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# Effect of Dietary Inclusion of Dehydrated Food Waste Products on Taiwan Native Chicken (Taishi No. 13)

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**ABSTRACT :** The effect of dehydrated food waste product (DFWP) inclusion in diets of Taiwan native chickens on the growth performance, carcass traits, clinical blood chemistry and nutrient digestibility was investigated with 320 male Taishi Native Chickens (Taishi No. 13). They were randomly allocated into four levels of DFWP inclusion (0, 5, 10, or 20%) treatment. Each treatment had 80 chickens with four replicates. At 15 weeks of age, 8 chickens were selected from each group for the nutrient digestibility trial. The results showed that body weight gain during the 0 to 4 week period decreased as the feed intake and feed conversion rate (FCR) increased linearly with increasing level of DFWP inclusion. During the 4 to 8 week period, greater body weight gains were recorded for the birds on the 5% DFWP inclusion level than for the control ($p<0.05$). During 8 to16 weeks, the feed intake and FCR increased linearly ($p<0.05$). Interestingly too, results of the carcass analysis showed that DFWP inclusion up to 20% in the diet significantly decreased the relative abdominal fat weight but increased the relative proventriculus and gizzard weights of the birds. However, other carcass parameters, meat quality and sensory scores were not significantly influenced by the dietary DFWP inclusion levels ($p>0.05$). Higher serum aspartate aminotransferase, γ-glutamyltransferase activity and crude protein digestibility, and lower gross energy digestibility were observed in the 20% DFWP group compared to the control ($p<0.05$). Dietary DFWP inclusion was inappropriate during the 0 to 4 week period. During 4 to 8 weeks, there was no adverse effect on chicken performance in the 20% group. There was no disadvantage on carcass properties and in the meat panel test. This result would not affect consumer determination. (**Key Words :** Dehydrated Food Waste Products, Taiwan Native Chicken, Growth Performance, Carcass Traits, Meat Quality, Nutrient Digestibility)

## INTRODUCTION

The amount of garbage produced in Taiwan has increased two-fold over the past ten years with the rapid development of the Taiwan economy to more than 7 million tons, of which food waste accounts for 18 to 20% of the recoverable resources (EPA, 2003). Food waste processing model plans in Taiwan currently include land fill, incineration, grinding of domestic food wastes released into the drainage, and recycling. These three processes involve very high costs and result in environmental contamination and pollution. The issue of food waste recycling has therefore become more important than ever before.

Formerly, farmers used wet food waste as another source of feed supply for pigs. However, the time-consuming nature of the work, low feed efficiency, nutrient imbalance, poor environmental hygiene and the difficulty of disease prevention, made feeding wet food wastes to pigs unpopular (Chen and Chen, 1995; Lin, 1996). It has already been shown that dehydrated food waste products (DFWP) used as a feedstuff for swine has no negative effects on growth performance and carcass properties, and could enhance its utilization as a feed resource (Rivas et al., 1995; Myer et al., 1999; Chae et al., 2000; Moon et al., 2004). Studies on comparative feeding of Peking and Muscovy duckling with wet and dehydrated food wastes inclusion by Farhat et al. (2001) showed higher feed efficiency than the control group. Dietary supplement of 10% dried leftover food have no significant differences with growth performance in broiler and egg production in laying hens (Cho et al., 2004a, b). However, there are only a few reports in the literature which evaluated the feeding value of food waste in chickens.

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**Table 1.** Composition of the DFWP (n = 5)

| Ingredient | Mean±SD |
|---|---|
| Moisture (%) | 12.40±0.31 |
| Crude protein (%) | 15.79±0.54 |
| Crude fat (%) | 15.98±0.61 |
| Crude fiber (%) | 10.80±1.20 |
| Gross energy (kcal/kg) | 4,053.54±1.04 |
| Ash (%) | 7.80±0.24 |
| Calcium (%) | 1.01±0.14 |
| Total phosphorus (%) | 0.67±0.05 |
| Salt (%) | 1.28±0.42 |
| Arginine (%) | 0.84±0.10 |
| Histidine (%) | 0.34±0.02 |
| Isoleucine (%) | 0.52±0.06 |
| Leucine (%) | 1.09±0.08 |
| Lysine (%) | 0.68±0.06 |
| Methionine (%) | 0.28±0.02 |
| Cysteine (%) | 0.08±0.02 |
| Phenylalanine (%) | 0.64±0.10 |
| Tyrosine (%) | 0.40±0.12 |
| Threonine (%) | 0.53±0.03 |
| Glycine (%) | 0.92±0.11 |
| Valine (%) | 0.76±0.07 |

