Pakistan J. Zool., pp 1-9, 2024. DOI: https://dx.doi.org/10.17582/journal.pjz/20230802064639

Supplementation of Chick Feed with Kitchen Waste has No Negative Effect on Production Performance and Egg Characteristics of *Gallus gallus domesticus*

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Article Information
Received 02 August 2024
Revised 18 August 2024
Accepted 21 August 2024
Available online 26 November 2024 (early access)

Authors' Contribution
HMAS methodology, writing original draft. JIQ conceptualization, supervision. SA data curation, formal analysis, resources. AH and AH resources, writing review and editing.

Key words
Artificial feed, Commercial feed, Egg quality, Food waste, Kitchen waste, Waste management, Arifwala

ABSTRACT

The study was based on comparison, production and optimization of internal and external physical characteristics of eggs produced by *Gallus gallus domesticus* fed with kitchen waste-based feed against commercial feed. Food waste was collected from different marriage halls within the vicinity of Arifwala city, district Pakpattan, province Punjab, Pakistan. It was thoroughly washed, sun dried, milled to semi powered form and heated at 90° for 10 minutes. It contained 90.2% dry matter, 17.3% crude protein, 7.5% crude fat,2.43% crude fibers, 6.68% ash, 46.5% starch, 3.45 % Ca, 0.95% P, 0.315% Na, methionine 0.43% and lysine 0.92%. Forty-eight egg laying *G. gallus domesticus* of 40-50 weeks old were divided into control group (C) and three experimental groups viz., KW-15%, KW-30% and KW-45% groups. Control was given 100% commercial feed, and experimental groups KW-15%, KW-30% and KW-45% were provided 15%, 30%, and 45% of the kitchen waste based feed respectively. Eggs were collected on daily basis and their physical characteristics were analyzed weekly. Values of egg length, egg width, egg surface area, egg volume, shape index and breaking strength were non-significantly differed among four groups ($p \leq 0.05$). Egg weight, shell weight, albumin height, albumin diameter, albumin index, albumin weight, yolk height, yolk diameter, yolk index, yolk weight, yolk ratio and Haughunit values were higher in KW-30% group ($p \leq 0.05$). Shell thickness and shell ratio were found higher in KW-15% and in control group respectively ($p \leq 0.05$). Higher values of albumin ratio and yolk color were found in KW-45% group ($p \leq 0.05$). Egg production and feed intake was higher in control group as compared to experimental groups ($p \leq 0.05$). Egg mass was higher and FCR was lower in KW-15% groups as compared to control (C), KW-30% and KW-45%groups ($p \leq 0.05$). Results of the study reveal that kitchen food waste is enriched in nutritional values. It can be used up to 30% as feed stuff for laying hens and has no negative effect on production performance and egg characteristics of *G. gallus domesticus*. Partial substitution of food waste as feed stuff may provide an efficient way of using wasted food. It could be helpful to meet the growing demands of the poultry production in decreasing cost of commercial feed of the birds, whereas on the other hand it could also provide cheap, tasty and nutritionally enriched organically raised eggs of best quality to the customers.

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0030-9923/2024/0001-0001 $ 9.00/0

INTRODUCTION

It is accepted that the nature of the nutrition given, age of the birds, health status and rearing system highly affect egg quality and production performance of the laying birds (Ahmadi and Rahimi, 2011). The feed plays a key role in maximizing the genetic potential of the birds with respect to eggs production, eggs quality and performance of the birds (Bouvarel *et al*., 2011). Poultry feeders use corn and soy as natural feed stuff in commercial diet. High feed prices of corn and soy has badly affected broiler production in many countries and domestic poultry production has decreased dramatically (Rondon and Ashitey, 2011). The limited availability of these grains all over the world has made it necessary to study effects of different natural and organic feed sources on poultry production. With increasing inflation rate the feeders are searching new economic natural resources of poultry feed to provide consumers cheaper and nutritionally enriched eggs of best quality.

