important responsibility to develop balanced and nutritious pet food meeting the international standards suggested by AAFCO and NRC. Pet foods prepared by the incorporation of meat trimmings and byproducts contain higher nutritious values but are deficient in fiber content leading to constipation and gastric disorders in pets. Fiber is considered as an essential nutrient in the diets of cats and dogs. Dogs do not derive any energy from fibers, however, improved colon health, and increased bulk and water in intestinal content are the benefits of having fibers in the diet, and therefore their presence in pet food is often considered beneficial for several medical conditions. Fibers lengthen intestinal transit time in pets that is slow down the rate at which food moves through the digestive tract. Dogs are omnivorous and have lower protein requirements than cats. Therefore, the formulations of dog pet food are more flexible and may include more vegetables and other plant materials. Vegetables normally contain higher amounts of fiber, minerals, and vitamins. Carrot contains 86% moisture, 0.9% protein, 0.2% fat, 10.6% carbohydrate, 1.2% crude fiber, 1.1% total ash, 80 mg/100 g Ca, 2.2 mg/100 g Fe and 53 mg/100g P (Holland *et al.* 1991). It is said to cleanse the intestines and also has diuretics, remineralizing, antidiarrheal, overall tonic, and anti-anemic properties (Thamburaj and Singh 2005). It also has significant antioxidant and anti-cancer properties which has raised considerable interest from scientists, food manufacturers, and consumers as the trend of the future is moving toward functional and therapeutical food with specific health effects (Velioglu *et al.* 1998). French beans *(Phaseolus vulgaris)* are nutritional and economically important fiber sources that may be used in the formulation of pet food. French beans provide nutrients such as multifaceted carbohydrates, elevated protein, dietary fiber, minerals, and vitamins and also contain a rich variety of polyphenolic compounds with prospective health benefits. French beans contain 80.1% moisture, 1.9% protein, 0.2% fat, 7.1% carbohydrate, 3.4% fiber, 56 mg calcium, 44 mg phosphorous, and 0.8 mg iron. They also contain almost zero fat and no cholesterol and are a rich source of fiber and vitamin C. Due to their high nutritional value with almost zero fat and no cholesterol and higher soluble fiber source; they may be used in pet food to control many digestive system diseases and skin coat disorders. Therefore, the present study was conducted to evaluate the effect of fiber-rich vegetables on the quality characteristics of poultry slaughterhouse byproducts incorporated in pet food.

MATERIALS AND METHODS

The experiment was conducted in the Department of Livestock Products Technology, College of Veterinary Science and Animal Husbandry, U.P. Pt. Dean Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go-Anusandhan Sansthan, (DUVASU) Mathura, 281001(UP), India.

Development of byproduct powder

Poultry byproduct powder was prepared as per the method given by Goswami *et al.* (2020) with slight modifications. Fresh and clean poultry byproducts were washed properly and drained to remove extra moisture, whereas frozen poultry byproducts were thawed under refrigeration overnight to have normal consistency. The intestines were emptied and properly cleaned under running water to remove intestinal content. These byproducts (head, feet, and intestine) were autoclaved at 121 ^{0}C for 15 minutes. The autoclaved material was cooled and then minced in a meat miner through 6 mm and 4mm plates. The minced byproducts were spread in stainless steel trays with uniform thickness and dried in a hot air oven at 70±1^{0}C for 16-18 hours till constant weight was obtained. This dried material was finely ground in a food processor (Inalsa Make), sieved, and stored in pre-sterilized PET jars at 25 ± 1^{0}C. Powder of the dried carrot and French bean was prepared in a grinder.

Preparation of product

Pet food was prepared as per the method given by Brindha and Rao (2017) with slight modifications (Flow diagram), where nutritional requirements and ingredients selection was done as per AAFCO (2008) and NRC (2006) for an adult dog maintenance diet. All the ingredients were weighted separately inaccurate amounts as per the batch requirement. Pre-weighed amounts of poultry byproduct powder and other ingredients (fiber-rich vegetables, iodized salt, vegetable oil, binder, wheat gluten, and white corn flour) were taken in a plastic tub and mixed well for 1-2 minutes. Then dry yeast, calcium carbonate, and mineral mixture were added in a plastic tub and all the ingredients were uniformly mixed/kneaded for 4-5 minutes to obtain well-blended dough with desired consistency. Now, the dough was sheeted on a wooden board with rolling pins. The dough was cut into different desired shapes using stainless steel food molders. This different-shaped raw pet food was baked in a hot air oven at 150 ^{0}C for 20-25 minutes. The baked pet food was then cooled to room temperature, immediately packaged in pre-sterilized LDPE bags, and stored in a cool dry place

at ambient temperature. The method of development of fiber-rich vegetable pet food is given in the flow diagram.