In order to promote the extensive use of DFWP as a potential feedstuff, this study therefore investigates the effects of dietary inclusion of DFWP on growth performance, carcass traits, clinical blood chemistry and nutrient digestibility in Taiwan native chickens.

## MATERIALS AND METHODS

### Preparation and composition of DFWP

The food waste was collected from Taichung City in Taiwan, and inorganic wastes were removed using artificial selection. Water was removed via filter bed. The waste was then ground, mixed with rice polishing, fermented for 8 h and dried at 85°C for 2 to 4 h. The composition of the product is shown in Table 1.

### Animal management and experimental design

Three hundred and twenty male Taishi Meat (Taishi No. 13) chickens were randomly assigned to four dietary treatment groups of 0, 5, 10 and 20% DFWP. Each treatment was replicated four times with 20 birds per replicate. The diets were adjusted to be iso-caloric and iso-nitrogenous (Table 2). Three periods of 0 to 4, 4 to 8 and 8 to 16 weeks were observed during the feeding trial. Chickens were raised in a battery brooder during 0 to 4 weeks before being moved to floor pens (3 m×1.7 m). The

**Table 2.** Composition of experimental diets

| | 0-4 wk | | | | 4-8 wk | | | | 8-16 wk | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DFWP (%) | | | | DFWP (%) | | | | DFWP (%) | | | |
| Ingredient (%) | 0 | 5 | 10 | 20 | 0 | 5 | 10 | 20 | 0 | 5 | 10 | 20 |
| Corn meal | 51.0 | 49.1 | 47.1 | 42.9 | 60.4 | 58.2 | 54.1 | 45.1 | 65.8 | 63.8 | 61.7 | 47.0 |
| Soybean meal (44%) | 37.0 | 35.6 | 34.3 | 31.6 | 33.4 | 32.1 | 31.2 | 30.7 | 27.7 | 26.6 | 25.5 | 23.0 |
| DFWP | 0.0 | 5.0 | 10.0 | 20.0 | 0.0 | 5.0 | 10.0 | 20.0 | 0.0 | 5.0 | 10.0 | 20.0 |
| Wheat bran | - | - | - | - | 1.0 | 1.0 | 2.0 | 2.0 | 0.9 | 0.6 | 0.3 | 8.0 |
| Fish meal (65%) | 2.00 | 2.00 | 2.00 | 2.00 | - | - | - | - | - | - | - | - |
| Soybean oil | 6.30 | 5.00 | 3.60 | 0.90 | 2.10 | 7.60 | 0.0 | 0.0 | 2.7 | 1.31 | 0.0 | 0.0 |
| Calcium phosphate | 1.57 | 1.52 | 1.45 | 1.34 | 1.34 | 1.24 | 1.15 | 0.94 | 1.55 | 1.41 | 1.35 | 1.18 |
| Limestone | 1.10 | 1.00 | 0.90 | 0.70 | 1.03 | 0.97 | 0.88 | 0.76 | 0.66 | 0.60 | 0.55 | 0.35 |
| Salt | 0.30 | 0.24 | 0.17 | 0.04 | 0.30 | 0.24 | 0.17 | 0.04 | 0.30 | 0.24 | 0.17 | 0.04 |
| DL-methionine | 0.21 | 0.22 | 0.22 | 0.24 | 0.16 | 0.16 | 0.16 | 0.17 | 0.10 | 0.11 | 0.11 | 0.13 |
| Choline choloride (50%) | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Mineral premix[a] | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Vitamin premix[b] | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Calculated analysis (%) | | | | | | | | | | | | |
| Crude protein (%) | 22.00 | 22.00 | 22.00 | 22.00 | 20.00 | 20.00 | 20.00 | 20.00 | 18.00 | 18.00 | 18.00 | 18.00 |
| ME (kcal/kg) [1] | 3,100 | 3,100 | 3,100 | 3,100 | 3,000 | 3,000 | 3,000 | 3,000 | 3,100 | 3,100 | 3,100 | 3,100 |
| Crude fiber (%) | 3.62 | 4.06 | 4.40 | 5.28 | 3.80 | 4.14 | 4.58 | 5.46 | 3.49 | 3.90 | 4.31 | 5.56 |
| Ca (%) | 0.90 | 0.90 | 0.90 | 0.90 | 0.79 | 0.79 | 0.79 | 0.79 | 0.77 | 0.77 | 0.77 | 0.77 |
| Methionine (%) | 0.50 | 0.50 | 0.50 | 0.50 | 0.44 | 0.44 | 0.44 | 0.44 | 0.36 | 0.36 | 0.36 | 0.36 |
| Analysis value | | | | | | | | | | | | |
| Crude protein (%) | 22.04 | 22.12 | 22.25 | 22.38 | 20.02 | 20.15 | 20.27 | 20.34 | 18.02 | 18.12 | 18.23 | 18.38 |
| GE (kcal/kg) | 3,779 | 3,793 | 3,821 | 3,829 | 3,669 | 3,680 | 3,692 | 3,708 | 3,779 | 3,793 | 3,816 | 3,835 |