All over the world, different food waste products are being converted into animal feed for laying hens and broilers. Parfitt *et al*. (2010) reported that 2.2 MT of food wastes were converted to animal feed stuff in the UK. In Australia, farmers were given almost 40000 MT of waste food as animal feed stuff by many retailors (Lewis *et al*., 2017). A food recovery division was made by the US Environmental Protection Agency in which conversion of food waste to animal feed was graded as number three after source reduction and given to poor people of the society (BSR, 2014). Many studies revealed that broilers performed similarly well when different percentages of food wastes were given to them as compared to necessary diets of corn and soya (Damron *et al*.,1965; Joshi *et al*., 2000; Al-Tulaihan *et al*., 2004; Wadhwa *et al*., 2013; Stefanello *et al*., 2016).

Westendorf *et al*. (1998) documented that food waste contains good nutritional values. It is free of genetically modified feed and food additives as compared to commercial feed of the birds. Necessary nutritional values are present in leftover food (Yoshida, 1973). Kim (1995) reported that leftover food may be supplemented for the laying *G. gallus domesticus*. Food wastes contains protein, fat, vitamin and mineral contents necessary for egg production (Kojima, 2005). By using food wastes and its by-products as poultry feed, high costs of commercial feed might be minimized (Ani and Okorie, 2005). Production of CO_2 from poultry industries can be reduced by using food waste as animal feed (Lee *et al*., 2010).

UN environment programme (UNEP) documented that people waste almost one-third of the food produced worldwide. In Pakistan, about 36 million tones of prepared food is wasted annually in weddings, parties, and hotels. Pakistan Environmental Protection Agency reported that food wastage accounts nearly 40 percent of the total food in Pakistan (Dawn, 2016). A grand hotel in Islamabad almost produces 870kg of food waste on daily basis (Mughal, 2018). In Pakistan 60% population is food insecure and 44% children of under age 5 are stunted (The Agha Khan University, 2011). Such a huge amount of food is wasted in the country where millions of poor people don't have access to balanced diet is alarming. This situation necessitates efficient usage of food waste by recycling it into livestock and poultry feed.

There are various ways of food waste management. It is mostly discharged by incineration or landfill process that is causing serious underground water and air pollution problems. An immediate and sustainable use of food waste is necessary in the country facing serious issues of pollution, inflation, malnutrition and food insecurity to provide better and cheaper poultry proteins to masses.

In the present study food waste was used as feed ingredients against commercial feed for the production, comparison and optimization of egg quality characteristics of laying *G. gallus domesticus*. Efficiency of food waste was screened out as feed supplements for eggs production from *G. gallus domesticus*. The comparison was made among eggs quality characteristics produced by birds fed with partially replaced commercial feed with organic feed. Utilization of food waste may be helpful in decreasing cost of commercial feed as well as food waste management with consistent production of high quality eggs.

MATERIALS AND METHODS

Feed preparation from kitchen food waste

Kitchen food waste (KFW) was collected from different marriage halls. Food waste mostly contained plate scraps and cooking residues of bread pieces (66%), rice (16%), bone (8.75%) and meat (9.1%). These leftovers were thoroughly washed and sun dried to make them completely dry. The dried material was milled to semi-powdered form and preserved in plastic bags after heating at 90°C for ten min.

It had brown color and mild odor. Before using it was mixed with commercial feed by 15%, 30% and 45% substitution level. Approximate analysis of the KFW was done in the laboratory. It was composed of 90.2% dry matter, 17.3% crude protein, 7.5% crude fat, 2.43% crude fibers, 6.68% ash and 46.5% starch, 3.45 % Ca, 0.95% P, 0.315% Na, methionine 0.43% and lysine 0.92% (AOAC, 1990). Commercial feed of ration number 22 was used for laying birds and its chemical composition was analyzed.

