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308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

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Dehydrated Kitchen Waste as a Feedstuff for Laying Hens

Sadao Kojima
Agricultural Products Development Division, Tokyo Metropolitan Agriculture and Forestry Research Center,
6-7-1 Shinmachi, Ome, Tokyo, 198-0024, Japan

Abstract: An experiment was conducted to determine the effects of dehydrated kitchen waste (DKW) product as a feedstuff for laying hens. Fresh food wastes of a retirement house were prepared for the experiment. This was mostly leftover food, plate scrapings and cooking residue. The kitchen waste was blended and dried by the temperature in the heater set at 80 to 85°C in which the product temperature reached 60 to 65°C. The DKW product contained 12.24% moisture, 15.14% Crude Protein, 5.33% crude fat, 2.34% crude fiber, 5.26% ash, 2.82% Ca, 0.29% P and 0.31% Na. A total of 40 laying hens were fed a control diet (diet 1) or one of three diets containing 12.5% DKW (diet 2); 25.0% DKW (diet 3); 50.0% DKW (diet 4). There were 10 birds per treatment and 5 birds per replicate. The diet with 50.0% DKW decreased egg weight ($P<0.001$). There were no significant differences in egg production rate and feed conversion. The birds fed diets 1, 2 and 3 increased body weights during feeding period. The eggshell strength tended to weaken with increased DKW. The lightness (L*) of eggshell color was significantly higher with increasing DKW ($P<0.001$), and the reverse was true for the redness (a*) of eggshell color. Roche color fan values decreased as DKW content increased. These results indicate that dehydrated kitchen wastes contains the nutritional value and that may be useful as feedstuffs for laying hens.

Key words: Waste feeding, laying hen, egg quality

Introduction

There are nutritional values on kitchen wastes, which consist of scrapings of plate waste and unusable leftovers for livestock animal. Feeding waste to the livestock is not a new concept. However, the kitchen waste typically contains 50% to 85% moisture (Myer *et al*., 1999). There are methods such as heating or voile drying in order to raise preserving property and safety. The results of using these products for feeding pigs were reported in other investigations (Rivas *et al*., 1995; Westendorf *et al*., 1998; Myer *et al*., 1999).

At present, the most part of food waste discharged in food production process, distribution, and consumption stage has been disposed by incineration or landfill. Therefore, there are purposes on examining the efficient use of food waste, environmental protection, resource preservation, and food self-sufficient problems. To the best of our knowledge, there is no report on the effect of the DKW feeding to laying hens. The objectives of the present work were to study the effects of the DKW products on nutritional value and its performance (egg production, fatty acid composition of yolk, and quality of eggs) as a feedstuff for laying hens.

Materials and Methods

For this product, fresh edible food wastes were prepared from a retirement house in Tokyo. These were mostly leftover food, plate scrapings and cooking residue. The kitchen wastes were blended and dried. The drying temperature was 80 to 85°C, and product temperature reached 60 to 65°C. 24 hours later, the resulting product was approximately 15% moistened. Samples of the DKW products were analyzed for moisture, crude protein, crude fat, crude fiber, ash, Ca, P, and Na. These were analyzed using AOAC (1990) procedures. Samples of the DKW products were also analyzed for fatty acid composition, and peroxide value.

40 Rhode Island Red were placed in individual wire-floored cages (39 cm x 22 cm, with a height of 45 cm) under artificial light for 16 h per day and hens not laying were replaced with hens laying when this experiment was started. The birds were assigned on a random basis of 10 birds per treatment. There were 10 birds per treatment and 5 birds per replicate. The hens were 22 wk of age when this experiment was initiated. The hens were fed a control diet (diet 1), or one of three diets containing 12.5% DKW (diet 2); 25.0% DKW (diet 3); 50.0% DKW (diet 4). Diets containing the DKW were prepared weekly and stored in airtight containers. Hens were fed daily. The birds were weighed initially and at weekly intervals. Hen recorded egg production, and egg weight values were kept throughout the 35-day period. Feed consumption was recorded every seventh day for each dietary treatment, for subsequent analysis of feed intake and feed conversion. Water was supplied for *ad libitum*. Feed was allocated at 130 g per bird day and fed at 0900 h during the treatment periods. All eggs were stored at 4°C overnight and measurements were taken the following day. Eggshell color was measured using a Minolta Spectrophotometer CM-508b[1] and reported in

