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NUTRIENT COMPOSITION AND RETENTION IN WHOLE TURKEYS WITH AND WITHOUT ADDED SOLUTION

MANAGEMENT AND PRODUCTION

Nutrient composition and retention in whole turkeys with and without added solution[1]

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ABSTRACT Whole turkeys sold in retail outlets are typically processed with added solutions to improve their taste and tenderness. The purpose of this study was to evaluate the nutrient composition of whole turkeys with and without added solution, and to update the nutrient profile of turkey for the USDA National Nutrient Database for Standard Reference. Eleven pairs of turkeys with added solution were obtained from statistically representative retail outlets using a nationwide sampling plan developed for USDA's National Food and Nutrient Analysis Program; 4 pairs of turkeys without added solution were purchased from local food outlets. Turkeys were roasted to an internal temperature of 165°F (74°C). Values of selected nutrients in light and dark meat, including skin, were determined by USDA approved laboratories using quality assurance protocols. Both raw and cooked turkeys, with and without added solution, were compared by one-way and 2-way factorial ANOVA. The results showed a significant interaction for fat ($P < 0.0001$) and zinc ($P = 0.0070$) between turkeys that were raw and cooked and those prepared with or without added solution. Fat was higher in raw turkeys with added solution compared to without added solution. Similarly, sodium, phosphorus, and calcium values were significantly higher in turkeys with added solution ($P < 0.05$) than in turkeys without added solution. Data from this study will be useful for developing strategies to address sodium-related health issues, nutrition monitoring, consumption surveys, and policy development.

Key words: Turkey, added ingredients, marination, sodium, nutrients

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INTRODUCTION

Fresh pork and poultry sold in the United States, including fresh turkey, often contain a considerable amount of sodium added during meat production in a process sometimes known as "marination." By injection and/or tumbling, a solution of water, salt, potassium, phosphorus salts, antioxidants, and flavorants are dispersed into a muscle during processing (Bianchi et al., 2009). The terms "without added solution" or "natural" are sometimes used for turkey products that contain no artificial flavors, coloring ingredients, chemical preservatives, or other artificial ingredients (National Turkey Federation, 2014).

Solutions added during processing may increase water content, change the flavor profile, and improve meat tenderness and juiciness. For example, added sodium chloride improves the water and fat-binding properties of meat products, resulting in the formation of a desirable gel texture upon cooking that increases moisture retention (Bianchi et al., 2009; Ergezer and Gokce, 2011). Solutions of sodium chloride and phosphates can also inhibit the growth of bacterial microorganisms (Farr and May, 1970; Brotsky, 1976; Ergezer and Gokce, 2011). Solutions added to meat products can also mitigate the moisture loss that results from cooking, particularly now that many fresh meat and poultry products are much leaner than 30 years ago due to new animal husbandry practices. This is especially important because tenderness and juiciness of meat seem to be the most important attributes of eating quality for consumers (Ergezer and Gokce, 2011).

However, consumption of turkey containing these solutions adds to high sodium and phosphate intakes. Excessive sodium intake has been linked to an increased risk of hypertension, stroke, and premature death from cardiovascular diseases, and 90% of Americans consume more sodium than is recommended in a healthy diet (Centers for Disease Control and Prevention, 2012). The Institute of Medicine (now the National Academy

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of Medicine) established 1,500 mg of sodium per day as the adequate intake level for most Americans and advised limiting sodium intake to less than 2,300 mg per day (Institute of Medicine, 2010). Likewise, the current *Dietary Guidelines for Americans* recommend that adults consume no more than 1,500–2,300 mg of sodium daily depending on age and other characteristics (USDHHS, 2015).

Phosphate, another ingredient commonly used in solutions added to fresh meat and poultry, is also of concern (Murphy-Gutekunst and Uribarri, 2005). Phosphate intake affects phosphorus blood levels, and evidence suggests that elevated blood phosphorus levels can cause hyperphosphatemia, a disorder that leads to kidney diseases (Sherman and Mehta, 2009). Thus, the amount of phosphate added during processing of foods such as meats, eggs, and milk should be considered in assessing diets for patients with kidney disease.