Animal care and feeding

This study was conducted at poultry shed of University of Veterinary and Animal Sciences, Ravi Campus, Pattoki. Forty-eight egg laying birds of aged 40-50 weeks were kept individually in iron cages (40 cm x 20 cm, with a height of 46 cm). Each bird was tagged with numbers written on paper and attached on legs of the birds with tape. The birds were divided into four treatment groups such as one control (C) and three experimental groups (KW-15%, KW-30%, and KW-45%). Control group (C) was provided 100% commercial feed. Other three groups viz., KW-15%, KW-30%, and KW-45% were given 15%, 30% and 45% of the kitchen food waste (KFW) respectively. Each treatment group had twelve birds and there were three replicates having four birds per replica. Method of feeding was according to recommendations of Lessons and Summers (2005). Simple drinking water was provided ad libitum (at unlimited amount on daily basis) and feed was given (120g/bird) daily at 6:00am morning. Weight of the birds was measured at start of the trial and after 15 days till 8 weeks. Eggs were collected, weighed, tagged and stored in refrigerator at 4°C on daily basis. Feed intake was measured on weekly basis to find out feed conversion ratio (FCR). Study was conducted from June to August. Light period was 16 h and dark period was 8 h. Semi-controlled conditions were maintained at poultry shed of UVAS Pattoki campus.

Measurements of egg characters

Every week three eggs were randomly picked from each replicate of the four treatments and carried to laboratory for internal and external physical characterizations. Weight of the eggs was measured by digital balance with 0.01 g accuracy. Digital vernier caliper was used to measure egg length and breath. Shape index was calculated as ratio of egg breath to egg length multiplied by 100. Egg surface area and volume were calculated by using formulas proposed by Narushin (2005).

Egg shell breaking strength was measured by using egg force reader. The inner membranes of the shell were removed and shells were completely dried. Shells were weighed with digital balance and shell weight was divided by egg weight to find out shell ratio. Shell thickness was measured at broad and narrow ends of the shells with the help of screw gauze of accuracy 0.01mm and averaged. The length, width and height of the albumin and yolk were measured in mm by using vernier caliper. Albumin height was taken from 3 sides 1 cm away from central yolk and averaged. Albumin and yolk indices were taken by dividing breath with height times 100. Yolk was carefully separated from white with the help of a spoon. Yolk color was determined by using Roche color fan (Vuilleumier, 1969) that showed 14 colors for grading. Each fan blade represents a color from 1 to 14 that can be produced in the yolk. Haugh units were calculated by weight of shell egg (W) and height of thick egg white (H). Narushin (1997) gave mathematical relation for, $HU=100\times\log(H-1.7\times w^{0.37}+7.6)$.

H= observed height of the albumen in millimeters, *w* = weight of egg in grams.

Egg production was calculated by collecting eggs daily and dividing them by the number of birds in each treatment. Egg mass was calculated by multiplying egg production with average egg weight of the birds. Feed intake was measured by weighing feed residues of each group weekly until 8 weeks. Feed conversion ratio (FCR) was calculated by dividing feed consumption with egg mass.

Statistical analysis

Physical trait means of treatments with standard errors were analyzed using Duncan's Multiple Range Test (Duncan, 1955) with SAS software (SAS, 1995).

RESULTS AND DISCUSSION

Proximate composition of commercial feed and kitchen waste feed is given in Table I. External and internal morphometric traits of eggs are given in Tables II and III, respectively. Production performances of the birds are detailed in Table IV. The phenotypic means of the eggs revealed that kitchen food waste has positive effect on egg quality characteristics when used at 30% substitute level in laying diet. The mean values of egg length, width, shape index, surface area, volume and breaking strength were non-significantly differed among control group (C), KW-15%, KW-30% and KW-45% groups. Egg length (5.43±0.03) and width (4.16 ± 0.04) values were found higher in KW-30% group. Rath *et al.* (2015) reported means value of same age birds as 5.439±0.11 mm and 3.992±0.07 mm for length and width of eggs, respectively. Lower mean values were reported by Yousif *et al.* (2011) for the same parameters.

Table I. Proximate composition of commercial feed and kitchen waste feed.

Ingredient (%)	Commercial feed	Kitchen waste feed
Dry matter	87.7	88.3
Crude protein	15.8	16.9
Crude fat	4.76	7.33
Crude fiber	3.0	2.48
Crude ash	5.39	6.46
Starch	44.0	46.51
Energy (ME) (kcal/kg)	2895	3210
Calcium	2.96	3.45
Phosphorus	0.82	0.95
Sodium	0.16	0.31
Methionine	0.36	0.43
Lysine	0.72	0.92

Table II. Effect of kitchen waste (KW) feed on egg morphometric traits of 40-50 weeks old *Gallus gallus domesticus*.