Flow diagram: preparation of pet food

Selection and weighing of poultry byproducts powder, fiber-rich vegetables, iodized salt, vegetable oil, binder, wheat gluten, white corn flour

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Mixing of ingredients for 1-2 minutes

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Addition of dry yeast, mineral, and vitamin mixture (water as per requirement)

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Blending/ kneading of dough for 4-5 minutes to have desired consistency

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Sheeting/rolling of dough (on a wooden board with a rolling pin)

↓

Cutting in different shapes using stainless steel food molders

↓

Baking at 150^{0}C for 20-25 minutes

↓

Cooling at room temperature

↓

Sample Analysis —— Packaging——Palatability test

↓

Storage at ambient temperature (25±1^{0}C).

Physical and chemical analysis of the product

Pet food was assessed for various quality parameters as per standard procedures. The pH of pet food was evaluated as per Trout *et al.* (1992) method. The baking yield was calculated and expressed in percentage as per (Murphy *et al.* 1975). The baking yield was determined by dividing the backed pet food weight by the raw pet food weight and expressed in percentage by multiplying it by 100. A proximate composition such as moisture, protein, and fat percentage was evaluated as per the Association of Official Analytical Chemists (1995). The water activity of each sample was measured using a water activity meter (Aqua Lab 3 TE, Inc. Pullman, WA). Textural profile analysis, *i.e.* hardness, springiness, cohesiveness, gumminess, chewiness, and resilience were evaluated and measured with the help of an instrumental texture profile analyzer (TA HD Plus Texture Analyser) as per Bourne (1978). The color parameters of the chicken patties were measured using a Hunter colorimeter of Colour Tech PCM+ (Colour Tec Associates Inc. Clinton NJ, USA). The coin-shaped lance of the instrument attached to the software was directly put on the surface of pet food at randomly chosen six different points (Hunter and Harold 1987). CIE *L*, a*,* and *b** values were determined as the indicators of lightness, redness, and yellowness, respectively.

Palatability test

The palatability test was evaluated for the response of the pet dog and owner's observations based on a questionnaire prepared in English as per the guidelines given by Ponmani (1997) and Karthikeyan (2004) and Karthik *et al.* (2010) for the evaluation of pet food characteristics using the 7-point descriptive scale, where 7 denoted extremely desirable and 1 denoted extremely poor. The palatability test was conducted on seven dogs for every trial from faculty and other staff members of DUVASU, Mathura, which were from the same age group and well-established breed. The pet food was fed to the dogs 3-4 hours after the normal feeding time. The reaction of the dog toward the pet food was observed. Observations were made based on the approach of dogs towards pet food, interest to eat, and nature of eating and these were recorded in the questionnaire. The opinion of the dog owner concerning the general appearance, color, pet food intensity, crispiness, consistency, odor, and overall acceptability was recorded in the scorecard.

Statistical analysis

The data obtained in the study on various parameters were statistically analyzed on 'The SPSS-20.0' software package for one-way ANOVA as per standard methods of Snedecor and Cochran (1995). Each parameter was conducted thrice in duplicate to have a total number of 6 samples (n=6) to meet international standards, whereas the Palatability test was performed on seven same dogs three times, so total observations were 21 (n=21), Data were subjected to one-way analysis of variance, homogeneity test and Duncan's Multiple Range Test (DMRT) for comparing the means to find the effects between samples.

RESULTS AND DISCUSSION

Several preliminary trials were conducted to prepare poultry byproducts (head, feet, intestine) powder incorporated with pet food to optimize the formulation based on the method prescribed by Brindha and Rao (2017) with slight modifications. Finally, pet food with 50% poultry by-product powder and baked in a hot air oven at 150^{0}C for 20-25 minutes was found optimum. The nutrient

content in developed pet food was maintained as per NRC (2006) specifications. Then developed pet food was incorporated with different levels, *i.e.* 5, 10, and 15% separately of carrot powder and French bean powder replacing grated cruciferous vegetables, where carrot powder @10% (CR) and French bean powder @10% (FB) was found to optimum. The selected treatments (CR) and (FB) were compared with control pet food (BP) for various physio-chemical properties and palatability tests.

