DEHYDRATED POULTRY WASTE: INFLUENCE ON BROILER GROWTH, FLAVOR, AND COMPOSITION

by

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INTRODUCTION

The world's demand for food, especially high quality protein, is increasing at an astounding rate. To help meet this increasing demand and to improve efficiency, today's poultry producer is handling a larger number of birds with greater unit density. A poultry unit may handle over one million birds, far larger than a typical unit of 500 a few years ago.

With more intensive production comes the problem of disposal or utilization of the droppings. A flock of 100,000 layers produces over 12 tons of manure daily; 4,380 tons per year. The annual U.S. poultry waste output totals over 50 million tons. Disposal of poultry manure has been one of the most inefficient and costly operations in the production of poultry.

Alternatives for utilizing this waste product include sanitary landfill, fuel production, fertilizer, poultry litter, fuel briquettes, livestock feed, and poultry feed ingredient. Recycling poultry waste after proper processing has been advocated for two reasons. It is a useful source of nutrients, especially needed with a feedstuffs shortage. Also recycling would help to reduce pollution problems.

In using a new feed ingredient, such as dehydrated poultry waste (DPW), we need to be concerned about certain possible problems that may arise, including changes in the physiological state of the bird, decreased growth, poor feed efficiency, flavor changes in the flesh, or changes in carcass composition and quality. Therefore, the purpose

of this study was to investigate the influence of feeding DPW to broilers on:

1. The resulting flavor of the flesh.
2. Growth and feed efficiency.
3. Certain parameters of dark meat composition and quality.

REVIEW OF LITERATURE

Poultry Waste Composition

Fresh poultry excreta contain approximately 75% water (Bressler, 1969). To incorporate it in feed requires drying and processing to lower the water content to 10-15% and to kill pathogenic organisms present in the feces. This may be accomplished by use of any of a number of commercial dryers (Anon., 1971).

After processing, the product is an entirely new feed ingredient. Names suggested for the product include dehydrated poultry waste (DPW), dried poultry excreta, dried poultry feces, dried poultry manure, dried poultry fertilizer, dried poultry litter, dried poultry droppings, dried poultry byproduct, recycled nutrients (Zindel, 1971b), poultry anaphage (Zindel, 1974), and toasted protein (Anon., 1971).

The composition of DPW varies with its age before drying; fresh moisture content; method of storage; kind, age and physiological status of the birds; composition of ration fed; feed spillage; environmental temperature; drying temperature; and speed of drying (Perkins and Parker, 1971). Table A-1 (Appendix) lists composition values determined by Blair (1973), Shannon et al. (1973), Zindel (1974), Price (1972), and Biely et al. (1972). These analyses show a high content of crude protein (N X 6.25). True protein accounts for one-third of the nitrogen; non-protein nitrogen (mainly uric acid) accounts for the remaining two-thirds. Except for tryptophan, the the amino acid composition of the protein is similar to that of barley.

The material has a high ash content with calcium and phosphorus being the predominant minerals (Blair, 1973).

Young and Nesheim (1972) list these nutrients as being economically important: amino acids, metabolizable energy, calcium, phosphorus, trace minerals, and B-complex vitamins. Because most vitamins and minerals can be included in premixes at a low cost, the metabolizable energy content (ME) of the poultry waste is the best measure of its value as a feed ingredient. ME estimates vary from 431 Kcal./kg. (Young and Nesheim, 1972) to 2050 Kcal./kg. (Biely et al., 1972).

Polin et al. (1971) used White Leghorn hens to determine the ME of DPW. He calculated values of 1290 and 1400 Kcal./kg., depending on the mathematical approach used to evaluate the data. As a result of this ME analysis, Polin et al. (1971) noted that the DPW nutrient profile was quite similar to other fibrous feedstuffs, including bran and alfalfa meal.

Recently the Association of American Feed Control Officials Inc. defined DPW as follows: "Dried Poultry Waste (D.P.W.) is a product composed of freshly collected feces from commercial laying or broiler flocks not receiving medicants. It shall be thermally dehydrated to a moisture content of not more than 15%. It shall not contain any substances at harmful levels. It shall be free of extraneous materials such as wire, glass, nails, etc. The product shall be labeled to show the minimum percent protein, minimum percent fat and maximum percent fiber. It may be used as an ingredient in sheep, lamb, beef and dairy cattle, broiler and layer chick feeds. Broiler and laying rations shall be limited to 20%

and 25% DPW, respectively." (Anon., 1974).

Poultry Waste as a Feed Ingredient

In most early work, poultry waste was utilized to provide an unknown growth factor (UGF). Rubin et al. (1946) supplemented a basal ration with 5% dried hen feces. Their results showed that the UGF was present in both hen feces and cow manure. Rubin postulated that synthesis of the growth factor occurred in the hen after ingestion of the feed.

Elam et al. (1954) added an autoclaved water suspension of poultry litter to a corn-soybean basal diet supplemented with the then recommended levels of the necessary vitamins and minerals. Growth was increased by addition of the litter preparation or fish solubles. The UGF response from feeding poultry waste has also been confirmed by Palafox and Rosenberg (1951) and Wehunt et al. (1960).