The U.S. Code of Federal Regulations specify that solutions of poultry broth, poultry stock, water, or edible fats (including functional substances, such as spices, flavor enhancers, emulsifiers, phosphates, and coloring materials) may be introduced by injection into the thick muscles of poultry products (Code of Federal Regulations, 2011). The Food Safety and Inspection Service (**FSIS**) of the U.S. Department of Agriculture (**USDA**) regulates the addition of solutions to meat products, requiring manufacturers to specify on the product's label the total amount of solution or "added ingredients" introduced by injection or marinade. Manufacturers may only use the term "marinated or with added solutions" to describe a meat product when they specify the amount of solution (FSIS, 2010; USDA, 2013).

To assess the availability of whole turkeys with and without added solution, an observational survey was conducted at retail outlet locations within the nationwide sampling plan developed for the USDA Nutrient Data Laboratory (**NDL**)'s National Food and Nutrient Analysis Program (**NFNAP**). The NFNAP program obtains reliable nutrient estimates through the collection and analysis of nationally representative samples of foods and beverages consumed in the United States (Perry et al., 2003). The survey found that most whole turkeys sold in US retail stores were processed with added solutions of salt, sodium phosphate, modified food starch, and other natural flavorings.

The study reported here was conducted by NDL in collaboration with the Texas Tech University (**TTU**) Animal and Food Sciences Department. The 3 objectives of this study were 1) determine the effect of added solution on the concentrations of proximate nutrients and selected minerals in raw and roasted whole turkeys with added solution (**WAS**) and without added solution (**WOAS**). 2) evaluate the nutrient retention factors, used to calculate the nutrient composition of cooked food based on the nutrient values of the uncooked food (Murphy et al, 1975), of selected minerals after cooking whole turkeys WAS and WOAS. 3) update the nutrient composition data for turkey in the USDA National Nutrient Database for Standard Reference (Standard Reference) (USDA, 2015).

MATERIALS AND METHODS

Sampling

Samples of whole turkeys WAS were procured from 12 US retail locations using the nationwide sampling (Perry et al., 2003) developed for NFNAP (Haytowitz et al., 2008). The outlets were in Colorado, Connecticut, Florida, Michigan, Missouri, North Carolina, Alabama, Northern California, Southern California, New York, Oklahoma, and Indiana (Perry et al., 2003). The whole turkeys WAS were purchased by agents employed by Superior Product Pick-up Service (Niles, IL), who were instructed to obtain whole turkeys with package labels indicating that a solution had been added. Two turkeys per location were purchased so that one sample from each location could be dissected and analyzed raw and the other could be dissected and analyzed after being roasted. One of the original 12 pairs of turkeys WAS was excluded from the study because its label indicated that its solution contained real cream butter, suggesting that its solution was different from the solutions added to the other WAS turkeys. The labels on the remaining turkeys WAS indicated that solutions accounted for 7–15% of the weight of each turkey. The labeled ingredients included solutions of salt, sodium phosphate, modified food starch, and other natural flavorings.

Due to the unavailability of turkeys WOAS at any of the NFNAP retail locations that agents surveyed, turkeys WOAS were ordered from 3 different types of stores: one of the turkeys was from a locally run meat specialty shop, another turkey was from a warehouse-type store, and the remaining turkeys (2) were from a natural foods store. All of the turkeys were frozen after purchase and shipped in insulated containers with dry ice to TTU for dissection and preparation.

Cooking Procedures

Thawed turkeys were unwrapped, and the weights of each turkey and its drippings, neck, organ meats, and packaging were recorded separately. A commercial conventional oven was preheated to 325°F (163°C). One turkey from each of the pairs was placed on a wire rack in a shallow roasting pan with 118 mL of water added to the bottom of the pan. The uncovered turkeys were roasted to an internal temperature of 165°F (74°C) and then removed from the oven. Internal temperature was monitored every 30 min until the final temperature was obtained in the center of the breast of each turkey using a digital thermometer. The post-cooking weight of each whole turkey was obtained after the meat had rested for 30 min at room temperature.

Sample Preparation

All 11 pairs of turkeys WAS (one raw and one cooked turkey from each location) and all 4 pairs of turkeys WOAS (one raw and one cooked turkey from each location) were dissected into parts: breast, wings, drumsticks, thighs, and back (including the tail) according to an internally validated standard protocol used for NFNAP meat studies. All turkey parts were weighed and refrigerated for up to 24 h. Each turkey part yielded the following components: meat, skin, separable fat, bone, and cartilage. Weights of meat, skin, and other components of each part were obtained before and after cooking to determine the relative weight of each component and to measure cooking yields.