Parameter	C	KW-15%	KW-30%	KW-45%	p value
Egg length (cm)	5.33 ± 0.03	5.37 ± 0.03	5.43 ± 0.03	5.37 ± 0.04	0.2258
Egg width (cm)	4.07 ± 0.05	4.07 ± 0.02	4.16 ± 0.04	4.12 ± 0.02	0.2412
Shape index	75.86 ± 0.46	74.67 ± 0.58	75.43 ± 0.58	76.58 ± 0.61	0.1272
Egg surface area (cm^2)	68.27 ± 1.13	68.31 ± 0.49	70.74 ± 0.58	69.18 ± 0.71	0.0994
Egg volume (cm^3)	52.04 ± 1.58	53.15 ± 0.64	55.14 ± 1.42	55.00 ± 0.66	0.1926
Shell strength (N)	36.05 ± 1.99	40.37 ± 2.08	37.17 ± 1.67	36.27 ± 1.74	0.3519

Every group in the current trial contained four hens and it was run in triplicate.

Table III. Effect of kitchen waste (KW) feed on egg quality traits of 40-50 weeks old *Gallus gallus domesticus*.

Parameter	C	KW-15%	KW-30%	KW-45%	p-value
Egg weight (g)	47.90 ± 0.82^{c}	50.73 ± 0.49^{b}	55.08 ± 0.81^{a}	50.64 ± 1.30^{b}	<0.0001
Shell weight(g)	5.11 ± 0.13	5.28 ± 0.05	5.59 ± 0.15	5.31 ± 0.15	0.0855
Shell thickness (mm)	0.33 ± 0.01	0.36 ± 0.01	0.35 ± 0.01	0.34 ± 0.01	0.2869
Shellindex (%)	10.62 ± 0.12	10.35 ± 0.09	10.35 ± 0.22	10.39 ± 0.12	0.4945
Albumen height (mm)	6.26 ± 0.29^{b}	7.02 ± 0.17^{a}	7.05 ± 0.12^{a}	6.78 ± 0.10^{ab}	0.0189
Albumen diameter (mm)	74.09 ± 0.75^{b}	77.60 ± 0.74^{a}	78.00 ± 0.28^{a}	76.68 ± 0.72^{a}	0.0007
Albumen index (%)	8.00± 0.19^{b}	8.77 ± 0.11^{a}	9.02± 0.15^{a}	8.76 ± 0.09^{a}	0.0001
Yolk height (mm)	15.48 ± 0.29^{c}	16.59 ± 0.17^{b}	17.66 ± 0.18^{a}	16.40± 0.19^{b}	<0.0001
Yolk diameter (mm)	39.95 ± 0.43^{c}	42.49 ± 0.47^{b}	44.78 ± 0.42^{a}	42.16 ± 0.51^{b}	<0.0001
Yolk index (%)	38.78 ± 0.40	38.98 ± 0.28	39.48 ± 0.15	38.82 ±0.18	0.2501
Yolk weight (g)	13.47 ± 0.17^{d}	14.98 ± 0.18^{b}	17.18 ± 0.21^{a}	14.26 ± 0.19^{c}	<0.0001
Yolk ratio (%)	28.23 ± 0.23^{c}	29.61± 0.33^{b}	30.69 ± 0.31^{a}	28.72 ± 0.19^{c}	<0.0001
Albumen weight (g)	28.60 ± 0.39^{c}	30.52 ± 0.23^{b}	31.61 ± 0.20^{a}	30.27 ± 0.16^{b}	<0.0001
Albumen ratio (%)	60.57 ± 0.24^{a}	60.39 ± 0.38^{a}	57.44 ± 0.25^{b}	60.73 ± 0.34^{a}	<0.0001
Haugh unit score	81.28 ± 0.98^{b}	85.38 ± 0.87^{a}	85.49 ± 0.75^{a}	85.16 ± 0.62^{a}	0.0019
Yolk color score	7.44 ± 0.50	7.11 ± 0.35	7.11 ± 0.42	7.67 ± 0.55	0.7936

Superscripts on different means within row differ significantly at $p \leq 0.05$. Every group in the current trial contained four hens and it was run in triplicate

Table IV. Effect of kitchen waste (KW) feed on some productive performance traits of 40-50 weeks old domestic hens.