When chicks were fed fresh hen feces, Warden and Schaible (1961) observed a significant growth depression. When the fecal material was oven dried at 100° C for 72 hours or autoclaved at 15 pounds pressure for 30 minutes, no growth depression occurred. Antibiotics also alleviated the growth depression. Yates and Schaible (1961) also found that fresh feces depressed growth, except in those groups which received high levels of antibiotics.

Flegal and Zindel (1970c) fed DPW at levels of 0, 5, 10, 15, and 20% to White Leghorn chicks and broiler chicks to four weeks of age. The mean body weight of the Leghorn chicks was not influenced by 20% dietary DPW. Levels of 10 and 20% reduced the broiler mean body weight. Feed efficiency was inversely related

to the level of DPW in the diet. Biely et al. (1972) also noted reduced growth rate and poorer feed efficiency with higher DPW levels fed to Leghorn chicks. Feed conversion ratios obtained with the respective levels were 0% - 2.46, 5% - 2.61, 10% - 2.75, 15% - 2.92.

Tietz (1971) reported work by Calvert where manure processed by fly larvae was compared to soybean meal as a feed ingredient. At the 22% level, manure did not support optimum growth of baby chicks. Teotia and Miller (1970) ground fly pupae (which had grown in poultry waste) and noted no loss in feed conversion or growth rate when the pupae served as the only protein supplement for chicks.

Biely et al. (1972) and Rinehart et al. (1973) evaluated the performance of broilers fed DPW to 8 weeks. Feeding DPW levels of 0, 5, 10, 15, and 20%; Biely and coworkers noticed that growth was depressed by 6.7% and feed efficiency by 25.4% at the 20% level. They indicated that DPW had a definite value as a broiler feed ingredient. Rinehart and others (1973), however, concluded that DPW had no value for young broilers. Their results showed a linear increase in feed consumption, an increase in fecal volume, and a depression of feed conversion as the level of DPW increased from 0 to 5, 10, 15, and 20%.

More emphasis has been placed on feeding DPW to layers than to broilers or baby chicks. Flegal and Zindel (1969 and 1970a) reported on utilization of DPW by laying hens. Mature pullets were fed rations containing 0, 10, 20, and 40% DPW. Inclusion of that material in the diet caused no significant differences in egg production, shell thickness or egg weights. Eggs from experimental groups exhibited better quality as measured by Haugh units.

Quisenberry and Bradley (1969) fed 3 types of accumulated litter (pullet, broiler, and laying hen) at levels of 10 and 20% to laying hens for 12 months. Performance on all diets was satisfactory. Egg production, feed efficiency, and egg weight from the DPW groups were equal or superior to the control.

In English feeding trials, DPW was included in the ration at a 10% level for caged layers. After 13 months, no significant differences were detected in egg yield, mortality or egg grade. The experimental flock had slightly better feed conversion than the control (Tietz, 1971 and Anon., 1971).

Flegal and Dorn (1971) continually recycled DPW at levels of 12.5% and 25% in White Leghorn layers. DPW was added initially to the feed and fed to the birds for 12 days. Waste accumulated in 12 days was dehydrated and fed back to the birds at the same levels. After the DPW was recycled through the diet 35 times, Zindel (1973) reported no significant differences in livability, feed conversion, or egg production. Proximate analyses revealed no buildup of crude fiber. Varghese and Flegal (1972) stated that levels of arsenic, mercury, copper, and zinc were not altered in the tissues, eggs, or feces by recycling DPW. Sloneker (Anon., 1973c) contended that the fiber was digested by the action of heat and enzymes. Increased enzyme activity may have occurred during accumulation of waste under the cages or in the chicken gut.

The results of Young and Nesheim (1972) and Scott (1973) were not so encouraging. When DPW was substituted for corn at a 22.5% level, production dropped and feed efficiency was depressed. Laying hens in-increased feed intake to achieve a constant metabolizable energy intake

around 300 kcal. ME per day. Fecal dry matter production increased from 5.8 to 9 pounds per 100 hens.

Because only 30% of the dry matter in DPW is digested, there is a limit to the level that laying hens can utilize without affecting nutrient intake and subsequent production. Blair (1973) recommended a maximum level of 20%, which would leave two-thirds of the manure to be removed by conventional means. Couch (1974) and Young and Nesheim (1972) agreed that only 20 to 25% of the feces could be handled by recycling. In trying to recycle all waste production, Ousterhout and Presser (1971) noted that the hen's fecal production increased rapidly while egg production dropped. Ousterhout recommended a maximum level of 25% dietary DPW.

Turkeys can also utilize some DPW. Fadika et al. (1973) incorporated DPW in turkey feed at levels of 0, 5, 10, and 30%; formulating the rations to be isocaloric with equivalent protein levels. Body weight gain was not significantly affected to 17 weeks of age. Zindel (1974) added that livability was not affected. Fadika (1973) pointed out that plasma uric acid levels were not altered but the plasma phosphorus level was raised in birds fed 30% DPW.

Poultry, having a monogastric digestive system, cannot utilize uric acid in poultry waste (Blair, 1972). Polin et al. (1971) observed that only 34% of the total nitrogen in DPW was used as a protein source by laying hens. Thus, Ostrander (1972) recommended that it be used for ruminants rather than poultry. Many writers have discussed feeding poultry waste to livestock (Miner, 1971; Long et al., 1969; Durham et al., 1966; Brown, 1967; and Anon., 1973b; Zindel, 1971). Catfish can also thrive on DPW (Anon., 1973a).