Table 1: Composition of dehydrated kitchen waste product

Item (%)	DKW
Dry matter	87.76
Crude protein (N x 6.25)	15.14
Crude fat	5.33
Crude fiber	2.34
Crude ash	5.26
Calcium	2.82
Phosphorous	0.29
Na	0.31
Salt equivalents (Na x 2.54)	0.79
Fatty acid (% of total fatty acids)	
14 : 0	2.49
16 : 0	18.65
16 : 1	3.05
17 : 0	0.11
18 : 0	5.91
18 : 1	36.62
18 : 2	24.25
18 : 3	4.55
20 : 0	1.11
20 : 1	0.22
20 : 2	TR[1]
20 : 3	0.05
20 : 4	0.64
22 : 5	0.11
22 : 6	0.09
Total saturates (%)	28.27
Total monosaturates (%)	39.89
Total polyunsaturates (%)	29.69
Unsaturated:saturated ratio	2.5 : 1
Initial peroxide value (mEq/kg[2])	12.60

[1]TR=trace. [2]Units of peroxide formation per kilogram.

the CIELAB system values of lightness (L*), redness (a*), and yellowness (b*). Eggshell-breaking strength was determined by a mechanical press (kg per egg) to measure the force necessary to break the shell when the egg was placed on its side between two horizontal plates. All eggs were weighed and broken out to measure albumen for height, Haugh units (HU), and yolk color. Yolk color was determined using visual comparisons with the Roche color fan (Vuilleumier, 1969). Shell membranes were removed when shell thickness was measured.

Egg yolks for lipid analyses were collected at 35th d of the feeding trial. Lipid extraction was conducted within 1 d postoviposition. Three eggs from each treatment group were selected at random. The eggs were weighed, and yolks were separated from white by a conventional household yolk separator, weighed, pooled and blended. Yolk lipids were extracted with chloroform-methanol according to the method of Bligh and Dyer (1959). Extracts were converted to fatty acid methyl esters by the method of Christopherson and Glass (1969). The fatty acid methyl esters were analyzed on a Hitachi G-5000 gas chromatograph[2] equipped with a Chrompack fused-silica capillary column (CP-Sil88;[3] 50 m x 250 μmi.d., 0.2 μm) and flame ionization detector. The samples were chromatographed at 170 to 190°C with a 2°C per min programmed temperature gradient. Helium was the carrier gas at a flow rate of 30 mL per min. Fatty acid peaks were measured using a Hitachi D-2500 computing integrator[2].

All data were analyzed by one-way analysis of variance and treatment means were compared using Tukey's multiple range test.

Results and Discussion

The dehydrated kitchen wastes were mashed, visibly in dark brown color, and had a mild odor. Composition of the major chemical components of the DKW product is given in Table 1. The DKW product contained 12.24% moisture, 15.14% crude protein, 5.33% crude fat, 2.34% crude fiber, 5.26% ash, 2.82% Ca, 0.29% P and 0.31% Na. The total P content was lower to that in dehydrated restaurant waste as reported by Westendorf *et al.* (1998). And, its value showed the range lower limit of that report. The Na content, however, was high. This Na content equate to a salt content of 0.79% in the DKW product. Properly sodium requirement of actively laying hens was 0.12% on NRC (1994), its equivalent to 0.30% salt (estimated NaCl content). The crude fat and the crude protein content of DKW are remarkably lower than the result of some other reports (Walker and Wertz, 1994; Rivas *et al.*, 1995; Myer *et al.*, 1999). There was the relation on these results in raw materials of the DKW. Leftover food and plate scrapings of the old people's home mainly contained vegetable chip and boiled rice. Then, eggshell and fishbone were included in cooking residue. And, for the health care of the inmate, it was based on making the accurate nutritional administration, further than the menu of the restaurant or the cafeteria. However, the tendency with high sodium content was common. Calcium content was higher than the other reports (0.5-0.8%). However, it was generally sufficient when compared to NRC standards (1994).