[a] Vitamin premix (per kg): vitamin A, 4.13 mg; vitamin $D_3$, 0.078 mg; vitamin E, 34.1 mg; vitamin $K_3$, 6.25 mg; vitamin $B_1$, 3.75 mg; vitamin $B_2$, 12.5 mg; vitamin $B_6$, 10.0 mg; Ca-pantothenate, 18.8 mg; Niacin, 50 mg; Biotin, 0.06 mg; Folic acid, 1.25 mg; vitamin $B_{12}$, 0.05 mg.

[b] Mineral premix (per kg): Cu ($CuSO_4$ $5H_2O$, 25.45% Cu), 6 mg; Fe ($FeSO_4$ $7H_2O$, 20.09% Fe), 50 mg; Mn ($MnSO_4$ $H_2O$, 32.49% Mn), 40 mg; Zn (ZnO, 80.35% Zn), 60 mg; Se ($NaSeO_3$, 45.56% Se), 0.075 mg.

[1] According to estimated utilization ratio of 80% for energy of DFWP.

**Table 3.** Effects of DFWP on growth performance in chickens

| Exp. period | 0% | 5% | 10% | 20% | SEM | Orthogonal comparison* |
|---|---|---|---|---|---|---|
| Body weight (g/bird) | | | | | | |
| 0 wk | 33 | 33 | 32 | 33 | 0.92 | - |
| 4 wk | 306[a] | 289[b] | 280[bc] | 270[c] | 3.05 | L |
| 8 wk | 676[ab] | 696[a] | 668[ab] | 654[b] | 4.86 | NS |
| 16 wk | 1,723[a] | 1,726[a] | 1,697[ab] | 1,663[b] | 6.55 | L |
| Weight gain (g/day/bird) | | | | | | |
| 0-4 wk | 39[a] | 37[b] | 35[bc] | 34[c] | 3.01 | L |
| 4-8 wk | 53[b] | 58[a] | 55[ab] | 55[ab] | 4.85 | NS |
| 8-16 wk | 150 | 147 | 147 | 144 | 6.53 | - |
| Feed intake (g/day/bird) | | | | | | |
| 0-4 wk | 19[b] | 19[b] | 20[ab] | 21[a] | 0.54 | L |
| 4-8 wk | 44 | 46 | 48 | 49 | 0.89 | - |
| 8-16 wk | 69[c] | 72[bc] | 73[b] | 77[a] | 0.72 | L |
| FCR (feed intake/weight gain) | | | | | | |
| 0-4 wk | 1.98[d] | 2.09[c] | 2.25[b] | 2.46[a] | 0.13 | L |
| 4-8 wk | 3.30[ab] | 3.15[b] | 3.47[ab] | 3.60[a] | 0.25 | NS |
| 8-16 wk | 3.67[c] | 3.90[b] | 3.97[b] | 4.28[a] | 0.17 | L |

* L indicates that the linear effect of treatment is significant ($p<0.05$). NS: not significant ($p>0.05$).