Poultry Flavor

In defining flavor, Kazeniac (1961) divided flavor into four groups along the lines proposed by Sjöstrom, an earlier flavor researcher. Those were taste (sweetness, sourness, saltiness, and bitterness), aroma (sensations perceptible by the nose), texture (body), and mouth satisfaction.

Poultry meat flavor is made up of a complex blend of different components. Certain substances in poultry originate upon heating and blend with other compounds already present, many of which are present in trace amounts and are quite labile (Kazeniac, 1961). Meat or muscle is the best source of chicken flavor (Lineweaver and Pippen, 1961). Although fat contributes to the aroma of chicken broth, Pippen et al. (1954) conceded that it did not have much effect on flavor. Chicken meat was found to be a better source of flavor than bones, skin, adipose tissue, or a mixture of the four.

Chemical analysis of poultry flavor has been investigated by many researchers. Components of chicken flavor have been identified by Bouthilet (1951), Kazeniac (1961), Lineweaver and Pippen (1961), Pippen and Nonaka (1963), Pippen (1967), Pippen et al. (1969), and others.

Flavor of broiler meat is affected by many factors, both antemortem and postmortem. Dawson and Bouwkamp (1969) reviewed the effect on poultry flavor of diet, breed, sex (males often more flavorful), age (more intense flavor in older birds), type of meat (dark usually more flavorful), grade, disease, hormones, enzymes, chilling method, freezing rate, storage conditions, packing, precooking, pH, bacterial load, and composition.

Effect of Diet on Flavor

The importance of feed as a factor influencing palatability of poultry has been pointed out by Kahlenberg et al. (1961), Dawson and Bouwkamp (1969), and others. Considerable work has been reported on the effect of feed ingredients in the production of off-flavor in poultry.

Fishy flavor has long been attributed to poultry rations. Carrick and Hauge (1926) were the first to attribute fishy and other off-flavors in broiler meat to fish oil. Birds fed over 2% cod liver oil developed unusual or serious fishy flavor in the meat. Two weeks on a cod liver oil-free ration were required for the undesirable flavor to disappear.

Cruickshank (1939) also noted the effect of cod liver oil and fish meal on flavor of poultry products, High grade fish meal caused no detrimental effect on flavor in fresh or stored meat. However, a diet containing 15% low grade fish meal plus 2% cod liver oil produced a fishy flavor noted only in the dark meat. Turkeys fed 25% high grade fish meal did not produce off-flavor when the birds were properly handled (Asmundson et al., 1938). An additional 2 or 5% sardine oil caused definite off-flavors. Fishy flavor has also been confirmed in laying hens and eggs (Holdas and May, 1966).

The type of fish meal affects the maximum level tolerated with no flavor defects. Menhaden fish meal imparted a stronger fishy flavor than white fish meal (Murphy et al, 1939). Fishy and other off-flavors have been produced with as low as 5% menhaden fish meal supplemented with 1 or 2% fish oil (Carlson et al., 1957).

Special processing of the fish products does not alleviate the

flavor problem. Leong et al. (1964) attempted to refine fish oil to contain less of the factor(s) responsible for off-flavor. Treatments included bleaching, distillation, ethylation and fractionation. All samples at a 5% level imparted varying degrees of off-flavor to the cooked birds. Marble et al. (1938) noted that vacuum-dried white fish meal still produced off-flavor at a 10% level.

Hardin et al. (1964) suggested that factors producing off-flavor in fish meal were associated with the oil, not the meal itself. Fry et al. (1965) replaced fish meal for soybean meal protein at levels as high as 100% without causing any flavor differences. Rojas et al. (1969) recommended that levels of fish oils not exceed 1 to 1.5%. Most workers agree that 2% fish oil in feed will produce off-flavor meat. Fish oil added as such may present more flavor problems than a like amount of oil added as a part of fish meal (Fry et al., 1965).

Fishy flavors can also be caused by feed ingredients other than fish products. Klose et al. (1951) demonstrated that highly unsaturated oils such as the drying oil of linseed can cause fishiness. Feeds high in tannin such as milo or rapeseed may impart fishy flavor in broilers (Peterson, 1970). A diet containing 1% tannin caused a fish flavor even when the diet did not contain any fish products. The fishy flavor was due to the chemical characteristics of the oil (Lineweaver, 1970). Unsaturated fatty acids from the oil undergo autoxidation much more readily than saturated fatty acids.

Fishy flavors are stronger in dark meat than white meat (Marble et al., 1938 and Cruickshank, 1939). Leong et al. (1964) detected off-flavor mainly in the skin, under the skin and next to the bones.

As a result of feeding teimethylamine to broilers, Halloran (1972)

suggested the possible importance of ammonia and amines in producing off-flavors. He implied that such components from the feces in litter should be considered as a factor in off-flavors.

Certain feed ingredients may enhance the flavor of broiler meat. Weisberg (1956) reported that 1.5 to 2% dry milk solids in broiler diets improved the acceptability of the meat. According to Maw (1939), corn, wheat, oats, and barley imparted characteristic flavors to poultry. His work (Maw, 1935) showed that corn-fed birds possessed the best flavor and texture of the four cereals used, followed in order by barley, oats and wheat. Odland et al. (1955) observed that broilers fed rations containing simple grain combinations of wheat, oats, or barley were equal or superior to those fed more complex grain combinations. In a study on the effect of corn, wheat, and barley on flavor of fried and roasted chicken, Poley et al. (1940b) obtained no significant flavor differences. Dark meat from corn-fed birds scored slightly higher than dark meat from birds fed wheat or barley. North (1941), however, found no cereal grain that produced superior flavor in turkeys. Recently Lineweaver (1970) asserted that the kind of grain or protein concentrate does not have any important effect on flavor.

