Marination Method and Honey Level Affect Physical and Sensory Characteristics of Roasted Chicken

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ABSTRACT

To provide information concerning the functionality of honey as a marinade ingredient for roasted chicken, bone-in breast quarters were marinated with lemon-pepper marinade either by immersion or injection. Honey (10, 20, and 30%) was substituted for water in the marinades. Injected chicken retained more marinade, lost less juice during roasting, and required less force to shear than immersed chicken. Descriptive sensory panel evaluation showed that injected chicken had a more glossy and moist appearance, more intense lemon flavor, more intense sweet and salty taste, and more tender texture than immersed chicken. For injected chicken, addition of honey to the marinade increased honey flavor without notably affecting appearance, aroma, other flavor attributes, or texture.

Key Words: chicken, marination, sensory, instrumental color, texture

INTRODUCTION

MARINATION IS A METHOD OF REDUCING AGING TIME REQUIRED FOR MEAT TENDERIZATION (Goodwin and Maness, 1984). Preparing chicken for roasting may include the use of a combination of marinades, dry rub, and glaze. Marinade ingredients such as salt, phosphates, acids, tenderizers, sugar, seasonings, and flavoring have been reported to have various functions when applied to chicken. These include increasing water-holding capacity, moisture retention, and tenderness of chicken meat and decreasing cooking loss and warmed-over flavor development (Landes, 1972; Shults and Wierbicki, 1973; Chen, 1982; Young et al., 1992). Marinades altered the pH and color of raw and cooked chicken fillets (Yang and Chen, 1993) and enhanced flavor.

Honey provides unique functionality when used as an ingredient in some products including sweetness; its high fructose content makes it sweeter than table sugar (sucrose). About half of the honey produced is used by the baking industry as a humectant to absorb moisture, keeping bread or cakes moist (Ensinger et al., 1994). Honey also contributes to Maillard browning reactions and flavor enhancement. These functions have been demonstrated in savory snacks and breakfast cereals (Cardetti, 1997). Honey increased the crispness (force required to break) of microwavable fat-free potato chips (Demetria-des et al., 1995). It also reduced oxidative breakdown of lipids and the resulting development of off-flavors in deli-style, processed turkey meats during storage (Dawson et al., 1994).

Marination of chicken has been the subject of several reports (Chen, 1982; Heath and Owens, 1991; Goodwin and Maness, 1984; Young and Chen, 1983), but none were found on the effects of honey as a marinade component for roasted chicken. Our objectives were to: (1) characterize the sensory profiles of honey-marinated chicken using the descriptive analysis technique and (2) investigate the effects of marination method and honey level on marinade retention, cooking loss, and instrumental measurements of color and texture.

MATERIALS & METHODS

Marination

Chicken (bone-in breast quarters with skin) was obtained from a commercial processing plant in northeast Georgia. Commercial lemon-pepper marinade powders (A.C. Legg, Inc., Birmingham, AL), clover honey (U.S. Grade A) and tap water were used to prepare seasoning mixtures for marination of chicken. A lemon-pepper seasoning powder (blend of salt, dextrose, sodium phosphates, black pepper, spice extractives, and lemon oil) was used for marination by immersion. A lemon-pepper poultry pump powder (blend of salt, sodium phosphates, sugar, extractives of spice, and celery-lemon oil) was used for marination by injection. A lemon-pepper seasoning powder (blend of dextrose, spice, spice extractives, lemon oil, and sodium alumino-silicate as an anti-caking agent) was applied to marinated chicken as a rubbed-on season- ing just before cooking. The marinades were hydrated with either water or water/liquid honey mixtures, according to directions supplied by the manufacturer.

Preliminary trials were conducted to establish appropriate conditions for marination and roasting/baking. Results showed that best results were obtained by immersing the chicken in the marinade overnight (16 h) or injecting (model N40, Schroder Maschinenbau GmbH, Werther, Germany) the chicken with marinade at pressure = 150 kPa and feed rate = 6 (48 cycles/min) and roasting at 177°C for 1 h to reach an internal endpoint of 80°C. Oven temperature was measured above the shelf and kept within ±1°C during baking. Internal temperature of chicken was measured with a T-type thermocouple connected to a 115 thermocouple (model #600 - 2810, Barnant Co., Barrington, IL) at the thickest part of the muscle, recording the minimum temperature as the internal temperature of the sample.