Whole turkey samples WAS from 2 locations were combined according to the statistically representative nationwide compositing plan (Perry et al., 2003) and used to create aliquots for analysis. For example, for the turkeys WAS, composites of raw light meat from 2 locations were paired and then homogenized and analyzed (n = 6). A similar procedure was used for the cooked light meat, raw dark meat, and cooked dark meat (n = 6 each). Light and dark skin samples from whole turkeys WAS from all locations were pooled for analysis in both the raw and cooked forms. For the turkeys WOAS, light meat and dark meat were analyzed from each location (n = 4) for both the raw and cooked forms. Light and dark skin from all of the turkeys WOAS were pooled, composited, and analyzed for selected nutrients for both raw and cooked forms.

Final nutrient values for whole turkey were obtained by using the analytical values for meat and for skin based on their relative contribution to the whole turkey. All nutrient values in this study were reported on a 100-gram basis.

Nutrient Analyses

Nutrient analyses were performed by TTU and a commercial laboratory whose analytical procedures were approved and monitored through the NFNAP process (Haytowitz et al., 2008). Quality assurance was monitored through the use of commercial reference materials, in-house control materials, and random blind duplicates. Nutrients selected for the nutrient composition analysis of raw and cooked forms of turkey were proximates (moisture, total fat, ash, and protein) and minerals (calcium, phosphorus, potassium, iron, sodium, magnesium, and zinc). Nutrient retention rates were calculated for each of these minerals. Standard AOAC International procedures were used to analyze moisture (AOAC 950.46), nitrogen or protein (AOAC 968.06), total fat (AOAC 954.02), and ash (AOAC 923.03) content. Mineral content was determined by inductively coupled plasma methodology (AOAC 985.01 and 984.27) for the nutrient composition and retention studies (Association of Official Analytical Chemists, 1995).

Nutrition Retention Factors

Nutrient retention factors are used to calculate the nutrient composition of cooked food based on the nutrient values of the uncooked food. To determine the effect of cooking on minerals in whole turkeys WAS and WOAS in this study, nutrition retention factors were determined. The true retention method was used for the calculations. This method measured the proportion of the nutrient remaining in the cooked food in relation to the amount of the nutrient originally present in the raw food (USDA, 2007). The weights of foods before and after cooking, as well as the nutrient content of the raw and cooked foods, were used (Murphy et al., 1975). The formula for calculating USDA true retention factors is as follows:

$$\%TR = (Nc^{*}Gc)/(Nr^{*}Gr)\ ^{*}\ 100$$

where:

TR = true nutrient retention factor
Nc = nutrient content per g of cooked food
Gc = g of cooked food
Nr = nutrient content per g of raw food
Gr = g of raw food

Statistical Analysis

Statistical analyses were used to compare values of selected nutrients in raw and cooked whole turkeys WAS and WOAS. Means and frequencies were used to describe the sample and to identify potential data patterns for proximate nutrients and minerals in turkeys WAS and WOAS and the cooking method. Statistical comparisons between raw and cooked WAS and WOAS turkeys were completed with 1-way and 2-way analysis of variance (**ANOVA**). When parametric assumptions could not be met, values were converted to ranks and analyzed using ANOVA methods.

Cross-product interactions between the factors (raw vs. cooked) were analyzed to determine where mean values of proximate and mineral nutrients differed across levels of WAS and WOAS raw and cooked turkeys. A 4-level categorical variable comprised of the 2 factors (raw vs. cooked, WAS vs WOAS) was used in post-hoc analyses to identify pair-wise differences. Tukey adjustments were used to control for family-wise error rates. All statistical analyses were completed using SAS version 9.3 (SAS Institute Inc., Cary, NC). Statistical evaluations were not used for retention factor analysis.

RESULTS

Values for proximate composition and selected minerals for raw and cooked turkeys WAS and WOAS are provided in Table 1. Data was statistically analyzed for the effects of cooking and effects of added

Table 1. Comparison of nutrient values of proximate composition and selected minerals in raw and roasted whole turkeys with added solution (WAS) and without added solution (WOAS).[1]

