Chicken meat quality raised in an integrated organic production system

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Summary and Implications

This work aimed to evaluate and compare the meat quality of chicken raised by traditional confinement (CR) and integrated (FR) conditions. Eighty chickens (40 for each group) were slaughtered, and parts yield, chemical composition, and meat quality parameters were measured. There was no significant difference in parts yield. Protein content in the breast of the CR group was significantly ($P < 0.05$) higher than that of the FR group. The ash content of chicken thighs in the FR group was significantly higher than in the CR group. The cooked chicken breast from the FR group was significantly more tender than that from the CR group. The TBARS values of breast and thigh meats on the sixth day after grinding did not differ between CR and FR groups. However, the chickens raised in the FR had better appearance (color), fatty acids composition, and tenderness perspective than those in the CR system. All these results indicated that the plant-animal integrated system is a good alternative to the traditional confinement production system that can enhance farm diversity, land use efficiency, and sustainability of farm agriculture.

Introduction

There has been a surge in organic vegetable production in the US. This rapid increase in organic acres, especially for vegetable crops, created challenges in managing soil fertility, high fertility management costs, and an intensive crop-focused production approach that overlooked the essence and value of integrated production systems. Organic producers manage soil quality and fertility by crop rotation, intercropping, polyculture, and cover cropping, but amendments, such as compost, manure, and organic fertilizers, are still needed to sustain yield and high produce quality. Even though organic agriculture rests on solid ecological principles, producers still find it challenging to create a holistic production system that promotes and enhances the integration of plant-animal production. A plant-animal integrated system offers a solution to this problem with the added advantages of enhancing farm diversity, land use efficiency, and profitability. One of the advantages of vegetable-poultry integrated systems is the opportunity for an organic producer to integrate chicken production into the farm's existing cropping system, where chickens provide natural fertilizer for crops. The addition of chickens, along with the already implemented cover crops, could move organic growers closer to their goals of relying upon on-farm produced inputs or those produced nearby and meet crop and livestock needs for feed and soil nutrition.

Organic poultry products are now becoming mainstream in supermarkets, providing consumers with an increased variety of product choices. Free-range poultry products raised following organic standards command a premium price for their appeal to the consumer's idea of a production method more conducive to animal welfare and a more balanced environment. By integrating vegetable-poultry-cover crops in a rotation system, produce farms can develop new pasture-based poultry systems that will increase the value of the meat produced.

The objective of this study was to test and compare the meat quality of chicken breasts and thighs from the integrated system and traditional confinement conditions.

Materials and Methods

This experiment was conducted at Iowa State University, Ames, IA. A total of 80 birds (Straight run Freedom Ranger broilers from Welp Hatchery in Bancroft, IA) were raised in brooders for 3 weeks, divided into eight blocks with 10 birds each, and then divided into experimental (FR) and control (CR) groups. The birds in the CR group were raised in the traditional confinement system, and the FR group was raised under the following integrated farm systems: April-mid June (broccoli), mid-June-mid-Aug (cowpea and teff grass), and mid-Aug-Sep (chicken). All the birds had the same feed as Nature's Grown Organics (21% Start-n-Grow-130091) feed for the first 5 weeks, then Nature's Grown Organics (19% Fine Finish-130092) feed for the remaining 4 weeks (Nature's Grown Organics, Premier Cooperative, Westby, WI 54667). The birds were slaughtered at 63 days of age.

The chickens were transported to and slaughtered on harvest day in Meat Science Laboratory at Iowa State University. The chicken carcasses were chilled in iced water for 4-6 hours, drained, and then deboned the next day. The weight of the entire chicken carcasses was collected first, and then the breasts, thighs, drumsticks, wings, and the rest were weighed individually to measure the carcass part yield (n=40) for both CR and FR birds.

Proximate analysis was measured in duplicates. Total lipid content in the breast and thigh were measured according to Folch's method. The lipid extract was used for fatty acid analysis. The fatty acids profile was determined using a GC-MS. Protein content was measured through a rapid protein analyzer (Sprint@ CEM Co-op). Moisture and ash content were tested using the AOAC methods. 24 h after slaughter, the pH was measured after removing the whole breast (pectoralis major) and thigh muscles (quadriceps femoris). The tenderness of cooked breast and thigh was determined using the Texture Analyzer (TA-XT2i) attached with a star probe. Each sample was tested on duplicates (Figure 1). Thiobarbituric acid reactive substances (TBARS) were measured to determine lipid oxidation in raw and cooked meats.

The experimental unit was a pen, and the chicken was used for the carcass and component yield data. Treatment (CR, FR) was used as a fixed effect. Results were shown as average and standard deviation. A t-test was applied to compare the mean values of the fixed effect. A p-value of < 0.05 was considered statistically significant.

Results and Discussion

All the edible parts between the CR and FR, including thigh, breast, wings, and drumstick, were not differ significantly. The meat composition was not affected by the raising conditions, except for the protein content in the CR breast, which was higher than that in the FR breast.