Titus and Fritz (1971) cited work asserting that adding 2 to 4% corn oil to the finishing diet enhances the flavor, and that peanut oil produces a flavor described as "sweet". Leong et al. (1958) compared the flavor of birds fed 26% white grease to those fed no fat. From taste panel evaluations, he concluded that fat level does not affect the flavor of either dark or white meat.

Panelists from a consumer panel and a trained panel could detect no flavor differences in broilers fed 2% tallow.

To compare the flavor of modern and old type chickens, Hanson et al. (1959) used two strains of broilers, one bred for rapid growth that received a high efficiency ration, and the other not selected for rapid growth that received a low efficiency ration. After the birds were cooked by 4 methods, they concluded that the modern bird had as much flavor as the old style bird. Goertz et al. (1955) studied various factors in turkeys fed high-density and low-density rations. The high-density ration slightly improved the acceptability of roasted turkey and braised turkey steaks.

Lewis et al. (1956b) observed that the flavor of broilers fed a standard diet of natural ingredients was preferred to that of birds fed a synthetic purified diet. Higher scores for intensity of flavor and aroma were obtained from the broth of naturally-fed birds. The results of Kahlenberg et al. (1961) differ somewhat. Trained taste panelists indicated no consistent preference for naturally-fed broilers over those receiving a semi-synthetic ration.

An off-flavor or changed flavor can occur in the cooked meat of poultry kept uneviscerated after slaughter. That flavor has been described as gamey, gutty, or visceral (Pippen, 1967). Although eviscerated poultry decomposed more rapidly, Nickerson and Fitzgerald (1939) discovered that undrawn poultry became off-flavored first. The off-flavors were first noticeable in the vent and kidney regions. Fitzgerald and Nickerson (1939) believed that enzymes or decomposition products effused through the intestine. Baker et al. (1956) agreed that flavoring compounds were carried to the muscle. This may help

explain the "green struck" phenomenon in univescerated birds noted by Nickerson and Fitzgerald (1939). Hydrogen sulfide diffuses through the gut wall; when it reaches the muscle and reacts with the heme pigments, green sulfmyoglobin is formed in the presence of air (Barnes and Shrimpton, 1957).

Shrimpton (1966) speculated that the gamey flavor which develops in uneviscerated birds was caused by microbological activity in the intestine and subsequent diffusion of the metabolites to the muscles. In earlier experiments, Shrimpton and Grey (1965) indicated that flavor components were transferred from the gut to the muscle of poultry. Using vapor phase chromatography, Grey and Shrimpton (1967) characterized 23 volatile flavor components of breast meat. Of these, 16 were found in the ceca of cannulated birds. When those birds were held uneviscerated after death at 15°C, the amounts of those substances increased in the breast muscle. Gamey flavor accompanied a high level of those compounds.

The metabolic activity of the intestinal flora can be influenced by the diet of the host animal. Shrimpton (1966) found that dietary changes resulted in changes in the hydrogen sulfide production of the intestine. If Shrimpton's hypothesis is true, that some chicken flavor components are of microbiological origin and synthesized by the intestinal flora, then the flavor would be influenced by the diet through the mediation of the intestional microflora. The work of Harris et al. (1968) supported Shrimpton's hypothesis. Their study indicated that certain flavor components, metabolites of intestinal bacteria, can be absorbed and carried to the muscle while the bird is alive. Chickens reared under germ-free, gnotobiotic, or conven-

tional conditions were compared for flavor utilizing the the triangle testing technique. Experienced panelists evaluated the dark and light meat separately. Results indicated a highly significant difference between flavor of germfree and conventional chicken meat. Conventionally-reared chickens had a stronger and more characteristic chicken flavor. Longsdale et al. (1969) disagreed somewhat with Harris's results. They found germfree birds to be slightly more flavorful than conventional birds. Harris et al. (1970) attempted to detect differences in flavor components from germfree and conventionally-reared birds using gas-liquid chromatography. No significant differences were found.

Little work has been reported on the effect of DPW on broiler flavor. In his work with natural and synthetic basal rations, Lewis (1955) added 10% feces to both rations as two of the treatments. His palatability panel gave highest preference scores to the birds fed the natural basal ration plus 10% feces. Because birds fed the synthetic basal ration plus 10% feces ranked low in preference scores, Lewis maintained that the addition of feces alone was not the only contributing factor.

To test for flavor carryover from dietary DPW, Quisenberry and Bradley (1969) conducted a triangular taste test to compare eggs from 4 treatments. Significant flavor differences were noted between the control group and the pullet litter and broiler litter groups. That difference was based on only 12 invididual responses. Other workers have not found any taste differences. Eggs from layers fed 0 and 30% DPW were boiled and presented to a consumer preference panel. The members did not consistently detect a difference between the control

eggs and the DPW eggs (Zindel, 1972b and Flegal et al., 1970).