[a, b, c, d] Means in the same row with different superscript are significantly different ($p<0.05$).

feeding management followed the Taiwan Native Chicken Generalized Handbook (1995). The feed and water were provided *ad libitum*.

### Analysis

The diets were analysed for their proximate composition according to AOAC (1984) methods. Individual body weights and group feed intake of the chickens were recorded each week and later used to calculate the average weight gain, feed intake and the feed conversion rate (FCR). Blood samples were taken from the brachial-vein after the birds were withdrawn from feed and water for 12 h at the end of the experiment. After centrifuging, serum was stored at -40°C for further analysis. Aspartate aminotransferase (AST), creatine kinase (CK), γ-glutamyltransferase (GGT) and lactate dehydrogenase (LDH) activity in the blood serum were analyzed using an automatic blood chemical analyzer with Roche testing kits (Roche COBAS MIRA PLUS, Switzerland).

At the end of the experiment, 24 chickens from each group were sacrificed to measure the weights of the heart, liver, abdominal fat (from gizzard to coeliac fat), comb, breast muscle (Pectoral major muscle) and thigh muscle (De-boned thigh drumstick muscle). The pH value of meat was measured using a portable pH meter. The moisture, ash, crude fat and crude protein of breast muscle were measured according to AOAC (1984) methods.

The meat color was measured using a color difference meter as described by Lyon et al. (1980) and the cooking loss analysis was done using the method of Florene et al. (1994). The meat sample was heated at 80°C for 30 minutes to measure the shear value using the Rheometer method (RT-2002D, Tokyo Rheotech Co., Ltd.). A panel comprising thirty-eight people (18 to 55 years in age) was constituted for the sensory score evaluation according to the method used by Lyon et al. (1980) to determine the flavor, color, juiciness, texture, tenderness and acceptability. Values of 1 to 7 (meaning worst to best) were scored and recorded for each of the samples.

Eight 15-week-old chickens of similar body weight were selected from each group and housed in wire cages (40×30×38 cm) for the nutrient digestibility trial. $Cr_2O_3$ was added to the experimental diet as an indigestible indicator. Excreta were collected for four days after a four-day adjustment period. Water was provided *ad libitum*. Feed was provided *ad libitum* during the adjustment period and 70% of the feed intake during the adjustment period was provided during the excreta-collection period.

Excreta were weighed after each collection and oven-dried for three days, then held at room temperature for 48 h and weighed. Excreta were then pulverized and stored at -40°C for further analysis. The analyses of crude protein, crude fat, ash and gross energy were performed according to AOAC (1984) methods. The $Cr_2O_3$ analysis was performed using atomic absorption spectrophotometry as described by Williams et al. (1962) and the digestibility of each nutrient was measured.

### Statistical analysis

Analyses of variance were calculated using the general linear model procedure of SAS (1989). Duncan's new multiple-range test was used to compare the means and partitioning of treatment sum of squares was performed by orthogonal comparisons in regression according to Steel and Torrie (1980).