The color a*-value of the raw breast from the FR group was significantly higher than that from the CR because of redder myofibers development due to more outdoor movements. After cooking, the L*-value of thigh meat in the FR group was lower (darker) than in the CR group. The higher darkness of cooked thigh meat in FR was caused by the myoglobin in the meat, denatured during cooking.

In chicken breast, the FR groups had a higher (P<0.05) b*-value, which could be related to the consumption of green leaves that the chickens had access to the leftover vegetables, which contain high pigments like carotenoids. In cooked meat, the tenderness of the thigh did not differ significantly, but the breast of the FR group was significantly more tender than the CR group. The TBARS values of raw breast and thigh meats were not different during the first 6 days of storage (Figure 2). The FR-breast had higher docosahexaenoic acid (DHA) than the CR-breast, but eicosapentaenoic acid (EPA) was not different (Table 5).

In conclusion, the meat yield between traditional confinement and the integrated organic producing system was not different, but meats from the integrated system (FR) had higher quality, including appearance (color), fatty acids composition, and tenderness perspective, than those from the CR system. However, the cooked meat from the FR group was more prone to lipid oxidation even though the TBARS values were within the acceptable ranges (< 1.0). All these results indicated that introducing chicken to the integrated organic production system could successfully produce high-valued chickens without losing meat yield and quality, which will help farmers by enhancing farm diversity, land use efficiency, and profitability.

Acknowledgements

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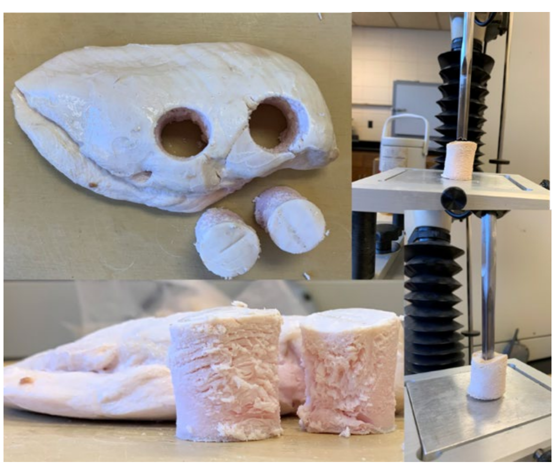

Figure 1. Tenderness test by a Texture Analyzer

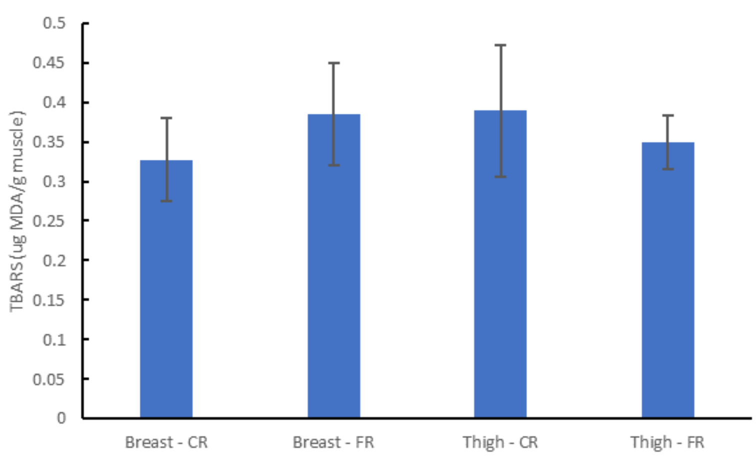

Figure 2. Lipid oxidation in chicken breast and thigh meat on the sixth day after grinding.

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Table 1. Component (thigh, breast, wing, and drumstick) yield.

Group	Component Yield %				
	Thigh	Breast	Wing	Drumstick	Rest
CR	17.46 ± 3.23^{a}	28.57 ± 4.28^{a}	11.38 ± 1.30^{a}	13.87 ± 3.67^{a}	25.52 ± 4.26^{a}
FR	17.58 ± 1.96^{a}	29.58 ± 3.28^{a}	11.12 ± 1.28^{a}	13.89 ± 1.87^{a}	27.35 ± 3.65^{b}

Different letters in the same column mean a significant difference (p<0.05).

Table 2. Proximate analysis of chicken thigh and breast.

Sample	Fat content (%)	Protein content (%)	Moisture (%)	Ash (%)	pH
Breast CR	1.13 ± 0.17^{a}	24.50 ± 0.21^{a}	73.94 ± 0.25^{a}	1.41 ± 0.16^{a}	5.94 ± 0.11^{a}
Breast FR	1.11 ± 0.15^{a}	23.78 ± 0.15^{b}	74.08 ± 0.22^{a}	1.44 ± 0.08^{a}	5.87 ± 0.12^{a}
Thigh CR	4.06 ± 0.50^{b}	20.535 ± 0.27^{c}	75.79 ± 0.71^{b}	1.06 ± 0.07^{b}	6.38 ± 0.06^{b}
Thigh FR	4.40 ± 0.32^{b}	20.35 ± 0.09^{c}	75.51 ± 0.35^{b}	1.18 ± 0.03^{c}	6.40 ± 0.09^{b}

Different letters in the same column between CR and FR mean a significant difference (p<0.05).