Effect of Diet on Composition

Most carcass composition research has centered around the type, amount, and distribution of fat in poultry. Harshaw (1939) pointed out that fat helps determine the quality of the dressed carcass. The finish of a bird is determined by the amount of external (or subcutaneous) fat but ultimate consumer quality depends on the degree of fat laid down in the muscle tissue (Maw, 1935).

Maw (1935) studied the effect of cereals in the finishing of chickens. He analyzed cockerels fattened 21 days on mixtures of one individual cereal with beef meal and dried milk. Birds fed the corn diet were fattest, followed in order by those fed wheat, barley, and oats diets. North (1941) and Poley et al. (1940a) obtained results that agreed with Maw rating corn as a fat-producing cereal.

Fraps (1943) observed that by adjusting dietary constituents, it was possible to produce chickens with widely varying amounts of fat. If the fat content required to produce chickens of optimum quality were known, it would be possible to produce such chickens by proper adjustment of the diet. Donaldson et al. (1956) compared diets with different calorie-protein ratios. An increased calorie-protein ratio resulted in an increase in body fat and a corresponding general decrease in body moisture. Protein levels remained relatively constant. Marion and Woodroof (1966) also pointed out that carcass lipid levels were inversely related to moisture levels.

Maw (1935) concluded that feeding different cereal grains resulted in a differential deposition of fat in the edible portions of the birds. The corn diet produced a greater relative amount of

fat in the flesh of the legs and breast than the other diets. The wheat diet, on the other hand, produced more subcutaneous and abdominal fat. Lewis et al. (1956a) observed the same trend - a large amount of external fat was usually accompanied by less ether extract deposited in the muscles, especially when corn was a major ingredient in the diet. The results from Harshaw (1939) do not support that pattern. The cereals in his study showed no tendency to cause a difference in the fat distribution between edible portions. Fat in the breast and leg muscles accounted for about 29% of total carcass fat. Dansky and Hill (1952) revealed that fat content of bone, leg muscle, gizzard and skin of broilers varied directly with fat content of the entire carcass. Birds fed a high energy ration deposited more fat than those fed a low energy ration, although growth rates were similar.

Essay and Dawson (1965) demonstrated that changes in fat deposition in the chicken were primarily in skin and adipose tissue with lesser changes in the muscle tissue. Harshaw (1936), Lewis et al. (1956a), and Dansky and Hill (1952) found more fat in dark meat than light meat. Dark meat varied much more in fat content than white meat.

MATERIALS AND METHODS

Day-old Hubbard meat-strain broiler cockerels were individually wingbanded and randomly assigned to 12 lots of 10 chicks each. They were reared in Petersime electrically heated, thermostatically controlled battery brooders with raised wire floor, in a temperature controlled and ventilated room. At 32 days of age they were transferred to unheated growing batteries until the end of the feeding period. Feed and tap water were supplied ad libitum.

Individual chicks weighed at 1, 7, 14, 31, 44 and 61 days of age. Mortalities were recorded.

Dehydrated poultry waste was included in four diets at levels of 0, 9.6, 19.1, and 38.2%. Formulae for the four rations are given in Table 1. All diets were calculated to be approximately isocaloric and isoproteinaceous using nutrient composition values given by Titus and Fritz (1971). Adequate amounts of all nutrients known to be required by the chick were included in each ration.

Fresh feces without added litter were collected from broilers in battery cages and allowed to dry partially at room temperature; then dried in a gravity convection oven at 120^{o} C for 8 to 12 hours, depending on their initial moisture content. The dried poultry waste was ground in a hammermill grinder and incorporated with the other feed ingredients at the K.S.U. Department of Grain Science and Industry.

The broilers were processed at 61 days of age in the K.S.U. poultry processing laboratory, and allowed to chill overnight under

Table 1

Composition of Broiler Rations

Ingredients	Treatment A	B	C	D
	Level DPW, %			
	0	9.6	19.1	38.2
Yellow corn (ground)	34.00	30.75	27.50	21.00
Grain sorghum (ground)30.	30.00	22.50	15.00	____
Soybean meal (44%)	24.00	23.75	23.50	23.00
Alfalfa meal (17%)	4.00	3.50	3.00	2.00
Distillers dried solubles	1.50	1.50	1.50	1.50
Fish meal (60%)	4.00	4.00	4.00	4.00
Iodized salt	0.50	0.50	0.50	0.50
Calcium carbonate	1.00	0.75	0.50	____
Dicalcium phosphate	1.00	0.75	0.50	____
Animal fat	____	2.50	5.00	10.00
Dehydrated poultry waste	____	9.56	19.12	38.25
Total	100.00	100.00	100.00	100.00

Added per 100 pounds of diet, grams

Trace mineral mix[1]	23
Vitamin A (10,000 USP units/gm.)	15
Vitamin D_3 (15,000 ICU/gm.)	8
B-complex mix[2]	30
Choline chloride, 25%	40
Coccidiostat (Amprol Plus)	23

[1]Contained 10% manganese, 10% iron, 12-14% calcium, 1% copper, 5% zinc, 0.3% iodine, and 0.1% cobalt.

[2]Contained mg. per pound: riboflavin 8,000; pantothenic acid 14,720; niacin 24,000; choline chloride 80,000.

slush ice. After draining, the carcasses were weighed, packed in polyethylene bags, sealed and held in a walk-in forced air freezer at -10°C until removed for evaluation. Eviscerated weights were used to calculate dressing percentages.

