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REVIEW ARTICLE

Tomato pomace as a Good source of Vitamin E in Broiler Diets

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ABSTRACT
Tomato pomace, a byproduct of tomato processing, is an excellent source of α-tocopherol (vitamin E), which is used as an antioxidant in broiler meat. In a feeding study, there were no significant differences in body weight and feed per gain in chicks given diets with or without tomato pomace. Tomato pomace could be used as a source of α-tocopherol in broiler diets to decrease lipid oxidation (fat deterioration) during heating and long-term frozen storage of dark meat, and to prolong shelf life. Because tomato byproducts contain high levels of unsaturated fatty acids, the pomace must be defatted without losing vitamin E to minimize its oxidation potential. Although we found no evidence that introducing a high-fiber feed ingredient significantly limited broiler growth, more research is needed to enhance its practical applications.
Key words: *Tomato pomace, Vitamin E, Broiler diets*

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INTRODUCTION

In Iran, farmers grew high amount of processing tomatoes which are made into juice and concentrated products such as catsup,salsa, paste, puree, soups and sauces. About 10% to 30% of the raw tomato weight becomes waste, part of which ishauled fresh to nearby cattle and dairy farms and sold for a token fee. Tomatowaste (pomace) consists of peels, cores,culls, seeds, trimmings, liquor and unprocessed green tomatoes picked by harvest machinery. The composition of tomato pomace varies according to agricultural and processingpractices, the degree of drying, moisture removal and separation of cellulose.Tomato pomace can contain upto 25% high-lysine protein and 242 parts per million (ppm) of α-tocopherol (vitaminE). Tomato pomace is recommendedfor cattle and dairy cow feed due to the ability of these animals to digest fiber. Likewise, tomato seeds are recommended as a source of protein isolate in food applications for humans [1,2]. However, the high temperatures used to process tomatoes may affect protein extractability [3]. Depending on the processing method, pomace can contain more than 31% fiber. Because high-fiber pomace (31%) is not easily digested by broilers and can dilute the available energy content of the feed, it has been used at less than 5% in the diets of these meat-type chickens. Because laying hens need less protein and are able to digest fiber, the potential use of tomato pomace in their feed is estimated as high as 15%. The levels of α-tocopherol in tomato pomace may be particularly useful in feeds for meat animals. Tocopherols, especially the alpha (α) form, help prevent lipid oxidation (deterioration of fats). They preserve the quality of heated or stored meat by reducing the end products of oxidation that cause discoloration, off odors and off flavors. Also, some byproducts of lipid oxidation may be hazardous to human health. A previous study showed that fortification of broiler diets with 150 ppmα-tocopherol per kilogram feed for3 to 6 weeks maintained 10 ppm ofα-tocopherol in postmortem meat,enough to retard lipid oxidation by upto 50% during refrigerated and frozen storage (4). Other investigators have shown that vitamin C and vitamin E improved feed conversion, layer performance and the effect of heat by terminating free-radical attacks and promoting greater thyroid activity, ultimately increasing the immune response (5,6, 7, 8). Previous research suggests that an agricultural waste product containing ample amounts of α-tocopherol could be added to feed to produce value-added meat product.

We studied tomato pomace in chicken diets to determine if α-tocopherol in the pomace would retard lipid oxidation in stored meat, and if pomace containing about 26% fiber significantly affected bird weights at 3 weeks of age. The fiber content in our experimental diet was about 10 times greater than that used for practical feeding regimens; as such, the results provide information about the possible use of tomato pomace but cannot be applied to practical situations.

FEED FORMULATION

Tomato pomace obtained from four tomato varieties commonly grown in the West Azarbayjan. Pomace obtained from a local tomato processing company, was transported to the laboratory within 24 hours after drying and stored at 44.6ºF. Immediately after each pomace batch was received, analyzed at least two samples for moisture, fat, protein, crude fiber, minerals, sterols, fatty acids and pesticides (carbaryl carbamates, organochlorines and organophosphates).Results from the initial analyses of dried pomace were incorporated into a database, which was used to formulate the control and experimental diets utilizing the Mix-it computer program to determine least-cost feed formulations. To maximize any effects of tomato pomace supplementation, a maximum amount was incorporated into test feed, resulting in unusually high fiber contents. To minimize this fiber effect, control diets were supplemented with cellulose to allow similar fiber composition across the tests. While no significant short-term effects due to high-fiber feeds have been described in the literature, such feeds are not typical in theindustry due to concerns that they may restrict growth. The control and pomace diets were formulated to meet or exceed the minimum nutrient requirements of poultry (table 1).