Chicken was either immersed overnight using lemon-pepper marinade seasoning (5.27% marinade powder and 94.73% tap water) or injected using lemon-pepper poultry pump (14.37% marinade powder and 85.63% tap water). Three levels of honey (10, 20, and 30%) were substituted for water in the marinades. Two processing replications of each treatment were prepared. Although these marinades provided different seasoning concentrations, they provided a mechanism for incorporating honey at levels common to both marinade methods. This approach was used because information was not available about the system for delivering the seasoning or the functionality of honey under these conditions.

Chicken samples were weighed individually, immersed in or injected with the marinade, placed individually into pre-labeled Ziploc® bags, held for 1-2 days at 5°C, drained, and reweighed individually, shortly before cooking. Marination uptake was determined as follows:

\[
\text{Marinade uptake} = \frac{\text{Wt after marination and holding} - \text{Wt before marination}}{\text{Wt before marination}} \times 100
\]

Lemon-pepper seasoning (1% of chicken weight) was applied as a rub to each marinated breast quarter shortly before cooking. Each...
breast quarter was reweighed (weight before cooking) after the rub had been applied.

**Cooking procedure**

A rotary hearth oven equipped with one shelf (dia 81.28 cm) rotating at 1.5 rpm (National Manufacturing, Lincoln, NE) was used to cook the chicken. Chicken samples were placed on aluminum baking pans lined with aluminum foil and roasted uncovered with the skin side up, using conditions established during preliminary trials. Cooked chicken was removed from the oven and allowed to cool for 15 min. Samples were weighed individually after cooling to calculate cooking loss as follows:

\[
\text{Cooking loss} = \left\{ \frac{\text{Wt before cooking} - \text{Wt after cooking}}{\text{Wt before cooking}} \right\} \times 100
\]

**Descriptive analysis**

Panelists (n = 13) were selected from a descriptive panel with experience in previous descriptive analysis studies. Panelists were females from 21 to 67 years of age and were paid a small honorarium. During a 9-h training period (over 4 days), panelists—with the help of the panel leader—identified sensory properties important in marinated chicken. Panelists tasted chicken samples marinated with or without honey to determine common descriptors or attributes. The panel agreed on all attributes considered necessary for evaluation of the marinated chicken, defined these attributes, and suggested external references for them. Attributes for appearance (color, peppery, glossy, and moist), aroma (pepper, chicken, and lemon), flavor (chicken, pepper, lemon, honey, salt, sweet, and sour), and texture (juicy, chewy, and tender) were used to evaluate the marinated chicken. Appropriate reference foods and solutions were selected and used during training to exhibit the attributes and set the anchors. For example, the lemon flavor reference was ReaLemon® juice, strong = 150 intensity. Protocols were developed for measuring appearance, aroma, flavor, and textural properties. References were available for panelists to assist in making evaluations.

A 150-mm unstructured line scale anchored with a term at each end was used. The terms were none and strong from the left end to the right end, respectively, for all attributes except for color (pale yellow to black), glossy (dull to shiny), moist (dry to wet/moist), juicy (not juicy to very juicy), chewy (not chewy to very chewy), and tender (tough to tender). The evaluation scores were recorded by panelists on the scale by placing a slash perpendicular to the line at the point that best described the attribute. The numerical score for each attribute was determined by measurement in mm with a ruler from the left hand side of the 150-mm line scale.