Nutrients	Unit	Turkey With Added Solution (WAS) Raw	Turkey With Added Solution (WAS) Roasted	Turkey Without Added Solution (WOAS) Raw	Turkey Without Added Solution (WOAS) Roasted	*P* value[2]
		n = 6	n = 6	n = 4	n = 4	
Moisture	g/100 g	70.7 ± 0.4	65.2 ± 0.8	73.3 ± 10.7	65.2 ± 1.7	N/A
Fat	g/100 g	$8.8^{a,3}$ ± 0.2	7.1^{b} ± 0.2	6.2^{c} ± 0.2	7.6^{b} ± 0.2	<0.0001
Protein	g/100 g	18.9 ± 0.4	23.9 ± 0.8	19.3 ± 0.9	26.5 ± 1.6	N/A
Calcium	mg/100 g	13.9 ± 0.2	15.1 ± 0.6	11.1 ± 0.5	14.3 ± 0.4	N/A
Iron	mg/100 g	0.7 ± 0.02	0.8 ± 0.02	0.9 ± 0.07	1.1 ± 0.07	N/A
Phosphorus	mg/100 g	194 ± 4.2	229 ± 4.0	180 ± 6.5	221 ± 3.9	N/A
Zinc	mg/100 g	1.7^{a} ± 0.04	2.2^{b} ± 0.05	1.9^{c} ± 0.04	2.7^{d} ± 0.05	0.0070
Sodium	mg/100 g	179 ± 16.8	217 ± 15.5	113 ± 7.6	103 ± 9.4	N/A
Potassium	mg/100 g	207 ± 5.7	234 ± 4.0	229 ± 5.6	238 ± 5.4	N/A
Magnesium	mg/100 g	20.5 ± 0.8	26.6 ± 1.2	24.7 ± 0.6	29.2 ± 0.5	N/A

[1]Values represent Least Square Means ± S.E.M.
[2]N/A refers to lack of Interaction.
[3]Values with similar superscript letters$^{(abcd)}$ are not significantly different at $P > 0.05$.

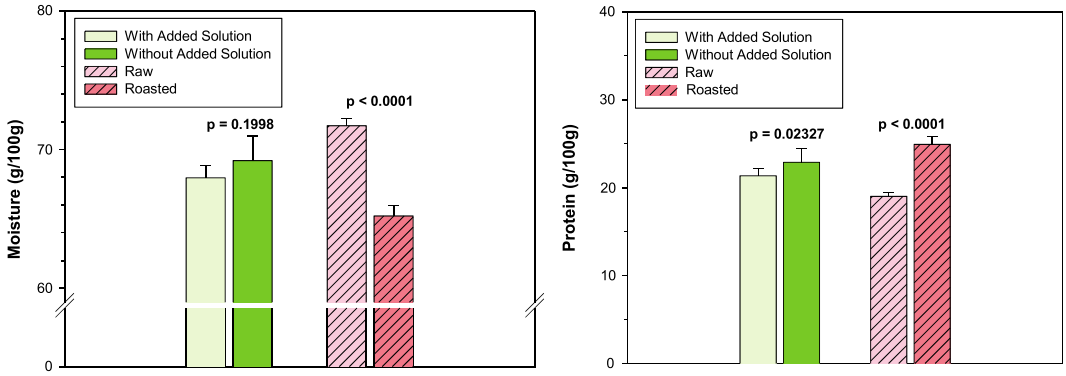

Figure 1a Figure 1b

Figure 1. (a-b) Effect of cooking on moisture and protein content of raw and roasted whole turkeys, with and without added solution. Statistical differences were determined by factorial ANOVA. Critical levels were set at $P < 0.05$.

solution (Figures 1-3). Significant interactions between cooking methods and added solutions were seen for fat ($P < 0.0001$) and zinc concentrations ($P = 0.0070$).

A significant interaction ($P < 0.0001$) was observed for total fat concentrations due to cooking (raw and cooked) and solution (WAS or WOAS). Mean fat value was significantly higher in raw turkeys WAS (8.8 g/100 g) when compared to raw turkeys WOAS (6.2 g/100 g). However, fat levels for roasted turkeys WAS were lower (7.1 g/100 g) than for roasted turkeys WOAS (7.6 g/100 g; Table 1).

Zinc levels were influenced by a significant interaction between cooking and the presence of solution ($P = 0.0070$). Specifically, zinc concentration was significantly higher in raw turkeys WOAS (1.9 mg/100 g) than in raw turkeys WAS (1.7 mg/100 g). Roasted turkeys WOAS had higher zinc concentration (2.7 mg/100 g) than roasted turkeys WOAS (2.2 mg/100 g; Table 1).