Table 1. Components of control and tomato pomace diets fed to broilers

	Diets	
Ingredients	**Control**	**Tomato Pomace**
Soybean meal	47.0	29.8
Dicalcium phosphate	1.5	1.5
Calcium carbonate	1.0	1.0
Fat	5.5	3.5
Mineral mix	1.0	1.0
Tomato pomace.	0	30.0
Vitamin mix	0.5	0.5
Methionine	0.3	0.3
Tryptophan	0.1	0.1
Choline chloride	0.2	0.2
Cellulose	4.4	0.0

Both diets met or exceeded minimum nutrient requirements of poultry. Tomato pomace consists of peels, cores, culls, seeds, trimmings, liquor and unprocessed green tomatoes.

Ground tomato pomace (224 ppm α-tocopherol) was added at 30% of the diet. Tomato pomace partially replaced soybean meal, cellulose and glucose and provided about 76 ppm vitamin E as a calculated value from components listed in table 1. The control diet contained about 29 ppm of vitamin E. Protein, fat (predominately from rendered chicken fat) and fiber were 22%, 8.0% and 7.0%, respectively, for both diets. The fatty acid content of both diets was determined at the beginning of each feeding trial.

Broiler feeding trials

For both feeding trials, 1-day-oldmale Arbor Acre Cross chicks were obtained from a local producer, banded and distributed randomly into groups, and placed into pens positioned in electrically heated batteries with raised wire floors. Birds were housed in a windowless room at 73.4ºF and14 hours of light per day. Feed and water were administered on demand. Weight gain was recorded twice weekly.

During the first week of the first trial, six groups of five birds were fed the control diet. For the following 2 weeks, the control or experimental diet was fed to three groups (replications) of five birds. The entire feeding trial was repeated with eight groups of six birds following the same procedure. Thirty-nine birds each (15 from the first and 24from the second trial) were fed the control or experimental diet.

Measuring lipid deterioration, expressible moisture

At the end of each trial, chicks were humanely slaughtered. Thigh meat was removed and pooled by treatment. It was frozen immediately in liquid nitrogen and stored at −185ºF. Meat from both treatments was thawed for 1 hour at 73.4ºF,then ground and analyzed immediately or after 4 days of storage (30.2ºF) for thiobarbituric acid reactive substances(TBARS) - four samples for each replication(9) - as an indicator of lipid deterioration and percent expressible moisture (%EM, three samples for each replication).Malonaldehyde, a byproduct of lipid deterioration, was extracted from meat. During heating, thiobarbituric acid was reacted with malonaldehyde to produce a solution ranging from pink to red, indicating the level of byproducts (mostly malonaldehyde) in the meat. The color was measured spectrophotometrically. Analysis for %EM measured the amount of moisture expressed from meat by centrifugal force (10). The %EM was calculated as the weight of moisture expressed divided by the original weight of meat, and is related to the quality of protein in the meat. When protein in meat is damaged due to chemical processes or lipid deterioration during storage, the meat fails to retain water. In general, the higher the %EM, the lower the overall functional (protein) quality of the meat.

Statistical analysis

Mean values were determined for each item in the initial analysis. An analysis of variance was conducted on the data for weight gain, feed efficiency, and fatty acid content of diets, TBARS and % EM. Duncan's new multiple range test was used to measure the significance of differences at $P < 0.05$.

Pomace in poultry diets

The tomato pomace used in this study contained 5.05% moisture,11.93% fat, 26.88% protein and 26.30%crude fiber. The fiber content is within the range of results reported by other investigators. The content of β−carotene and selected sterols and minerals is shown in table 2.