The pH values of BP and CR were significantly ($p<0.05$) higher than FB; however, there was no significant between BP and CR. The variations in pH of control and treatments might be because of the difference in pH values of fresh cruciferous vegetables, carrots, and French beans/legumes powder that ranged between 6.0-6.4 (Malav *et al.* 2016); 5.80-6.40 (Reiter *et al.* 2003) and 6.2-6.4 (Malav *et al.* 2016) respectively. Baking yield values of CR and FB were significantly ($p <0.05$) higher than BP due to higher water-binding properties of fiber-rich vegetable powder than grated fresh cruciferous vegetables. According to Aleson-Carbonell *et al.* (2005), fruits and vegetable fiber being rich in starch and pectin form gels in contact with water which resulted in greater retention of water and lipids in food. Moisture, ash content, and water activity values of CR and FB were significantly ($p <0.05$) higher than BP, whereas no significant difference was observed between CR and FB. Higher moisture content and water activity values might be due to moisture absorption and retention capacity of fibers rich vegetables resulting in higher cooking yield and moisture content of pet food. Protein and fat content of BP were significantly ($p <0.05$) higher than CR and FB; however, there was no significant difference between CR and FB. Syuhairah *et al.* (2016) observed that the pH values, cooking loss, and water holding capacity were significantly ($p<0.05$) affected by the incorporation of fiber-rich vegetables *viz.* carrot, spinach, purple cabbage, capsicum, and grey oyster mushroom at 30, 40 and 50% level in chicken sausages.

Hardness values of BP were significantly ($p<0.05$) higher than CR and FB due to differences in the composition of fiber-rich vegetables resulting in different protein/fat/water ratios; however, there was no significant difference between CR and FB. Syuhairah *et al.* (2016) also reported that the purple cabbage incorporation in

Table 1. Comparative amount of raw materials required per day for 1kg formulation of poultry byproducts incorporated pet food.

Ingredients	Poultry byproducts added pet food (BP)	Poultry byproducts incorporated pet food with 10% carrot powder (CR)	Poultry byproducts incorporated pet food with 10% French bean (FB)
Poultry byproducts (head, feet and intestine)	500gm	500gm	500gm
Freshly grated cruciferous vegetables	150 gm		
Fiber rich carrot		150 gm	
Fiber rich french beans			150 gm
Rice flour	150	150	150
White corn flour	50 gm	50 gm	50 gm
Wheat gluten meal	40gm	40gm	40gm
Vegetable oil	70gm	70gm	70gm
Calcium carbonate	15gm	15gm	15gm
Dry yeast	15gm	15gm	15gm
Iodised salt	5gm	5gm	5gm
Vitamin & mineral mix	5gm	5gm	5gm
Total	1000 gm	1000 gm	1000 gm

Table 2. Physico-chemical properties (Mean±SE) of poultry byproducts incorporated pet food with different levels of fiber rich vegetables (n=6).

Parameters	B P	C R	FB	Treatment mean
pH	6.32^{a} ±0.03	6.31^{a} ±0.02	6.22^{b} ±0.02	6.28 ±0.02
Baking yield (%)	78.89^{c} ±0.09	82.03^{a} ±0.07	80.31^{b} ±0.03	80.41 ±0.06
Moisture (%)	4.69^{b} ±0.07	4.95^{a} ±0.05	4.89^{a} ±0.07	4.84 ±0.06
Protein (%)	21.87^{a} ±0.08	19.63^{b}±0.04	19.98^{b}±0.03	20.49 ±0.03
Fat (%)	15.60^{a} ±0.04	14.77^{b}±0.02	14.32^{b} ±0.06	14.89 ±0.04
Ash (%)	4.79^{b} ±0.06	5.03^{a} ±0.09	5.06^{a} ±0.04	4.96 ±0.06
Water activity (a_w)	0.604^{b}±0.06	0.612^{a} ±0.09	0.615^{a} ±0.05	0.610 ±0.06

BP (control): Poultry byproducts incorporated pet food with 10% cruciferous vegetables powder, CR: Poultry byproducts incorporated pet food with 10% carrot powder, FB: Poultry byproducts incorporated pet food with 10% french beans powder. Overall means bearing different superscripts in a row differ significantly ($p<0.05$).