Parameters	C	KW-15%	KW-30%	KW-45%	p-value
Egg production (%)	65.01± 0.34^{a}	62.68 ± 0.47^{b}	63.52 ± 0.39^{b}	57.95± 0.45^{c}	<0.0001
Egg mass (g/bird/day)	30.47 ± 0.30^{a}	30.57 ± 0.40^{a}	29.32 ± 0.26^{b}	29.17 ± 0.24^{b}	0.0025
Feed intake (g/bird/day)	96.29 ± 0.61^{a}	88.46 ± 1.54^{c}	92.64 ± 1.08^{b}	95.22 ± 1.29^{ab}	0.0002
FCR	3.10 ± 0.03^{a}	2.92 ± 0.04^{b}	2.96 ± 0.02^{b}	3.16 ± 0.03^{a}	<0.0001

Superscripts on different means within row differ significantly at $p \leq 0.05$. Every group in the current trial contained four hens and it was run in triplicate.

The normal range of the shape index for same age birds is 72-76 (Altuntas *et al*., 2008). Shape index in all four groups under study was in normal range but KW-45% group (76.58 ± 0.61) showed higher values. According to the values of shape index, eggs of the C, KW-15% and KW-30% groups were top graded (AA) but KW-45% eggs were rounded and second to AA. Higher shape index value (77.36±0.36) was reported by Haunshi *et al*. (2011) in domestic birds of equal age. Other reports also showed higher values for the parameter (Rajkumar *et al*., 2009).

Egg surface area and volume means remained comparable among all the groups. Surface area values ranged from 68.27 ± 1.13cm^2 to 70.74 ± 0.58cm^2 and volume values ranged from 52.04 ± 1.58cm^3 to 55.14 ± 1.42cm^3. Paganelli *et al*. (1974) reported lower values of egg surface area and volume for domestic chickens as compared to present findings. Rasali *et al*. (1993) documented surface area value of 69.17cm^2 in Philippine from domestic hens. Narushin (2005) documented greater egg volume value of 60.19 cm^3.

Egg shell breaking strength was found higher (40.37 ± 2.08) in the KW-15% group that was given 15% KFW. Utilization of 15%, 30% and 45% KFW did not exert any negative effect on shell strength. Kibala *et al*. (2018) reported an average egg shell strength of 40.2 N with minimum 10N and maximum 71.5N from birds of the 33 weeks old. Results of the study were in line with egg shell breaking strength values reported by other researchers (Ketta and Tumova, 2018).

Studies revealed that weight of the eggs might be affected by many factors such as age, feed and genes of the birds (Yakubu *et al*., 2008; Msoffe *et al*., 2002). Ukwu *et al*. (2017) divided eggs into three groups i.e., light weight eggs (less than 49.99 g), medium eggs (50 to 55 g) and heavy eggs (greater than 55 g). Egg weight was highest in the KW-30% group (55.08 ± 0.81) that was given 30% KFW. The KW-15% and KW-45% groups also showed greater values of egg weight than control group ($p \leq 0.05$). The groups KW-30%, KW-15% and KW-45% showed 14.98%, 5.9%, and 5.7% higher egg weight than control group, respectively. As compared to present study, Hussain *et al*. (2013) reported lower and higher weight of different eggs collected from market and poultry farm as 53.95 ± 0.53 and 58.13 ± 0.60 respectively. Liswaniso *et al*. (2020) documented lower egg weight value of 49.72 ± 0.44g from indigenous free range hens from Zambia. Increased protein level in feeding diets had negative impact on egg weight values (Lee *et al*.,1987).

Egg shell weight, thickness and shell ratio were comparable among all the treatment groups under study. Higher shell weight (5.59±0.15) and shell ratio (10.62±0.12) were found in KW-30% and control group, respectively. Comparing to present study higher shell weight (6g) and lower shell ratio (10.42%) values were reported by Rath *et al*. (2015) but lower values for both the parameters were reported by Sreenivas *et al*. (2013). Shell thickness must be around 0.33mm to withstand handling breakage. Higher shell thickness (0.36mm) was found in KW-15% group that was greater than other reports (Nonga *et al*., 2010). As compared to present findings, Liu *et al*. (2020) reported higher values of egg shell thickness of laying hens fed with selenium from different sources at different levels.