The broilers were cut medially in half while frozen. Centigrade thermometers were inserted into the midportion of the breast muscle with the aid of a cork borer. Broiler halves were cooked by the modified broiling method suggested by Hay et al. (1953). A half was placed skin side up on a wire rack 8 inches in height set in a shallow pan and cooked to an end point temperature of 88°C in a rotary gas oven maintained at 325°F (163°C). Halves were not turned during cooking because heat reached them uniformly from all sides.

To test for flavor differences between treatment A and treatment D (receiving 0% and 38.2% DPW, respectively), a triangular taste test of the type proposed by Roessler et al. (1948) and outlined by Amerine et al. (1965) was conducted. The taste panel consisted of 7 experienced panel members. All 8 tasting sessions were conducted in the Foods and Nutrition Organoleptic Laboratory. An orientation session was held to acquaint panel members with the procedures and objectives of the triangular taste test.

To prepare samples for tasting, the breast and thigh muscles were removed from the carcass and cut into half inch squares. They were kept warm in small ceramic casserole dishes set on an electric hot tray (35° ± 1°C) until evaluation. Because the thigh muscles from the broilers were relatively small, no effort was made to use single muscles for the evaluations. However, at each session, a panel member received samples of the same color and from the same respective area

of the thighs.

To eliminate possible influence attributable to the order of samples, they were assigned by lot to each position. First, panelists were given 3 samples of white meat, 2 of which were from the same bird, and asked to identify the different (or odd) sample. Panel members indicated their choice on a score card. (Figure 1). To aid in the statistical analysis as outlined by Bradley (1963), the panel was asked to indicate the degree of difference between the different samples. Panel members were instructed to rinse their mouths with water after each taste. Following a short pause, samples of dark meat were evaluated in the same manner as the white meat.

Another set of birds was used for composition analyses. Dark meat of the thigh and leg was removed from the femur, tibia and fibula after the frozen bird had thawed. Care was taken not to include any skin, subcutaneous fat, joint cartilage, or joint fat in the sample. Samples were ground three times through a Hobart grinder, placed in polyethylene bags, sealed, and frozen at -10^{o}C until time of analysis. Small core aliquots were taken from the frozen sample in the bag using a cork borer.

Meat protein (N X 6.25) was determined by macro Kjeldahl nitrogen determination (AOAC, 1970). Duplicate samples were run on dark meat. Four percent boric acid with bromocresol green indicator was used to collect the ammonia distillate.

For ether extract determination, petroleum ether was allowed to reflux through the dried sample for eight hours in a soxhlet condenser. The weight lost in the extraction was assumed to be ether extract.

Calcium and phosphorus determinations required obtaining a clean

Name_____

Date_____

Two of these samples are alike and the other is different. Please circle the number of the different sample. Also score the degree of difference between the different samples using the scale:

0 - no difference
2 - very slight difference
4 - slight difference
6 - moderate difference
8 - large difference
10 - very large difference

Meat type	Sample Number	Degree of Difference	Comments
Dark	1 2 3	_____	_____
Light	1 2 3	_____	_____
_____	1 2 3	_____	_____

Figure 1. Score Card for Triangle Taste Test

ash by placing a dried sample in a cold furnace and heating to 550°C. The ash was dissolved in 6N hydrochloric acid and warmed slightly. The solution was brought to volume with distilled water. Phosphorus determination followed that outlined by Gomorri (1953). Absorbance of the phosphomolybdate solution was read against a blank at a wave-length of 700 nm on a Gilford 240 spectrophotometer. The same ash solution was mixed with 1% strontium chloride solution for the calcium determination. A balanced flame on a Jarrell-Ash Model 82-500 Atomic Absorption Spectrometer was used to atomize the calcium in solution. Peak height on the recorder was compared to those obtained with standard calcium solutions to calculate concentrations.

Differences among treatments in meat rancidity was measured by the malonaldehyde content of the meat after 2½ months frozen storage. The 2-thiobarbituric acid (TBA) test was used (Tarladgis et al., 1960). Absorbance of the malonaldehyde-TBA complex solution was read at a wave-length of 538 nm on a Bausch & Lomb 340 Colorimeter. The reading was multiplied by 7.8 to give milligrams of malonaldehyde per 1000 grams of meat.

Data analyzed by analysis of variance included final live weights, eviscerated weight, dressing percentages, feed efficiency, protein, calcium, phosphorous, ether extract, and TBA values.

RESULTS AND DISCUSSION

The influence of different dietary levels of DPW fed to broilers on final live weight, eviscerated weight, dressing percentage, and feed conversion is shown in Table 2. Mean values for each lot are included in Table A-2 (appendix). Analysis of variance was run on those measurements (Tables A-3, A-4, A-5, and A-6). The analyses indicated that diets were significantly different for final live weight and eviscerated weight. Only the group receiving 38.2% DPW was significantly affected by the inclusion of DPW in their diet.

Analysis of feed conversion data showed that differences among diets were non-significant at the 5% level. However, the F-ratio was significant at the 10% level of probability. Feed conversion ratios indicate that the DPW used was lower in energy value than that estimated for formulating the rations (ME = 1650 Kcal./kg.). This agrees with the assertion of Rinehart et al. (1973) and Ostrander (1972) that DPW is of limited value for broilers at high levels.