**Table 4.** Effects of DFWP on carcass traits in chickens

| Item | 0% | 5% | 10% | 20% | SEM | Orthogonal comparison* |
|---|---|---|---|---|---|---|
| Carcass weight (g) | 1,484 | 1,457 | 1,434 | 1,428 | 5.55 | - |
| Dressing percentage (%) | 80 | 79 | 79 | 79 | 1.00 | - |
| Relative heart weight (g/100 g BW) | 0.63 | 0.64 | 0.61 | 0.63 | 0.14 | - |
| Relative liver weight (g/100 g BW) | 2.18 | 2.20 | 2.16 | 2.30 | 0.27 | - |
| Relative intestines weight (g/100 g BW) | 4.24 | 4.22 | 4.34 | 4.41 | 0.12 | - |
| Relative proventriculus and gizzard weight (g/100 g BW) | 3.46[b] | 3.40[b] | 3.55[b] | 3.86[a] | 0.36 | L |
| Relative testes weight (g/100 g BW) | 4.24 | 4.22 | 4.34 | 4.41 | 0.35 | - |
| Relative abdominal fat weight (g/100g BW) | 1.20[a] | 1.04[ab] | 0.72[ab] | 0.55[b] | 0.43 | L |
| Relative comb weight (g/100 g BW) | 1.01 | 1.04 | 1.05 | 1.00 | 0.31 | - |
| Relative breast weight (g/100 g BW) | 6.81 | 6.71 | 6.91 | 6.80 | 0.37 | - |
| Relative thigh weight (g/100 g BW) | 10.37 | 10.25 | 10.51 | 10.06 | 0.50 | - |

* L indicates that the linear effect of treatment is significant ($p<0.05$). NS: not significant ($p>0.05$).

[a, b] Means in the same row with different superscript are significantly different ($p<0.05$).

## RESULTS AND DISCUSSION

### Appearance and growth performance

Table 3 presents the DFWP effects on the growth performance of chickens. During 0 to 4 weeks of age, the body weight and weight gain decreased while the feed intake and FCR increased linearly with increasing inclusion levels of DFWP ($p<0.05$). During 4 to 8 weeks of age, the weight gain of the birds at the 5% inclusion group was higher than that obtained for the control ($p<0.05$). During 8 to 16 weeks of age, the feed intake and FCR increased linearly with increasing level of inclusion of the test ingredients ($p<0.05$). No unusual appearances were found in the feathers, excreta and comb.

Because of standardization, the DFWP composition showed limited variability (Table 1). Furthermore, the dioxin, organic chloride, agrochemical and heavy metal concentrations in DFWP were analyzed and conformed to FDA regulations. The diets were adjusted to be iso-caloric and iso-nitrogenous, and each amino acid content accorded with the nutritional requirement. Because DFWP contains higher crude fiber (10.8%) and gastro-intestinal tract function and development were not completely developed during 0 to 4 weeks of age, the lower digestion and absorption efficiency resulted in a linear decline in growth rate ($p<0.05$) with increasing inclusion levels. During 4 to 8 weeks of age, however, the gastro-intestinal tract function of the chickens is suspected to have developed more potential to digest and absorb the crude fiber partially. Compensatory growth is also suspected at this later phase of growth since the growth performance was inhibited during 0 to 4 weeks but subsequently the initially lower body weight was elevated to a level comparable ($p>0.05$) to the control group. Weight gain in the 5% DFWP group was higher than that for the control indicating that DFWP could make up at least 20% of the diet.

During 8 to 16 weeks of age, the feed intake and FCR increased ($p<0.05$) with the increasing DFWP inclusion, however, the weight gains were comparable. The increased feed intake could be attributed to higher fiber content of the diet. The inclusion of wheat bran (a fibrous feedstuff) to adjust this diet to be iso-caloric and iso-nitrogenous with the others may be a factor to consider. It is worthy of note that the crude fiber content of this diet, which was higher than for the other diets, lowered bulk density. Consequently, more feed was required to sustain their nutrient requirements yet, similar weight gains occurred among the groups ($p>0.05$), hence FCR increased linearly with the increase in inclusion ($p<0.05$). The same results were found in pigs fed more dehydrated food wastes, resulting in lowered feed efficiency during the finishing period because of higher amount of crude fiber (Chae et al., 2000; Myer et al., 1999). In this trial, it is important to note that the fresh food waste contained 51.2% fruit and vegetables on average. Hence, the dehydrated food waste was expected to contain higher crude fiber. Above all, the use of DFWP as a feedstuff in chicken diets needs to be limited.