No significant interactions were found between turkeys WAS or WOAS or between cooked or raw turkeys for moisture, protein, calcium, phosphorus, iron, sodium, magnesium, or potassium (Table 1). Moisture concentration was similar between whole turkeys WAS and WOAS. However, moisture content was lower in roasted than in raw turkeys ($P < 0.0001$; Figure 1a). Protein content was significantly higher ($P < 0.0001$) in roasted than raw turkeys (Figure 1b).

Calcium content was significantly higher ($P = 0.0042$) in turkeys WAS than in turkeys WOAS. Cooking elevated the calcium values significantly ($P = 0.0015$) in roasted turkeys compared to raw turkeys (Figure 2a). Iron content was higher in WOAS turkeys than WAS turkeys ($P < 0.0001$); roasted turkeys showed higher iron values than raw turkeys ($P = 0.0014$; Figure 2b). Turkeys WAS had higher phosphorus levels than turkeys WOAS ($P = 0.0347$). Roasted turkeys had significantly higher ($P < 0.0001$) phosphorus content than raw turkeys (Figure 2c).

Sodium concentration was significantly higher in turkeys WAS than in turkeys WOAS ($P < 0.0001$; Figure 3a). Potassium levels were higher in turkeys WOAS than in turkeys WAS. Magnesium concentrations were significantly higher in turkeys WOAS than turkeys WAS ($P = 0.0027$). Although cooking had no significant effect on sodium levels, cooking significantly increased levels of potassium ($P = 0.0009$; Figure 3b) and magnesium ($P < 0.0001$; Figure 3c).

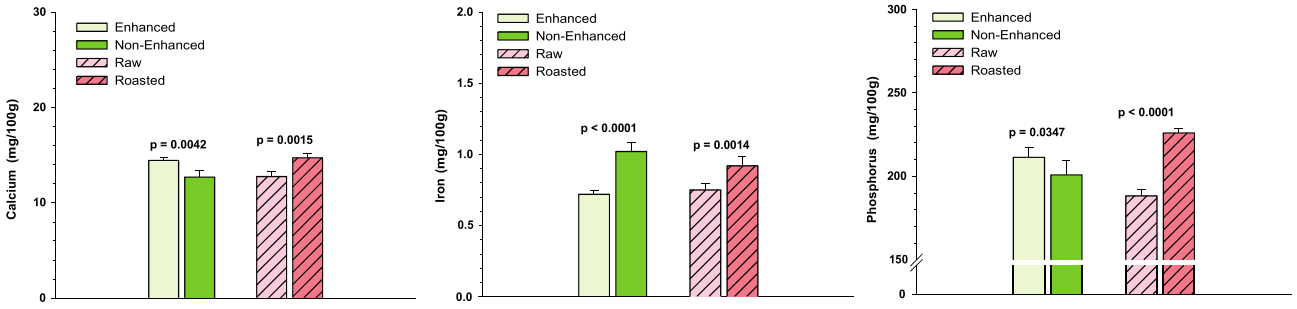

Figure 2a Figure 2b Figure 2c

Figure 2. (a-c) Effect of cooking on calcium, iron and phosphorus content of raw and roasted whole turkeys, with and without added solution. Statistical differences were determined by factorial ANOVA. Critical levels were set at $P < 0.05$.

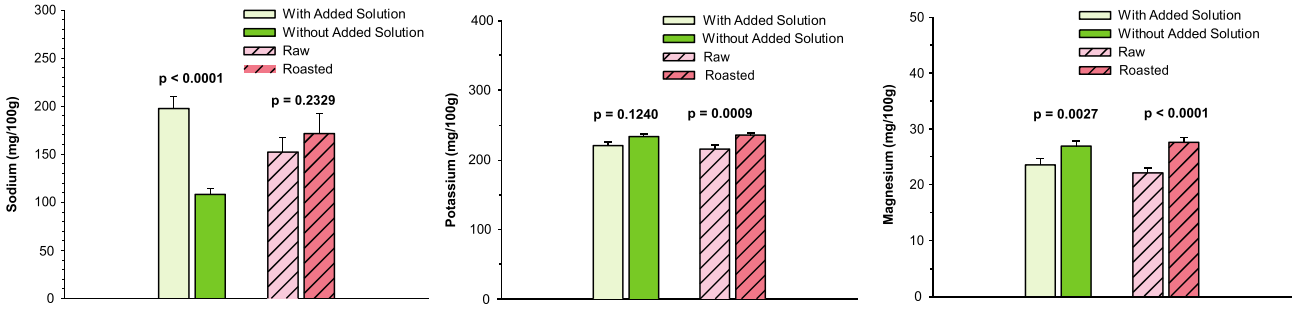

Figure 3a Figure 3b Figure 3c

Figure 3. (a-c) Effect of cooking on sodium, potassium and magnesium content of raw and roasted whole turkeys, with and without added solution. Statistical differences were determined by factorial ANOVA. Critical levels were set at $P < 0.05$.