Albumin weight (17.18±0.21), height (7.05±0.12), diameter (78.00±0.28) and index (9.02±0.15) values were higher in group KW-30% except albumin ratio ($p \leq 0.05$). The KW-15%, KW-30% and KW-45% groups showed 6.71%, 10.52% and 5.83% higher albumin weight than control group, respectively. The groups KW-15%, KW-30% and KW-45% showed 12.1%, 12.61% and 8.3% higher values of the albumin height than control group, respectively. The KW-15%, KW-30% and KW-45% groups showed 4.73%, 5.27% and 3.49% higher albumin diameter than control group, respectively. Except albumin diameter, Rath *et al*. (2015) reported higher values of these albumin parameters than the present study. Anene *et al*. (2020) reported higher albumin height values of 10.4 mm ± 1.5 from ISA brown hens (25-30 weeks old). Nasri *et al*. (2020) reported greater albumin diameter value of 89.6mm from broiler breed of 42 weeks old.

Yolk weight (17.18 ± 0.21), height (17.66 ± 0.18), diameter (44.78 ± 0.42), index (39.48 ± 0.15) and ratio (30.69 ± 0.31) were highest in the KW-30% group as compared to other treatment groups ($p \leq 0.05$). The KW-15%, KW-30% and KW-45% groups showed 7.17%, 14.08% and 5.94% higher values of yolk height than control group, respectively. The KW-15%, KW-30% and KW-45% groups showed 6.35%, 12.09% and 5.53% higher yolk diameter than control, respectively. The KW-15%, KW-30% and KW-45% groups showed 11.2%, 27.54% and 5.86% higher values of the yolk weight than control group, respectively. Results of many reports showed contradictory values for these yolk parameters of same age birds (Yakubu *et al*., 2008; Rajkumar *et al*., 2009; Islam *et al*., 2010). Mengsite *et al*. (2019) documented higher YH values of 18.83 ± 1.24mm, 18.79 ± 1.04mm and 18.29 ± 1.07mm in SassoT44 breed from three districts of Ethiopia. Yousif *et al*. (2011) reported lower yolk diameter values of 37.15+0.21mm and 37.96+0.21mm from native chickens including dwarf betwil (BT) and bare neck (BN) from Sudan. Iqbal and Pampori (2008) documented greater yolk index value of 45.5% from domestic chicken of Kashmir. Kumar *et al*. (2013) documented lower yolk weight value of 13.21g from eggs of Tellicherry chicken.

Haugh unit values were highest in the KW-30% group (85.49 ± 0.75) as compared to other treatments. This quality of eggs is related to the freshness of eggs. Results were not consistent with lower HU value of 59.62-71.62 as reported by Chatterjee *et al*. (2006) from white leghorn strains and higher values of HU (100.25-106.29) indicated by Nwachukwu *et al*. (2006). It is revealed that level of 30% KFW optimized this quality of eggs. Decreased protein level in the hen diet does not affect Haugh unit values as reported by Hamilton (1978). Abbas *et al*. (2022) reported lower Haugh unit values of eggs of caged layers than present findings. They provided different percentages of sodium bicarbonate in the diets of layer.

Yolk color values (1-15) of the groups differed non-significantly among all the treatment groups in the present study ($p \leq 0.05$). Values of red and yellow xanthophylls as well as their ratio determined the yolk color (Fletcher and Halloran, 1981). Group KW-45% showed higher yolk color values (7.67 ± 0.55) than other groups under study. As compared to present study, lower yolk color values (4.5) were reported by Islam *et al*. (2001) from naked neck birds. Kljak *et al*. (2021) documented comparable yolk color values of 7.73 ± 0.59 and 7.87 ± 0.52 from eggs of laying hens fed with 1% and 3% dandelion flower as supplements in diets.