### Carcass traits

Table 4 presents the DFWP effects on some carcass

**Table 5.** Effects of DFWP on meat quality, composition and panel test in chickens

| Item | 0% | 5% | 10% | 20% | SEM | Orthogonal comparison |
|---|---|---|---|---|---|---|
| Meat quality | | | | | | |
| pH value | 6.18 | 6.20 | 6.19 | 6.25 | 0.14 | - |
| Shear value (kg/cm)[2] | 1.47 | 1.31 | 1.41 | 1.40 | 0.10 | - |
| Cooking loss (%) | 24.76 | 25.64 | 25.48 | 24.59 | 0.51 | - |
| L value | 48.67 | 49.18 | 48.55 | 48.69 | 0.34 | - |
| a value | 4.68 | 4.49 | 4.23 | 4.86 | 0.24 | - |
| b value | 12.64 | 12.92 | 12.27 | 12.57 | 0.22 | - |
| Meat composition | | | | | | |
| Moisture | 74.27 | 74.32 | 74.22 | 74.34 | 0.16 | - |
| Ash | 1.24 | 1.25 | 1.26 | 1.24 | 0.05 | - |
| Crude protein | 26.06 | 25.95 | 26.06 | 26.21 | 0.15 | - |
| Crude fat | 1.06 | 1.07 | 1.07 | 1.07 | 0.03 | - |
| Panel score test[1] | | | | | | |
| Flavor | 4.50 | 4.21 | 4.03 | 4.03 | 0.18 | - |
| Color | 4.16 | 4.13 | 4.16 | 4.16 | 0.16 | - |
| Juiciness | 4.29 | 3.76 | 3.63 | 3.63 | 0.20 | - |
| Texture | 4.45 | 4.05 | 3.87 | 3.87 | 0.20 | - |
| Tenderness | 4.39 | 3.89 | 3.79 | 3.79 | 0.20 | - |
| Acceptability | 4.76 | 4.45 | 4.37 | 4.37 | 0.18 | - |

[1] Scores of 1 to 7; 1 = dislike extremely, 7 = like extremely.

**Table 6.** Effects of DFWP on clinical blood chemistry in chickens

| Item | 0% | 5% | 10% | 20% | SEM | Orthogonal comparison* |
|---|---|---|---|---|---|---|
| AST (U/L) | $233^{bc}$ | $221^{c}$ | $268^{ab}$ | $288^{a}$ | 1.54 | L |
| LDH (U/L) | 1,372 | 1,289 | 1,259 | 1,373 | 15.02 | - |
| CK (U/L) | $639^{ab}$ | $543^{b}$ | $659^{ab}$ | $719^{a}$ | 10.97 | NS |
| GGT (U/L) | $61^{b}$ | $64^{b}$ | $62^{b}$ | $75^{a}$ | 0.81 | L |

* L indicates that the linear effect of treatment is significant (p<0.05). NS: not significant (p>0.05).

[a, b, c] Means in the same row with different superscript are significantly different (p<0.05).

traits in the experimental chickens. DFWP inclusion showed no significant effect (p>0.05) on the dressing percentage, carcass weight and relative weights of the liver, heart, comb, abdominal fat, breast, thigh and intestine when compared to the control. However, with increasing inclusion, the relative abdominal fat weight linearly decreased (p<0.05) and was accompanied by a linear increase (p<0.05) in the relative proventriculus and gizzard weights.

Elevated crude fiber content has been reported to decrease fat absorption and retention in poultry (Janssen and Carr'e, 1989; Longstaff and Mc Nab, 1991) and enhance the development of the proventriculus and gizzard in pullets (Scheideler et al., 1998). Compared with the other treatment groups in this trial, there was a higher crude fiber content in the 20% group which also showed the highest relative proventriculus & gizzard weights (p<0.05).