After cooking, the roasted chicken was covered with aluminum foil and held in a conventional oven at 77°C until presented/ served on white polyfoam plates (dia 22.54 cm) to the panelists. Eight samples (4 honey levels × 2 processing replications for each marination method) were presented monadically in a random sequence to panelists who participated in pairs at 1-h intervals between 9:30 a.m. and 4:30 p.m. They returned a second day to evaluate the second marination method samples. The serving size was a whole breast quarter, and samples were served with the skin. Evaluation was conducted in an air-conditioned sensory evaluation laboratory in individual partitioned booths. Each booth was illuminated with two 40-watt incandescent bulbs which provided 9.64 watts/m² of light at the chicken surface. Samples were identified by a 3-digit code number. Panelists were instructed to evaluate appearance first and aroma second and then to remove the wing and skin. Panelists cut a strip from a specific part of the breast (middle) and cut it into cubes; these cubes were used for flavor and texture evaluation. Samples were chewed 15 times to evaluate juiciness and tenderness. For chewiness, panelists counted the number of chews needed to swallow the chicken after the first 15 chews. Water and unsalted crackers were provided for cleansing the palate between samples.

**Color measurement**

Instrumental color evaluation was determined using a colorimeter with a measuring area of 8 mm dia (CR 200, Minolta Chroma Co., Ltd., Osaka, Japan). A standard white tile (L* = 97.44, a* = −0.44, and b* = 2.50) was used to calibrate the colorimeter for measurement of the wing and breast color with skin (exterior); a standard white tile (L* = 97.44, a* = −0.44, and b* = 2.50) was used for calibration of the colorimeter for measurement of the breast color after removing the skin (interior). Lightness (L*), redness (a*), and yellowness (b*) values were obtained at 5 locations on the breast and 3 locations on the wing before removing the skin, and 5 locations on the breast after removing the wing and the skin. Mean values for L*, a*, and b* measurements were determined, and these were used to calculate chroma [C = (a*² + b*²)²], hue angle [tan⁻¹(b*/a*)], and total color difference

\[
\Delta E = \sqrt{(L* - L*^*)^2 + (a* - a^*)^2 + (b* - b^*)^2}/2
\]

**Texture measurement**

A multi-bladed Allo-Kramer Shear Press attachment was connected to a 500-kg load cell. The cell was attached to a Universal Testing Machine (Model 1122, Instron Corp., Canton, MA). Crosshead and chart speeds were 200 mm/min. The wing and skin were removed from the breast and a 3.5 cm strip was cut from the breast, the same area used by the descriptive panel. A 3.5 cm square was cut from the strip. The piece was weighed, and its thickness was measured on the 4 sides with a Vernier caliper (0–150 mm range, Cole-Parmer Instrument Co., Vernon Hills, IL) to assure that all samples were uniform in size. The sample was oriented so that the blades sheared across the fibers, and the maximum peak height of the force-deformation curve was recorded to measure the breaking force as kg/g sample (Lyons and Lyon, 1990).

**Statistical analysis**

Sensory and instrumental data were analyzed by ANOVA using the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS Institute, Inc., 1995) with a significance level of p=0.05. The method of marination and honey level and the interaction between marination method and honey level were tested as main effects for all data. Significant means were separated using the Least Significant Difference Test (LSD).

**RESULTS & DISCUSSION**

DURING PREPARATION AND PROCESSING, honey mixed easily with the water and other marinade ingredients. The honey marinades were easily pumpable and did not necessitate changes in operation of the injector or other process conditions. The probabilities of F-Statistic for the main effects (marination method and honey level) and their interactions on marinate pH, marinate uptake, cooking loss, and instrumental color and texture were determined (Table 1). Both the method of marination and honey level had effects on the pH of the marinade, marinate uptake, and cooking loss. Marination method had an effect on chroma and hue angle of the wing and instrumental texture. Except for hue angle of the breast (interior), which was affected by marination method, none of the breast color characteristics—either exterior or interior—was affected by marination method or honey level. There was interaction between marination method and honey level for the pH of the marinade, cooking loss, and for the total color difference (ΔE) of the wing.