Table 3. Textural parameters (Mean±SE) of poultry byproducts incorporated pet food with different levels of fiber rich vegetables (n=6).

Parameters	B P	CR	FB	Treatment Mean
Hardness (N/cm^2)	1248.13^{a}±0.05	1195.11^{b}±0.09	1196.83^{b}±0.05	1213.35±0.06
Springiness (cm/mm)	0.40 ±0.06	0.38 ±0.05	0.39 ±0.07	0.39±0.06
Cohesiveness (Ratio)	0.45 ±0.05	0.43 ±0.04	0.44 ±0.08	0.44±0.05
Gumminess (N/cm^2)	$1923.21^{b\pm}$0.03	1953.24^{a} ±0.08	1963.53^{a} ±0.07	1946.66±0.06
Chewiness (N/cm)	527.87^{b} ±0.03	552.05^{a} ±0.07	555.34^{a} ±0.05	545.08 ±0.05
Resilience (Ratio)	0.21 ±0.02	0.22 ±0.04	0.23±0.05	0.22 ±0.03

BP (control): Poultry byproducts incorporated pet food with 10% cruciferous vegetables powder, CR: Poultry byproducts incorporated pet food with 10% carrot powder, FB: Poultry byproducts incorporated pet food with 10% french beans powder. Overall means bearing different superscripts in a row differ significantly ($p<0.05$).

Table 4. Colour parameters (Mean±SE) of poultry byproducts incorporated pet food with different levels of fiber rich vegetables (n=6).

Parameters	BP	CR	FB	Treatment Mean
Lightness *(L*)*	30.90^{b}±0.06	34.40^{a}±0.03	29.58^{c}±0.09	31.62±0.06
Redness *(a*)*	13.58^{b}±0.05	12.71^{c}±0.08	14.52^{a}±0.06	13.60±0.06
Yellowness *(b*)*	7.58^{b}±0.04	8.30^{a}±0.07	7.11^{c}±0.03	7.66±0.04

BP (control): Poultry byproducts incorporated pet food with 10% cruciferous vegetables powder, CR: Poultry byproducts incorporated pet food with 10% carrot powder, FB: Poultry byproducts incorporated pet food with 10% french beans powder. Overall means bearing different superscripts in a row differ significantly ($p<0.05$).

chicken sausage showed significantly ($p<0.05$) higher hardness values than carrot, spinach, capsicum, and grey oyster mushroom incorporated chicken sausage at 30-50% level. Savadkoohi *et al.* (2014) and Wan Rosli *et al.* (2015) also observed significantly ($p<0.05$) lower hardness values of tomato pomace and oyster mushroom powder incorporated meat sausage than control. There were no significant differences in springiness, cohesiveness, and resilience values between control and treatments. Gumminess and chewiness values of CR and FB were significantly ($p<0.05$) higher than BP; where no significant difference was observed between CR and FB. Upadhaya (2014) reported significantly ($p<0.05$) higher firmness and chewiness values in jackfruit powder incorporated chicken

Table 5. Palatability scores (Mean±SE) of poultry byproducts incorporated pet food with different levels of fiber rich vegetables (n=6).

Attributes	BP	CR	FB	Treatment Mean
General appearance	6.65^{a}±0.09	6.63^{a}±0.06	6.50^{b}±0.05	6.59±0.06
Colour	6.62^{a} ±0.04	6.63^{a} ±0.08	6.39^{b}±0.06	6.54 ±0.06
Odour	6.61^{a}±0.06	6.63^{a} ±0.04	6.46^{b}± 0.07	6.56 ±0.05
Crispiness	6.63^{a}±0.03	6.61^{a}± 0.06	6.48^{b} ±0.07	6.57 ±0.05
Consistency	6.62^{a}±0.09	6.64^{a}±0.02	6.45^{b}±0.03	6.57±0.04
Meat flavour intensity	6.62^{a}±0.05	6.61^{a} ±0.04	6.47^{b} ±0.07	6.56 ±0.05
Overall acceptability	6.65^{a}±0.04	6.66^{a}±0.08	6.49^{b}±0.05	6.60±0.04

BP (control): Poultry byproducts incorporated pet food with 10% cruciferous vegetables powder, CR: Poultry byproducts incorporated pet food with 10% carrot powder, FB: Poultry byproducts incorporated pet food with 10% french beans powder. Overall means bearing different superscripts in a row differ significantly ($p<0.05$).

kabab than in carrot and winter melon powder incorporated kababs. In the present study, higher chewiness and gumminess values in treatments might be due to the binding of pectin present in vegetable powder with protein molecules of poultry byproducts powder resulting in more stretchability and gumminess of the product (Tiwari and Vidyarthi 2015).