The fatty acid profile of the fat in the DKW product and results of quality assessment of this fat are shown in Table 1. The fatty acid profile of the DKW products indicated a mixture of fats of animal and vegetable origin. The experiment was carried out without problems concerning appetite or health.

There were no significant differences in hen-day egg production rate and feed conversion (Table 3). The diets 1, 2 and 3 increased body weight during feeding period. At the termination of the 5-wk experiment, body weight was significantly decreased for diet 4 ($P<0.01$). Feed intake was highest for diets 2 and 3, and lowest for diet 4. Egg mass was also highest for diet 3, and lowest for diet 4. Egg weight was highest for diets 2 and 3, and

Table 2: Composition of the diets fed

% Feedstuffs	1[1]	2	3	4
Dehydrated kitchen waste product	0.0	12.5	25.0	50.0
Yellow corn	45.0	39.3	33.7	22.5
Hulled rice	15.4	13.5	11.5	7.7
Soybean meal	10.2	8.9	7.6	5.1
Rapeseed meal	9.2	8.0	6.9	4.6
corn grten meal (CP60)	7.2	6.3	5.4	3.6
Fish meal (CP60)	1.0	0.9	0.8	0.5
Defatted rice bran	1.0	0.9	0.8	0.5
Lime stone	5.1	4.5	3.8	2.5
Tallow	2.6	2.3	2.0	1.3
Dicalcium phosphate	2.6	2.3	2.0	1.3
Salt	0.3	0.2	0.1	0.0
Vitamin-mineral premix[2]	0.35	0.35	0.35	0.35
DL-methionine	0.05	0.05	0.05	0.05
Calculated analysis:				
Crude protein (%)	18.72	18.26	17.84	16.95
ME (kcal/kg)	2917	2866	2816	2710
Calcium (%)	2.89	2.92	2.91	2.91
Phosphorous (%)	0.90	0.83	0.76	0.59
Na (%)	0.16	0.16	0.15	0.18
Determined analysis:				
Crude protein (%)	18.66	18.21	17.69	16.21

[1]Control diet. [2]Provided per kilogram of diet: vitamin A, 5,000 IU; vitamin D_3, 1,000 IU; vitamin E, 7.5 IU; vitamin K_3, 2mg; thiamine from thiamine niturate, 4 mg; riboflavin, 20 mg; niacin, 4 mg; pyridoxine from pyridoxine hydrochloride, 4 mg; vitamin B_{12}, 0.02mg; pantothenic acid from calcium pantothenate, 8.8 mg; folic acid, 2 mg; biotin, 0.2 mg; choline from choline chloride, 276 mg from ferrous sulfate, 6 mg; zinc from zinc carbonate, 50 mg; manganese from manganese sulfate, 80 mg; copper from copper sulfate, 0.6 mg; iodine from calcium iodate, 1 mg.

was significantly depressed when the content of DKW diet was 50.0% or higher. The comparison between dietary treatment of control and other DKW diets shows that replacing hen diet with DKW product at level of 25.0% did not influence egg production. However, the decline in egg production observed with increasing levels of DKW products shows those high levels of DKW products negatively influencing the egg production. Summers and Leeson (1983) indicated that levels of dietary protein had little or no effect on early egg weight. Summers and Leeson (1993) also reported that hens to 55wk of age produced a similar number but heavier eggs when fed a 17 versus 13% protein diet. Harms and Russell (1993) reported that when the hens had a greater feed intake, only three amino acid (Lysine, Methionine, Tryptophan) supplementation of a low-protein diet would enhance performance. Atteh and Leeson (1985) observed that there were no significant effects for feed intake, weight gain, egg production, egg weight, and eggshell deformation on fat levels (0, 5, or 10%) or dietary calcium levels (3.0, 3.6, or 4.2%) in the feed. Said *et al.* (1984) showed that egg production rate, feed intake, egg weight were significantly improved, when the total phosphorus is made to be 0.5%, by adding dicalcium phosphate to the basal diet which contains total phosphorus to 0.4%. In laying performance, there were many items to which the 25.0% DKW result showed the peak in four treatments. In the calculated analysis, crude protein, Ca, and P in diet 2 contained 18.26%, 2.92%, and 0.83%, respectively. The present experiment shows that dehydrated kitchen waste product contains the nutritional value and may be useful as feedstuffs for laying hens. However, the reduction in egg production and egg weight observed for the highest levels of dietary DKW product indicate that DKW product in diets for laying hens should be kept below 25%.