Dressing percentage was not lowered significantly by the high levels of DPW. Since birds were on feed up to the time of slaughter, this may indicate that intestinal size was not significantly increased by including dietary DPW.

Sensory Panel

Results obtained from the triangle taste test are presented in Table 3. The probability of a correct guess was one-third and two-thirds for an incorrect guess. For both white and dark meat, the number of correct responses was less than one-third. A Chi-square analysis applied to those data showed no significance. Further, no significance was noted in using the complex analysis of Bradley (1963) where the

Table 2

Effect of Dietary DPW on Broiler Growth, Yield, and Feed Efficiency

	Treatment A	B	C	D
	Level DPW, % 0	9.6	19.1	38.2
Final live weight (grams)[1]	2244.7	2251.3	2197.7	2084.8
Eviscerated weight (grams)[1]	1467.0	1494.3	1427.4	1345.4
Dressing percentage	65.3	66.4	65.0	64.5
Feed efficiency[2] (Kg. feed per kg. gain)	2.34	2.30	2.44	2.61

[1]Treatments underscored with same line are not significantly different at a 5% level of probability.

[2]Feed conversion ratios underscored with same line are not significantly different at a 10% level of probability.

Table 3

Panel Responses from the Triangle Taste Test

Panel member	White meat		Dark meat	
	Total	Correct	Total	Correct
M. B.	7	2	7	3
D. S.	7	1	7	1
P. P.	6	1	6	1
U. M.	8	2	8	1
H. K.	8	4	8	1
G. L.	8	1	8	2
S. G.	8	2	8	3
Totals	52	13	52	12
Percent correct	25 ns.		23 ns.	

ns. - not significant at a 5% level of probability.

degree of difference was involved.

Since the taste panel could not correctly distinguish between meat from the group receiving 38.2% DPW and the control, further comparisons between the control and treatments B or C were unnecessary.

Panel results show that flavor changes in the meat should not present a problem when broilers are fed practical levels of DPW. Halloran (1972) suggested that certain components in the fecal material of litter may contribute to off-flavors of broiler meat. Data presented here do not support this suggestion.

In their work, Quisenberry and Bradley (1969) noted a significant effect of DPW on flavor of eggs. Their results may have differed if the number of panel responses had been greater than 12.

Dark Meat Composition Analyses

The results of the dark meat composition analyses are shown in Table 4. Analyses of variance are shown in Table A-7.

Protein varied from 19.2% in treatment D to 20.1% in treatment B. Though that difference is not statistically significant, it may seem large when considering that protein level usually remains fairly constant (Donaldson et al., 1956).

DPW is rather high in calcium and phosphorus, both of which are highly available (Blair, 1973). Those higher levels of dietary calcium and phosphorus did not affect dark meat values significantly (Table 4). In their work with turkeys, Fadika et al. (1973) noticed higher levels of plasma phorphorus in birds receiving 30% DPW. The dark meat levels obtained here do not agree with the serum levels obtained by Fadika (1973).

No consistent trend was observed in the ether extract values.

Table 4

Summary of Dark Meat Analyses

	Treatment A	B	C	D
	Level DPW, % 0	9.6	19.1	38.2
% Protein (N X 6.25)	19.3	20.1	19.6	19.2
Calcium (Mg./100gm.)	12.6	11.7	11.9	12.3
Phosphorus (Mg./100gm.)	163.6	162.0	180.5	170.6
% Ether extract	3.96	3.76	3.49	3.87
TBA value (Mg. malonaldehyde/1,000gm.)	1.41	1.26	1.44	1.27

In the work of Marion and Woodroof (1966), birds fed higher density rations had higher levels of tissue fat. Lewis et al. (1956) found that the amount of fat varied greatly in dark meat. No great variation among treatments was noticed in this study.

TBA rancidity values do not show any significant difference in quality of birds fed higher levels of DPW. Quarles et al. (1968) noted that fat levels had no effect upon the quality of broiler meat (as measured by TBA values) stored for 16 weeks.

SUMMARY AND CONCLUSIONS

The effect of feeding 4 levels (0, 9.6, 19.1, and 38.2%) of dehydrated poultry waste (DPW) to broilers was studied. Hubbard meat-strain male chicks were reared in electrically heated battery brooders to 32 days of age. They were then transferred to unheated batteries. At 61 days of age the broilers were processed, chilled overnight, and individually frozen in polyethylene bags.

Performance of the group receiving 38.2% DPW was poorest as evidenced by lowest average live weight ($p < .05$) and poorest feed conversion ($p < .10$).

Flavor differences were studied by using the triangle taste test. Analysis of the correct responses revealed that panel members could not detect accurately flavor differences between the 2 extreme treatments (those receiving 0 and 38.2% DPW).

Dark meat composition changes were studied by analysis of the dark meat for protein, ether extract, calcium, phosphorus, and TBA value. No significant ($p < .10$) differences in composition were noted among treatments.

Under the conditions of this study, dehydrated poultry waste had no noticeable effect on carcass quality, though growth was somewhat depressed at the highest level. Thus, DPW may be fed to broilers at a level below 20% without serious consequences.