Table 3. Color test of raw and cooked breast and thigh meat.

Sample		L*	a*	b*
Raw	Breast CR	60.81 ± 1.95^{a}	11.66 ± 1.24^{a}	5.34 ± 1.58 ^{a}
	Breast FR	59.55 ± 2.08^{a}	12.14 ± 0.53^{a}	7.17 ± 1.72^{b}
	Thigh CR	55.90 ± 1.99^{b}	11.45 ± 1.23^{b}	5.29 ± 1.55 ^{c}
	Thigh FR	55.47 ± 1.60^{b}	14.42 ± 0.85^{c}	6.31 ± 2.09 ^{c}
Cooked	Breast CR	79.78 ± 1.78^{a}	2.21 ± 0.78^{a}	13.23 ± 2.16^{a}
	Breast FR	79.32 ± 2.24^{a}	2.72 ± 0.43^{b}	12.37 ± 1.10^{a}
	Thigh CR	72.59 ± 2.47^{b}	2.88 ± 0.46^{c}	13.61 ± 0.82 ^{b}
	Thigh FR	69.80 ± 2.96^{c}	2.95 ± 0.44^{c}	13.85 ± 1.07 ^{b}

Different letters in the same column between CR and FR mean a significant difference (p<0.05).

Table 4. Cooking yield, tenderness, and moisture content in cooked breast and thigh meat.

Sample	Cooking yield (%)	Tenderness (force/kg)	Moisture (%)
Breast CR	83.99 ± 2.07^{a}	2.19± 0.18^{a}	66.68 ± 1.41 ^{a}
Breast FR	83.49 ± 3.44^{a}	1.83 ± 0.26^{b}	67.26 ± 0.99^{a}
Thigh CR	71.45 ± 3.61^{b}	1.75 ± 0.37^{c}	68.01 ± 4.30^{c}
Thigh FR	68.92 ± 2.78^{b}	1.63 ± 0.51^{c}	64.50 ± 2.53^{c}

Different letters in the same column between CR and FR mean a significant difference (p<0.05).

Table 5. Fatty acid profile in chicken breast and thigh meat (%).

Abrev.	Fatty acids	Thigh CR	Thigh FR	Breast CR	Breast FR
C10:0	Decanoic acid	0.05	0.01	0.01	0.01
C12:0	Dodecanoic acid	0.06	0.04	0.04	0.05
C14:0	Tetradecanoic acid	0.45	0.48	0.46	0.42
C14:1	Myristoleic acid	0.07	0.07	0.04	0.05
C15:0	Pentadecanoic acid	0.08	0.09	0.1	0.07
C16:0	Hexadecanoic acid	22.64	24.44	24.87	23.13
C16:1 (n-3)	9-Hexadecenoic acid	2.89	2.87	1.07	1.23
C17:0	Heptadecanoic acid	0.17	0.18	0.2	0.17
C18:0	Stearic acid	11.83	13.62	15.16	14.86
C18:1	11-Octadecenoic acid	0.43	0.78	0.86	0.5
C18:1	9-Octadecenoic acid	20.29	21.04	15.17	17.12
C18:2 (n-3)	12,15-Octadecadienoic acid	0.4	0.47	0.71	0.5
C18:2 (n-6)	9,12-Octadecadienoic acid	21.21	19.36	15.45	15.17
C18:3 (n-3)	9,12,15-Octadecatrienoic acid	2	1.81	0.97	0.86
C20:0	Arachidic acid	5.08	3.6	6.76	8
C20:1	11-Eicosenoic acid	0.26	0.14	0.1	0.11
C20:2 (n-6)	Eicosadienoic acid (cis-11,14-Eicosadienoic acid)	0.17	0.29	0.19	0.11
C20:3 (n-6)	8,11,14-Eicosatrienoic acid	0.74	0.66	1.31	1.23
C20:3 (n-9)	5,8,11-Eicosatrienoic acid	0.67	0.87	0.81	0.76
C20:4 (n-6)	5,8,11,14-Eicosatetraenoic acid (Arachidonic acid)	5.51	4.69	7.74	8.52
C20:5 (n-3)	5,8,11,14,17-Eicosapentaenoic acid (EPA)	0.24	0.17	0.3	0.3
C22:4 (n-6)	7,10,13,16-Docosatetraenoic acid	1.75	1.93	2.76	2.39
C22:5 (n-3)	7,10,13,16,19-docosapentaenoic acid (DPA)	0.69	0.58	1.5	1.28
C22:5 (n-6)	4,7,10,13,16-docosapentaenoic acid	0.27	0.26	0.59	0.5
C22:6 (n-3)	4,7,10,13,16,19-Docosahexaenoic acid (DHA)	0.68	0.59	1.28	1.54
C24:0	Tetracosanoic acid	0.11	0.12	0.17	0.14
C24:1	15-Tetracosenoic acid	0.95	0.48	0.85	0.37