Table 2. Sterol and mineral contents in tomato pomace

type	**Amount (*ppm*)**
Sterols	
δ-tocopherol	913
γ-tocopherol	922
α-tocopherol	224
Brassicaster	430
Cholesterol	784
Minerals	
Cadmium	0.17
Calcium	148.84
Copper	0.83
Iron	6.62
Magnesium	289.75
Phosphorous	602.10
Potassium	610.23

Peels, cores, culls, seeds, trimmings, liquor and unprocessed green tomatoes.

Fatty acids contents were similar except that linolenic acid (C18:3) was statistically greater in the control diet(7.34 ppm) than in the tomato pomace diet (4.62 ppm)(table 3). Linolenic acid can increase lipid deterioration in feed and poultry meat.Carbamate, organochlorine and or organophosphate pesticides are known to be harmful to poultry and humans. These three pesticides were below detectable levels in the tomato pomace we tested.

Weight gain

Weight gain for birds fed the experimental diet (801 grams)was statistically similar to that of birdsfed the control (743 grams) at $P < 0.05$.Feed conversions (weight gain divided by feed consumed [grams]) of 1.6 and1.8 for the control and tomato pomace diets, respectively, were also similar at$P < 0.05$. Our results contrast with those of other investigators who reported that feeding 22.94% crude fiber (tomato seed meal) at 34% of the diet depressed growth by about 13% in 4-week-oldchicks when compared to those consuming cotton seed meals (11). However, our results are similar to those of Squires et al. (12), who showed that feeding upto 20% untreated tomato cannery waste had no significant effect on measured production parameters. Squires et al. (12) suggest that alkali treatment of pomace may improve nutrient digestibility, decreasing the potential detrimental effects of supplementation.

Table3. Fatty acid content of dried ground tomato pomace* and diets

	Diets		
Fatty acid	**Ground pomace**	**Control**	**TomatoPomace**
C14	0.13	0.15	0.11
C16	13.10	13.31	11.94
C16:1	0.34	0	0
C18	4.61	4.65	4.43
C18:1	9.47	20.45	19.18
C18:2	58.01	58.00	55.67
C18:3	2.61	7.34	4.62
C20	0.41	NA	NA
C20:4	0.15	NA	NA
C24	0.20	NA	NA

* Peels, cores, culls, seeds, trimmings, liquor and unprocessed green tomatoes.

Lipid oxidation, expressible moisture

For each storage condition, TBARS values - indicators of lipid deterioration levels - were similar for the uncooked meat of broilers fed the pomace and control diets. After4 days of refrigerated storage, the TBARS value for meat from the control (1.23) was about 23.0% higher than from the pomace diet. This trend suggests a significant antioxidative effect for α-tocopherol from tomato pomace in meat heated before or after storage (for example, a maximum of 7days at 39.2ºF to 44.6ºF or more than2 weeks at −68ºF).Investigators have shown that by products from fat deterioration associate with protein to change functional properties like %EM. Our study showed that %EM was not significantly different in meat from birds fed pomace (47.27%) and the control (51.52%).This finding seems to support the results for TBARS values. Although TBARS and %EM were statistically similar for both diets, the values for diets containing tomato pomace werealways numerically lower. In a preliminary study in which lipid oxidation was accelerated by heatand pro-oxidants, TBARS values for the meat from birds fed pomace were significantly lower (30%) than the control. These findings indicate that some combination of tomato pomace- as a useful waste product - and α-tocopherolwould be beneficial to prevent lipidoxidation in stored unheated and heated poultry meat. Ultimately, theadded value of using tomato pomace for its α-tocopherol content must be assessed relative to its fiber content.

A promising vitamin E source, when tomato pomace was fed to broilers at 30% of the diet, growth was not significantly decreased. Though not significant, the decrease in feed efficiency (0.2) that is economically restrictive may be corrected with heat treatment and by lowering the available nutrient composition of tomato pomace. Alpha-tocopherol is mainly foundin tomato seeds. Microscopic analysis showed that tomato pomace contains About 50% tomato seed. If seeds were separated and fed to growing broilers in combination with pomace (not to exceed an excessive fiber level that could significantly retard growth) more α-tocopherol could be added to diets, possibly substantially reducing lipid deterioration in heated or stored poultry meat. Additional research will determine the lowest amount of pomace and seed that could be fed to achieve the desired antioxidant effect with no decrease in weight gain.

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