The pH of clover honey was 3.6. The marinade pH decreased with increasing honey level for both marinade methods. Addition of 30% honey decreased the PH of lemon-pepper marinade seasoning from 6.87 to 6.22 and that of lemon-pepper poultry pump from 6.56 to 6.19 (Table 2). Comparing the two methods, injected chicken retained more marinade (x = 9.24%) and lost less juice during cooking (x = 21.16%) than immersed chicken (x = 1.75% and x = 23.72%, respectively). As the percent of honey increased in the lemon-pepper marinade seasoning used for immersion, marinate uptake decreased (Table 2). Cooking loss of immersed chicken was not affected by honey level. As the level of honey increased in the lemon-pepper poultry pump used for injection, marinate uptake decreased. This may be due to a higher marinade viscosity and less marinade being pumped out when honey was used at a high percentage (data not shown) as well as the...
effect of pH. Chicken injected with 0, 20 or 30% honey marinated less juice during cooking than that injected with 10% honey marinate (Table 2).

Some instrumental color measurements of marinated chicken were affected by marination method (Table 3). Injected chicken had a higher hue angle for the interior breast color than immersed chicken. The wing color of injected chicken was more intense or saturated (higher chroma) and had a higher hue angle than that of immersed chicken. There was interaction between marination method and honey level on the hue angle (total color difference) of the wing. Data were not presented because neither of the main effects was significant and the R² was low (0.33). Hue angles between 40–75 are indicative of brown color with a lower angle indicating more brown. Hue angles indicated that immersion resulted in browner interior breast color and browner wing color than injection. Visual observation confirmed that immersed pieces were browner than injected pieces. Color development was typical of that associated with nonenzymatic browning. Both marination methods produced baked chicken with very desirable color.

Instrumental texture measurements of the breast meat of marinated chicken were also compared (Table 3). Chicken marinated by injection required less force to shear 1 g breast meat than when marinated by immersion. Lyon and Lyon (1990) reported that a value of 8.8 kg/g would correspond to a sensory score of “slightly tender” and 6.0 to 3.2 kg/g would correspond to “moderately tender” to “very tender.” Although chicken marinated by immersion required more force to shear than injected samples, all of the treatments would be “very tender.”

The probabilities of F-Statistic for the main effects and their interaction on sensory characteristics of roasted chicken are summarized as follows: Marination method had an effect on sensory characteristics of color, glossy and moist appearance, lemon and honey flavors, sweet and salt tastes, and juicy and tender texture of marinated chicken. Honey level had an effect only on honey flavor. There was interaction between marination method and honey level on sensory color and juiciness.

Several sensory characteristics of marinated chicken were affected by process treatments (Tables 4, 5). The descriptive sensory panel detected changes in the appearance, flavor, and texture characteristics of marinated chicken. Chicken immersed in marinade containing 20 or 30% honey was rated by panelists as having more intense brown color than that immersed in marinade without honey. Panelists did not reliably discern color differences in injected chicken, as indicated by the variability in color intensity ratings. Honey flavor of immersed chicken was not affected by honey level. For injected chicken, the influence of honey level on honey flavor was most apparent at the 20 and 30% honey levels.
honey flavor was most intense. Juicy texture of injected chicken was not affected by honey level. For the immersion method, chicken marinated without honey was rated as the most juicy while that immersed in 20% honey marinade was rated least juicy. The difference in juiciness may be due to the greater amount of marinade retained by the chicken marinated without honey (Table 2).

Appearance, flavor, and texture characteristics were affected by the marination method (Table 5). Panelists rated injected chicken as having a more glossy and moist appearance, more intense salt, lemon, and sweet flavors, and more tender texture than immersed chicken. The sensory results for tenderness confirmed those shown by instrumental measurements.

CONCLUSIONS

HONEY WAS READILY EFFECTIVE AS A MARINADE INGREDIENT, FUNCTIONING WELL IN THE MARINADE PROCESS AND ROASTING PROCEDURE. Processors desiring a roasted product with an intense honey flavor should select the injection method and 20 or 30% honey levels. Those desiring a less salty, lemony, or sweet flavor should select the immersion method. Both methods of marination and seasoning combinations produced very acceptable roasted products with desirable color, tender texture, and different flavor profiles. Acceptance tests to determine consumer attitudes toward honey-marinated roasted chicken are warranted.

REFERENCES

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