Lightness and yellowness values of CR were significantly ($p<0.05$) higher than BP and FB due to carotenoid pigments present in carrot powder. Redness values of FB were significantly ($p<0.05$) higher than BP and CR due to the greenish-brown color of French bean powder imparting darkness to the product. The difference in color values of control and treatments was also probably attributable to the enzymatic oxidation of vegetable fibers by the Polyphenyl oxidase enzyme during drying (Eim *et al.* 2008). *L*, a**, and *b** values of meat products are affected by the color of added dietary fiber sources (Saricoban *et al.* 2008).

Fig. 1. Poultry byproducts incorporated pet food with 10% carrot powder.

General appearance, color, odor, crispiness, consistency, meat flavor intensity, and overall acceptability scores of BP and CR were significantly ($p<0.05$) higher than FB; however, there was no significant between BP and CR. Lower scores of French bean powder might be due to dark-colored products and typical beany flavor resulting in a less acceptable aroma and color of pet food as reported by pet owners in palatability scorecard performance related to acceptability of pet food. Valenzuela-Melendres *et al.* (2014) also reported significantly ($p<0.05$) lower color scores of green-colored avocado paste-incorporated sausage than red-colored tomato pastes incorporated sausage. The carrot powder incorporated pet food had the same consistency, flavor, and color as BP with significantly ($p<0.05$) higher overall acceptability scores than FB. Dogs used for palatability tests showed eagerness towards CR and ate a higher amount of this product than FB in one meal. Therefore, CR- poultry byproducts incorporated in pet food with 10% carrot powder were selected as the best treatment and taken as the control in the next experiment.

CONCLUSION

Pet food prepared by baking in a hot air oven at 150^{0}C for 20-25 minutes was found optimum; however, their acceptance and fiber content might be improved with the incorporation of fiber-rich vegetables. Replacement of cruciferous vegetable powder with carrot and French bean powder not only improved textural and color properties but even significantly affected the palatability scores of pet food. Carrot powder @10% level was found as the best fiber source in terms of phsyico-chemical, textural,

and color properties as well as based on palatability scores and found as an excellent source of nutrients blended with the taste of modern pet food and trend to the dogs.

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REFERENCES

AOAC (1995) Official methods of analysis 16 th edn. Association of official analytical chemists. Washington DC, USA.

AAFCO (2008) Official publication of the Association of American Feed Control Officials Inc, Atlanta.

Aleson Carbonell L, Lopez JF, Zhi N, Alvarez JAP, Kuri V (2005) Antioxidant and antibacterial activities of natural extracts and application in beef meatballs. Meat Science 69(3): 371-380.

Bourne MC (1978) Texture profile analysis. Food Technology 32: 62-66.

Brindha N, Rao VA (2017) Cost effective utilization of poultry and cruciferous vegetable waste as a raw material to develop a shelf-stable pet food. J Anim Res Nutrit 2: 7.

Eim VS, Simal S, Rosselló C, Femenia A (2008) Effects of addition of carrot dietary fibre on the ripening process of a dry fermented sausage (sobrassada). Meat science 80(2): 173-182.

Goswami M, Sharma BD, Mendiratta SK, Pathak V (2020) Quality inprovement of refiend wheat flour with incorpration of fucntional ingredients. J Food Process Preserv 45(4): e14945. https://doi.org/10.1111/jfpp.14945.

Holland B, Unwin JD, Buss DH (1991) Vegetables, herbs and spices. Fifth supplement to McCance and Widdowson's London, 35-54.

Jayathilakan K, Sultana K, Radhakrishna K, Bawa AS (2012) Utilization of byproducts and waste materials from meat, poultry and fish processing industries: a review. J Food Sci Technol 49(3): 278-293.