The lightness (L*) of eggshell color was significantly higher with increasing DKW ($P<0.001$), and the reverse was true for the redness (a*) of eggshell color. There were no significant differences in the yellowness (b*). There was no effect on eggshell thickness. However, eggshell-breaking strength was significantly weak ($P<0.001$) for diet 4 treatment (Table 4). In many countries, eggshell color is an important egg quality. Markets in Japan, brown eggs are utilized as marketing strategy for sales of egg retailer. Therefore, it was not desirable phenomenon that the color of the eggshell lowered. Tamura and Fujii (1967) reported that porphyrin was distributed in the cuticle and shell. Lang and Wells (1987) stated that further biochemical and physiological studies are required to understand the nature of the

Table 3: Performance of laying hens fed diets containing a dehydrated kitchen waste product (DKW)

Item	Dietary treatment				
	1	2	3	4	P-value
Number of hens	10	10	10	10	-
Hen weight at 28wk (g)	2346.2	2201.2	2242.8	2206.4	0.65
Weight gain (g)	121.2^{ab}	77.0^{b}	56.6	-22.3^{c}	<0.01
Feed intake (g/day)	122.0^{b}	128.0^{a}	127.6^{a}	117.2^{c}	<0.001
Egg mass (g/hen/day)	54.1^{ac}	57.4^{ab}	58.4^{b}	50.9^{c}	<0.001
Egg weight (g)	57.3^{b}	59.6^{ab}	60.1^{a}	54.3^{c}	<0.001
Hen-day egg production (%)	94.3	96.6	97.1	93.7	0.31
Feed conversion (g feed/g egg)	2.25	2.23	2.18	2.30	0.26

$^{a-c}$Means in a row without a common superscripts are different (P<0.05).

Table 4: Egg shell strength, shell thickness, shell color, Roche color fan values of egg yolks, thickness of albumen, and Haugh units of hens fed diets containing a dehydrated kitchen waste product (DKW)

Item	Dietary treatment				
	1	2	3	4	P-value
Egg shell strength (kg)	4.49^{bc}	4.58^{a}	4.20^{c}	3.74^{c}	<0.001
Shell thickness (x 0.01mm)	35.7	36.0	34.5	34.5	0.43
Lightness (L*) of egg shell	61.5^{b}	63.6^{a}	64.3^{a}	67.5^{a}	<0.001
Redness (a*) of egg shell	17.1^{a}	15.9^{b}	15.3^{bc}	13.2^{c}	<0.001
Yellowness (b*) of egg shell	30.5	30.2	30.9	30.2	0.45
Roche color fan values (1-15)	8.59^{a}	8.14	8.06	7.86^{b}	<0.01
Thickness of albumen (mm)	8.62	7.88	8.42	7.45	0.55
Haugh units	92.9	89.2	92.0	88.5	0.84

$^{a-c}$Means in a row without a common superscripts are different (P<0.05).

eggshell pigmentation processes. Keshavarz and Jackson (1992) observed that eggshell strength did not weaken, even if the protein content was lowered. Gordon and Roland (1998) reported that increasing dietary phosphorus significantly improved egg specific gravity and eggshell weights. Sohail and Roland (2002) showed that effect of phosphorus deficiency made bone density and bone mineral content to decrease. Leeson *et al*. (1993) observed that eggshell deformation was significantly lowered, when the feed contained 0.25% dietary available phosphorus (0.45% of total phosphorus) was supplied to brown-egg birds. This result shows that the DKW diet may make use of eggshell pigmentation control. This may explain the effect on eggshell color in the present study, which may be affected by crude protein quantity in the feed or phosphorus quantity or the both. However, the reason is uncertain.