Control group showed highest egg production rate among all the four treatment groups. It had production rate values of 66.79±0.16%. Egg production rate of experimental groups i.e., KW-15% (62.68 ± 0.47), KW-30% (63.52 ± 0.39) and KW-45% (57.95 ± 0.45) were lower than the control group ($p \leq 0.05$). The control group showed 2.33%, 1.49%, and 7.06% higher egg production than KW-15%, KW-30% and KW-45% groups respectively. It revealed that use of KFW decreased the egg production rate. In contrast, Kojima (2005) reported higher production rate of eggs when 25 % food waste was substituted. Results of the present study are in line with the report of Cho *et al*. (2004) suggested that addition of extra protein in hen diet showed higher production rate. Desired production performances could be achieved by adding amino acid concentration to low energy diets (Johnson and Fisher, 1959; Quisenberry, 1965; Petersen *et al*., 1971).

Eggs of the treatment group KW-15% had highest mass values. It was found that 15% substitution level of KFW improved the egg mass than control, 30% and 45% level of KFW. Lowest egg mass values were calculated in the group KW-45% (29.17 ± 0.24) that was given 45% KFW ($p \leq 0.05$). Comparable results of the egg mass were reported by the different studies (Kojima, 2005; Cho *et al*., 2004). Abd El-Hack *et al*. (2018) documented higher egg mass values of 51.80, 52.61, 54.02, 52.87 and 63.48 from Hisex brown laying hens fed with Zn-Met (mg/kg) (0, 25, 50, 75 and 100) as supplements in their diet.

Feed intake was highest for the control group (96.29 ± 0.61). Feed consumption was recorded lowest in the KW-15% group that was given 15% KFW ($p \leq 0.05$). Control group utilized higher amount of feed up to 8.85%, 3.93% and 1.12% as compared to experimental groups i.e., KW-15%, KW-30% and KW-45% groups, respectively. Maeng *et al*. (1997) reported higher feed intake of leftover feed in laying birds. Experiments of the Cho *et al*. (2004) showed greater values of food intake in groups fed with kitchen waste based feed. Atteh and Lesson (1985) reported non-significant effects on feed intake at different levels of fat and calcium.

Feed conversion value was lowest in the KW-15% group (2.92 ± 0.04) as compared to control, KW-30% and KW-45% groups ($p \leq 0.05$). Highest value was recorded in the KW-45% (3.16 ± 0.03). Replacement of the commercial feed with 15% and 30% KFW increased the performance of the birds up to 6.16%, 4.72%. At 45% substitution of KFW the performance of the birds decreased up to 1.93%. Performance of the birds might be enhanced by replacing the commercial feed with KFW as feed supplement. Results were in line with the study of Hossein and Dahlan (2015). Kojima (2005) reported significantly higher FCR values when 20% KFW was given in hen diet. Other studies showed non-significant results of FCR as compared to present study (Cho *et al*., 2004). Kurtoglu *et al*. (2004) documented lower FCR values of 1.90±0.01, 1.84±0.0, 1.86±0.01 and 1.87±0.02 from laying hens fed with commercial probiotics at various concentrations.

CONCLUSIONS AND RECOMMENDATIONS

It is concluded that the kitchen food waste has important nutritional contents necessary for the diet of laying hens. It can be substituted up to 45% as feed stuff but optimum level of KFW is 30%. Egg quality characteristic of the groups fed organic diet were improved as compare to the control that was given 100% commercial feed. Recommendations of using KFW in the hen diet is appreciated by the present study. Supplementation of kitchen food waste in the diet of laying hens might decrease the cost of commercial feed with consistent production of high quality eggs.

DECLARATIONS

Acknowledgements

We are greatly thankful to management, Institute of Zoology, University of the Punjab, Lahore, Pakistan.

Funding

No funding was received for this study.

IRB approval

The Advanced Studies and Research Board of the University of the Punjab, Quaid-i-Azam Campus, Lahore provided approval of the research at its meeting held on 27-01-2022.

Consent to publish

All the authors agreed with the content and gave explicit consent to submit and they obtained consent from the responsible authorities at the institute/organization where the work has been carried out.

Availability of data and materials

These will be provided by the corresponding author on reasonable request.

Statement of conflict of interest

The authors have declared no conflict of interest.

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