Hunter RS, Harold RW (1987) The Measurement of Appearance, 2 nd edn. 124-130.

Karthik P, Kulkarn VV, Sivakumar K (2010) Preparation, storage stability and palatability of spent hen meal-based pet food. J Food Sci Technol 47(3): 330-334.

Karthikeyan N (2004) Effect of processing methods in nutritional quality and storage stability of poultry by product meat based pet foods. Ph.D. Thesis submitted to Indian Veterinary Research Institute (IVRI), Bareilly (Uttar Pradesh), India.

Malav OP, Sharma BD, Kumar RR, Talukder S, Ahmed SR, Irshad A (2016) Quality characteristics and storage stability of functional mutton patties incorporated with red kidney bean powder. Indian J Small Rumin 22(1): 83-91.

Murphy EW, Criner PE, Gracy BC (1975) Comparisons of methods for calculating retentions of nutrients in cooked foods. J Agricult Food Chemist 23: 1153-1157.

NRC (2006) In: Nutrient Requirements of Dogs and Cats. Animal Nutrition Series. National Research Council of the National Academies, Washington, DC, USA.

Ponmani V (1997) Studies on the preparation of dog chew and evaluation of its shelf-life. MVSc Thesis submitted to Tamil Nadu Veterinary and Animal Sciences University, Chennai (Tamil Nadu), India.

Reiter M, Neidhart S, Carle R (2003) Sedimentation behaviour and turbidity of carrot juices in relation to the characteristics of their cloud partiles. J Sci Food Agricult 83(3): 35-42.

Saricoban C, Özalp B, Yilmaz MT, Özen G, Karakaya M, Akbulut M (2008) Characteristics of meat emulsion systems as influenced by different levels of lemon albedo. Meat science 80(3): 599-606.

Savadkoohi S, Hoogenkamp H, Shamsi K, Farahnaky A (2014) Color, sensory and textural attributes of beef frankfurter, beef ham and meat-free sausage containing tomato pomace. Meat science 97(4): 410-418.

Snedecor GW, Cochran WG, (1995) Statistical methods, 8th edn, The Iowa State University Press, Ames, Iowa.

Syuhairah A, Huda N, Syahariza ZA, Fazilah A (2016) Research article effects of vegetable incorporation on physical and sensory characteristics of sausages. Asian J Poultry Sci 10: 117-125.

Thamburaj S, Singh N (2005) Textbook of vegetables, tuber crops and spices. Indian Council of Agriculture Research, New Delhi. 151.

Tiwari AK, Vidyarthi AS (2015) Nutritional evaluation of various edible fruit parts of jackfruit (*Artocarpus heterophyllus*) at different maturity stages. International J Chemic Pharmaceut 1: 21-26.

Toldrá F, Reig M (2012) Analytical tools for assessing the chemical safety of meat and poultry. In: Analytical tools for assessing the chemical safety of meat and poultry. Springer Briefs in Food, Health, and Nutrition, vol 9. Springer, Boston, MA. https://doi.org/10.1007/978-1-4614-4277-6_1.

Trout ES, Hunt NC, Johnson DE, Claus JR, Kastner CL *et al.* (1992) Chemical, physical and sensory characterization of ground beef containing 5 to 30 percent fat. J Food Sci 57: 25-29.

Upadhyay S (2014) Development and quality assessment of fiber fortified enrobed chicken kabab. MVSc Thesis submitted to Pandit Deen Dayal Upadhyay Pashu-Chikitsa Vigyan Vishwavidyalaya Evam Go Anusandhan Sansthan (DUVASU), Mathura (Uttar Pradesh), India.

Valenzuela-Melendres M, Torrentera-Olivera NG, González-Aguilar G, Villegas-Ocho M, Cumplido-Barbeit LG, Camou JP (2014) Use of avocado and tomato paste as ingredients to improve nutritional quality of pork frankfurter. J Food Res 3: 132-143.

Velioglu YS, Mazza G, Gao L, Oomah BD (1998) Antioxidant activity and total phenolics in selected fruits, vegetables and grain products. J Agricult Food Chemist 46: 4113-4117.

Wan Rosli WI, Maihiza N, Raushan M (2015) The ability of oyster mushroom in improving nutritional composition, β-glucan and textural properties of chicken frankfurter. Intern Food Res J 22(1): 34-42.

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