Table 2. Nutrient retention (%) in roasted whole turkeys with and without added solution.

Food item	Calcium	Iron	Magnesium	Phosphorus	Potassium	Sodium	Zinc
Turkey, whole, meat and skin without added solution, cooked, roasted	90	89	84	86	75	65	98
Turkey, whole, meat and skin with added solution, cooked, roasted	76	86	92	86	82	89	93

Nutrient Retention

Zinc had higher retention factors than all of the other minerals, at 98% for turkeys WOAS and 93% for turkeys WAS (Table 2). The lowest retention factor (65%) was for sodium in turkeys WOAS. Retention factors were higher for turkeys WAS than turkeys WOAS for magnesium, potassium, and sodium. Phosphorus had the same retention factors for turkeys WAS and WOAS.

DISCUSSION

The higher fat concentrations in raw turkeys WAS than in raw turkeys WOAS might be primarily due to the fact that some of the added solutions contained fat, from the natural flavors and modified starch were listed on the ingredients label of some turkeys WAS.

Similar results to our finding regarding protein concentrations were found in a study by Borowski et al. (1986). In the Borowski study, mean protein concentration increased after cooking in turkeys WOAS. Our study findings for moisture and protein may be explained by the dry-heat method (roasting) that may have been responsible for the increase in protein and mineral concentration due to loss of moisture during the cooking process.

In a study by Bianchi et al. (2009), sodium chloride and phosphate salt solutions were added to turkey breasts, resulting in a less dry and juicier meat. Similarly, in our study, the higher levels of sodium and phosphorus in raw turkeys WAS than in raw turkeys WOAS, suggest that these 2 minerals had been added to the solution. In this study, zinc was the only mineral whose levels were influenced by the significant interaction between WAS or WOAS status and raw vs. cooked status.

Nutrient Retention

Accurate nutrient measurement for individuals and groups requires information on the nutrient content of cooked foods. Nutrient retention data are important for determining nutrient values when cooked analytical data are not available because most meats are cooked

before consumption. Post-cooking retention results in our study showed that calcium, iron and zinc were lower in whole turkey WAS compared to WOAS, although higher retention percentages were seen for magnesium, potassium and sodium in WAS compared to WOAS turkeys. Because of the wide disparity in nutrient retention data between whole turkeys WOAS and WAS for most of the minerals in this study, it is important to determine retention factors of meat products, both WAS and WOAS, so that the appropriate retention factors can be applied to each type of product.

Study Limitations

This study was limited by the small number of turkeys WOAS that were analyzed compared to turkeys WAS. Furthermore, due to the lack of turkeys WOAS in the NFNAP retail outlets, the turkeys WOAS were obtained from local outlets and thus were not nationally representative of US retail locations.

CONCLUSIONS

Data from this study have been issued for public access through the USDA National Nutrient Database for Standard Reference. The USDA National Nutrient Database for Standard Reference contains nutrient data for over 8,600 foods and is the major source of nutrient data on food products consumed in the United States, including meat and poultry. The data play a crucial role in US nutrition monitoring, policymaking, and regulations. The addition of these study data to the USDA food composition databases provides specific and current nutrient information on whole turkeys WAS and WOAS.

The results of this study suggest that consuming turkey WAS can increase individuals' total dietary intakes of such minerals as sodium and phosphorus. High sodium and phosphorus intakes could have adverse health effects in people with hypertension, cardiac disease, or renal disease. Additional research is needed to determine the impact on health from added solutions in turkey and other meats. The FSIS issued a new rule effective January 1, 2016 (FSIS, 2014) establishing common, easy-to-understand names for raw meat and poultry products that indicate whether marinades or other solutions have been added to products, whose presence might not otherwise be evident to consumers. These labels will help consumers make informed choices about the meat and poultry products they purchase, taking into consideration components that increase risk for individuals with impaired renal function or hypertension.

The data from this study can be used in nutrition monitoring, food policy development, and dietary counseling of individuals, particularly those with sodium-related and phosphorus-related health issues. These data also provide the scientific basis for research and dietary practice in the United States (Ahuja et al., 2013).

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