Thickness of albumen and Haugh units were not affected by dietary treatment (Table 4). Roche color fan value was significantly lower (P<0.01) for eggs from hens fed diet 4 than diet 1. Hamilton (1978) reported that the lowering protein feed of laying hens had no significant effect on Haugh unit values. Fletcher and Halloran (1981) showed that yolk color is determined not only by total xanthophylls but also by the ratios of red and yellow xanthophylls present. Fletcher and Halloran (1982) reported that the magnitude of change of the a* and b* values is what would be expected for changes in dietary levels of yellow and red pigment sources. It was concluded that the levels of DKW diet affected the yolk color. The high DKW content feeding resulted in a pale colored yolk, however, did not influence thickness of albumen and Haugh unit values.

Table 5 shows the fatty acid composition of egg yolk. Significant differences among treatment were found for contents of the fatty acids C16:0 (P<0.01), C18:0 (P<0.05), and C18:2 (P<0.001). PUFA as the sum of C18:2, C20:2, C20:3, C20:4, C22:5, and C22:6 was highest for hens fed diet 4 (P<0.001), while the contents of SFA as the sum of C14:0, C16:0, C17:0, C18:0, and C20:0 was significantly low for hens fed diet 4 (P<0.01). The contents of C18:1, and C18:3 tended to increase with increasing DKW, whereas the proportions of C16:1, and C20:4 tended to decrease. Unsaturated:saturated fatty acid ratio of the DKW products was 2.5:1 (Table 1), and the ratio for diet 4 was biggest (P<0.001) among four treatments (Table 5). It is well known that the fat in the diet affects the fatty acid composition in egg yolk. The effects of various dietary levels of fish oils or fish meals on the fatty acid composition of egg yolk have been reported by a number of investigators (Hargis *et al*.,

Table 5: Major fatty acids in egg yolks[1] from hens fed diets containing a dehydrated kitchen waste product (DKW)

Item	Dietary treatment				
	1	2	3	4	P-value
Fatty acid profile, relative %					
16 : 0	26.6[a]	26.1[a]	25.7[a]	22.5[b]	<0.01
16 : 1	4.3	4.0	4.2	3.9	0.94
17 : 0	0.1	0.1	0.1	0.1	0.83
18 : 0	7.4[b]	8.5[a]	8.3	7.8	<0.05
18 : 1	44.5	45.4	46.1	46.4	0.07
18 : 2	13.4[b]	12.9[c]	12.7[c]	16.2[a]	<0.001
18 : 3	0.4	0.5	0.6	0.7	0.07
20 : 4	2.3	1.9	1.7	1.7	0.27
Total saturates (%)	34.5[a]	34.8[a]	34.4[a]	30.8[b]	<0.01
Total monounsaturates (%)	48.8	49.4	50.3	50.3	0.18
Total polyunsaturates (%)	16.6[b]	15.8[c]	15.4[c]	18.9[a]	<0.001
Unsaturated:saturated ratio	1.9:1	1.9:1	1.9:1	2.2:1	

Means in a row without a common superscripts are different (P<0.05).[1]In the 35-d samples.

1991; Nash *et al*., 1995; Meluzzi *et al*., 2000; Kjos *et al*., 2001). Hargis *et al*. (1991) reported that diets containing omega-3 fatty acids (3% menhaden oil) resulted in an increase in yolk EPA and DHA, and also reported that saturated fatty acid composition of yolk was not significantly influenced by diet. Schreiner *et al*. (2004) feeding diets containing 1.25% seal blubber oil led to an increase (P<0.0001) in the long-chain omega-3 fatty acids of egg yolk lipids when compared with a tallow based control. They have mainly made the production of the rich egg of the omega-3 fatty acid to be a purpose. The present study shows that adding up to 50.0% DKW to the diet causes some major changes in fatty acid composition of egg yolk when compared with the control. In particular, total polyunsaturates increased, and total saturates decreased, however total monounsaturates hardly was affected by dietary treatment.

The results of this study indicated that the DKW products used were safe and nutritious feedstuffs for inclusion in hen diets. High levels of the DKW in the diet caused reduced several laying performance. However, in the laying performance, significant difference was noted between control and 50.0% DKW was only average egg weight during test period. 25.0% DKW was efficient, when the laying performance and the egg quality were considered. Thus, the study concluded that there is no negative influence to the 25.0% DKW level of the food waste recycling.

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[1]Konica Minolta Holdings, Inc., Tokyo, Japan.
[2]Hitachi, Co., Tokyo, Japan.
[3]Varian Co., Palo Alto, CA.