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APPENDIX

Table A-1

DPW Composition as Determined by Various Workers

	Blair (1973) Average	Blair (1973) Range	Biely et al. (1972)	Shannon et al. (1973)	Price (1972)	Zindel (1974)
Moisture (%)	9.6	3.9 - 17.7	9.4 - 9.8	3.9 - 17.7	5.0	6.7
Crude Protein (%)	27.0	15.0 - 36.6	20.1 - 31.1	18.1 - 38.8	27.0	19.5
True Protein (%)	10.6	8.8 - 12.9	16.8 - 23.2	10.1 - 14.8	____	10.3
Fat (%)	1.8	0.9 - 3.0	1.6 - 2.3	_____	2.5	3.4
Fiber (%)	14.9	10.1 - 24.6	10.7 - 20.8	_____	15.0	15.6
Calcium (%)	7.4	3.8 - 12.5	3.8 - 8.3	5.1 - 15.1	10.9	6.3
Phosphorus (%)	2.1	1.7 - 2.8	1.9 - 2.0	1.9 - 3.4	2.1	2.6
Ash (%)	26.5	18.1 - 40.8	18.1 - 23.8	20.7 - 49.4	33.6	___
Metabolizable Energy (Kcal./kg.)	900	480 - 1350	1819 - 2050	640 - 1270	___	___

Table A-2

Lot Averages for Final Live Weight, Eviscerated Weight, Dressing Percentage, and Feed Efficiency

Treatment	Lot No.	Final Live Weight (grams)	Eviscerated Weight (grams)	Dressing Percentage	Feed Efficiency (Kg. Feed/Kg. Gain)
A	1	2261.3	1472.4	64.8	2.32
	2	2259.6	1490.4	66.0	2.28
	3	2213.2	1438.2	65.0	2.43
B	4	2317.2	1539.2	66.5	2.41
	5	2214.0	1480.4	66.9	2.24
	6	2222.6	1463.3	65.8	2.26
C	7	2199.5	1427.0	65.0	2.29
	8	2181.0	1400.7	64.2	2.56
	9	2212.0	1454.6	65.8	2.48
D	10	2108.5	1349.4	64.0	2.78
	11	2090.3	1340.4	64.1	2.39
	12	2055.5	1346.4	65.5	2.65

Table A-3

Analysis of Variance for Final Live Weight

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Diet	3	533,786.6	177,928.9	14.26**
Lots within Diet	8	99,845.3	12,480.7	0.50
Birds within Lot	107	2,645,889.1	24,727.9	
Total	118	3,279,521.0		

**Significant at 1% level of probability.

Table A-4

Analysis of Variance for Eviscerated Weight

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Diet	3	0.3785	0.1262	16.62**
Lots within Diet	8	0.0607	0.0076	0.71
Birds within Lot	107	1.1496	0.0107	____
Total	118	1.5888		

**Significant at 1% level of probability.

Table A-5

Analysis of Variance for Dressing Percentage

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Diet	3	0.00571	0.00190	2.76^{ns}
Lots within Diet	8	0.00550	0.00069	1.51
Birds within Lot	107	0.04857	0.00045	___
Total	118	0.05978		

^{ns}Not significant at 5% level of probability.

Table A-6

One-way Analysis of Variance for Feed Conversion

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Diet -- Treatment	3	0.1644	0.0548	2.99†
Lots within Diet	8	0.1467	0.0183	
Total	11	0.3111		

†Significant only at 10% level of probability.

Table A-7

Analyses of Variance for Dark Meat Analyses

Source of Variation	D.F.	Sum of Squares	Mean Square	F
% Protein				
Diet	3	0.7589	0.2530	0.92^{ns}
Error	4	1.0937	0.2734	___
Total	7	1.8526		
Calcium				
Diet	3	4.0085	1.3362	2.28^{ns}
Error	28	16.3987	0.5857	___
Total	31	20.4072		
Phosphorus				
Diet	3	1,716.6	572.2	1.60^{ns}
Error	28	9,987.9	356.7	___
Total	31	11,704.5		
%Ether Extract				
Diet	3	1.2033	0.4011	0.94^{ns}
Error	36	15.2871	0.4246	___
Total	39	16.4904		
TBA Value				
Diet	3	0.1029	0.0343	1.45^{ns}
Error	12	0.2831	0.0236	___
Total	15	0.3860		

^{ns}Not significant at 5% level of probability.

DEHYDRATED POULTRY WASTE: INFLUENCE ON BROILER GROWTH, FLAVOR, AND COMPOSITION

by

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The effect of feeding 4 levels (0, 9.6, 19.1, and 38.2%) of dehydrated poultry waste (DPW) to broilers was studied. Hubbard meat-strain male chicks were reared in electrically heated battery brooders to 32 days of age. They were then transferred to unheated batteries. At 61 days of age the broilers were processed, chilled overnight, and individually frozen in polyethylene bags.

Performance of the group receiving 38.2% DPW was poorest as evidenced by lowest average live weight ($p < .05$) and poorest feed conversion ($p < .10$).

Flavor differences were studied by using the triangle taste test. Analysis of the correct responses revealed that panel members could not detect accurately flavor differences between the 2 extreme treatments (those receiving 0 and 38.2% DPW).

Dark meat composition changes were studied by analysis of the dark meat for protein, ether extract, calcium, phosphorus, and TBA value. No significant ($p < .10$) differences in composition were noted among treatments.

Under the conditions of this study, dehydrated poultry waste had no noticeable effect on carcass quality, though growth was somewhat depressed at the highest level. Thus, DPW may be fed to broilers at a level below 20% without serious consequences.