**Meat quality**

Table 5 shows the effects of DFWP on meat quality, composition and sensory score in chickens. DFWP inclusion showed no effect (p>0.05) on pH and shear values, cooking loss and color (L, a and b values) as compared to the control group. Also no effect was observed in the meat composition as shown by the comparable moisture, ash, crude protein and crude fat contents among the groups. The result of the sensory evaluation scores of the breast muscle showed that the dietary inclusion of DFWP had no significant (p>0.05) effects on flavor, color, juiciness, texture, tenderness and acceptability of the meat.

When DFWP is added to chicken diets, the first priority for the consumer is food safety, followed by chicken quality. In this trial therefore, it was observed that the dioxin, organic chloride, agrochemical and heavy metal concentrations in the chicken meat agreed with FDA regulations (2004). The meat quality, composition and sensory test scores for the DFWP inclusion groups showed no differences from the control (p>0.05). These results thus show that DFWP inclusion, even at 20%, had no unfavorable effects on chicken quality.

**Clinical blood chemistry**

Table 6 presents the DFWP effects on the clinical blood chemistry in chickens. Serum AST and GGT activities linearly increased (p<0.05) with the increase in DFWP inclusion. These were significantly higher in the 20% group

**Table 7.** Effects of DFWP on coefficient of nutrient digestibility in chickens

| Item | 0% | 5% | 10% | 20% | SEM | Orthogonal* comparison |
|---|---|---|---|---|---|---|
| Dry matter | 93.51 | 92.50 | 93.37 | 93.19 | 0.34 | - |
| Ash | 53.29 | 53.59 | 53.48 | 52.64 | 0.38 | - |
| Crude protein | $68.60^{b}$ | $68.52^{b}$ | $70.23^{ab}$ | $72.08^{a}$ | 0.50 | L |
| Crude fat | 83.67 | 83.75 | 83.59 | 83.20 | 0.33 | - |
| Gross energy | $87.11^{a}$ | $86.79^{b}$ | $86.59^{bc}$ | $86.42^{c}$ | 0.19 | L |

* L indicates that the linear effect of treatment is significant ($p<0.05$).

[a, b, c] Means in the same row with different superscript are significantly different ($p<0.05$).

than in the control ($p<0.05$).

The clinical enzyme level is often regarded as an indicator in disease diagnosis. AST and LDH are distributed mainly in the heart, liver, kidney and brain of chickens, whereas GGT is the specific enzyme of chicken kidney. CK is the specific enzyme of muscle. The increase in blood CK or GGT concentration is indicative of damaged muscle and kidney. If GGT and CK concentrations are within the normal range, an increase in AST and LDH is indicative of liver damage (Wang, 1992). In this trial, LDH activity was not elevated, while the AST and GGT activities of the 20% group were significantly higher than those in the control. This suggests that the kidney tissue might be damaged. The dioxin, organic chloride, agrochemical and heavy metal concentrations in the DFWP agreed with FDA regulations (2004), while the other adverse factors in DFWP need further determination to understand the effects on kidney function.

**Nutrient digestibility**

Table 7 shows the effects of DFWP on the coefficient of nutrient digestibility in chickens. A linear increase in the crude protein digestibility and a decrease in gross energy digestibility ($p<0.05$) were observed with increasing inclusion level of DFWP. The digestibilities of both nutrients at the 20% inclusion levels were significantly different from the control group ($p<0.05$).

The higher protein digestibility obtained at this treatment level has also been observed in an earlier study on growing pigs given food wastes (Westendorf et al., 1998; Chae et al., 2000). The dry matter, crude fat and neutral detergent fiber digestibilities reported by Farhat et al. (1998) for Peking and Muscovy ducks fed food waste were not significantly different from those fed a corn diet. However, nitrogen retention was higher because of improved crude protein digestibility, similarly to the results obtained in this trial. The relatively higher crude fiber content of the test ingredient, resulting in increasing crude fiber content of the diet as DFWP level increased, is suspected to have decreased the energy digestibility similarly to previous findings in chickens and geese (Mraz et al., 1956; Su et al., 1996). The lower abdominal fat weight resulting from the highest DFWP inclusion implied a similar response to crude fibre content.

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