Effect of Fermented Boiled Organic Soybean in Diet on Carcass Composition and Meat Quality of Broiler Chickens

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***Abstract*—This research aimed to investigate effects of fermented, boiled organic soybean in diets on carcass composition and meat quality of broiler chickens. Two hundred-thirty-four one-day old commercial broiler chickens were allocated into 6 groups with 3 replications and fed with soybean meal control diet, boiled organic soybean diet, boiled organic soybean supplement with fermented boiled soybean 25%, 50%, 75% and 100%, respectively. The results found that the fermented boiled organic soybean decreased percentage of carcass, dressing, loins and tender loins (P<0.05). The fermented boiled organic soybean no affects to the pH, color and shear force of the meat (P<0.05).**

***Index Terms*—Broiler chicken, Fermented of boiled organic soybean, Carcass composition, Meat quality**

I. Introduction

The organic animal feeds were derived from agricultural production sources that followed organic farming procedures. The organic production was excluded from genetically modified seeds, chemicals and fertilizers [1]. However, this processing was limited in that it required a very high amount of raw materials. Soybeans were considered one of the main raw materials widely used in animal feed. The organic soybean production had fewer problems compared to organic corn production, as soybeans were planted in the dry season after rice farming. Moreover, soybeans can be produced year-round [2].

Soybean (*Glycine max* (L) Merr) serves as a feed material that provides high nutritional value and is a major source of quality protein and fat [3, 4]. Furthermore, organic soybeans are raw materials that are considerably cheap and easy to acquire. They have similar nutritional value compared to that of soybean meal despite being cheaper. Nonetheless, the use of soybean was often limited by the anti-nutritional factors, including protease inhibitor, lectin, oligosaccharide, phytate, and anti-vitamin [5]. These factors reduce the nutritional value of food that will affect the utilization or metabolism of nutrients in animals.

There were several methods to eliminate the anti-nutritional factors in animal feed materials such as heating [6], microbial fermentation [7], and heating with fermentation. The reduction of anti-nutritional factors in fermented food ingredients was enhanced with increased lactic acid levels [8]. The trypsin inhibitor can be digested with bacterial enzymes [9]. In addition, boiling enhances digestibility of soybeans in the stomach as it increases the amount of sugars such as xylose, mannose, galactose, and glucose [10]. However, soybeans have high fat content which affects the efficiency of food production. Panya et al. [11] found that the use of boiled soybeans and fermented organic soybeans improved the performance in small broilers in terms of growth, the amount of food in Phase broiler, and carcass quality of the broilers.

In this study, we investigated the effects of different levels of fermented boiled organic soybeans in broiler diet on carcass composition and meat quality of a commercial broiler.

II. MATERIALS AND METHOD

The boiled organic soybeans and fermented boiled organic soybeans were prepared according to the method described in [11]. Both boiled and fermented, boiled organic soybeans were sun-dried and further dried in the hot air oven for 48-72 hours. They were ground thoroughly before use.

The present study followed the complete randomized design (CRD) setup that used 234 commercial broilers with the age of 1-day old. They were randomly divided into 6 groups. Each group was distributed into three replicates with thirteen broilers per replicate. The food compositions for broilers in different groups were:

Group 1: 100% soybean meal (control diet)

Group 2: 100% boiled organic soybeans

Group 3: 25% fermented boiled organic soybeans + 75% boiled organic soybean

Group 4: 50% fermented boiled organic soybeans + 50% boiled organic soybean

Group 5: 75% fermented boiled organic soybeans + 25% boiled organic soybean

Group 6: 100% fermented boiled organic soybeans

The experimental feed was prepared for broiler into 2 periods comprising as starter feed (age 0-3 weeks) and a grower feed (chicks age 3-7 weeks). The basal diet was based on organic broken rice and soybean meal (see Table I and II) and was balanced to meet the nutritional requirements for broiler chickens according to the NRC (1994) [12]. Feeding and water were provided ad libitum for 7 weeks.

Experimental data of the carcass characteristics and meat quality were collected. At the end of the experiments, all of the broilers were sacrificed in accordance with the animal welfare principles to investigate the animal live weight, warm carcass weight, percentage of dressed warm carcass weight, and the percentage of various parts from the carcasses. The chest and hip muscles were used for determination of the color, pH, percentage of drip loss from chilling and cooking, shear force and the meat oxidation.

All data were analyzed using Analysis of Variance (ANOVA). Significantly different means were separated according to the method of Duncan's New Multiple Rang Test (DMRT) according to the procedure described in Steel et al. (1997) [13].

TABLE I

INGREDIENTS AND CALCULATED CHEMICAL COMPOSITION OF THE EXPERIMENTAL DIETS (0-3 WEEKS)

Ingredient	**Groups**					
	1	**2**	**3**	**4**	**5**	**6**
Organic broken rice	43.6	43.6	43.6	43.6	43.6	43.6
Soybean meal (44% CP)	52.4	0	0	0	0	0
Boiled organic soybean	0	52.4	39.3	26.2	13.1	0
Fermented, boiled organic soybean	0	0	13.1	26.2	39.3	52.4
Dicalcium phosphate	2.65	2.65	2.65	2.65	2.65	2.65
Fine limestone	0.50	0.50	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50	0.50	0.50
Premix*	0.25	0.25	0.25	0.25	0.25	0.25
Probiotic	0.05	0.05	0.05	0.05	0.05	0.05
Calculated Chemical composition (%)						
Crude Protein (%)	23.1	23.1	23.1	23.1	23.1	23.1
Metabolizable Energy (kcal/kg)	2877	2877	2906	2936	2965	2995
Calcium (%)	0.99	0.99	0.99	0.98	0.98	0.97
Available Phosphorus (%)	0.78	0.78	0.76	0.72	0.69	0.65

*Commercial premix

TABLE II

INGREDIENTS AND CALCULATED CHEMICAL COMPOSITION OF THE EXPERIMENTAL DIETS (4-7 WEEKS)

Ingredient	**Groups**					
	1	**2**	**3**	**4**	**5**	**6**
Organic broken rice	50.5	50.5	50.5	50.5	50.5	50.5
Soybean meal (44% CP)	45.5	0	0	0	0	0
Boiled organic soybean	0	45.5	34.2	22.8	11.4	0
Fermented, boiled organic soybean	0	0	11.4	228	34.2	45.6
Dicalcium phosphate	2.65	2.65	2.65	2.65	2.65	2.65
Fine limestone	0.50	0.50	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50	0.50	0.50
Premix*	0.25	0.25	0.25	0.25	0.25	0.25
Probiotic	0.05	0.05	0.05	0.05	0.05	0.05
Calculated Chemical composition (%)						
Crude Protein (%)	20.1	20.1	20.1	20.1	20.1	20.1
Metabolizable energy (kcal/kg)	2940	2940	2966	2991	301 7	3043
Calcium (%)	0.99	0.99	0.98	0.97	0.97	0.96
Available phosphorus (%)	0.77	0.77	0.73	0.70	0.67	0.64

*Commercial premix

III. RESULTS

The results showed that all 6 experimental groups were not significantly different (P > 0.05). (Table III). The hot carcass of all experimental groups was not significantly different (P > 0.05) although that of treatment 3 was lower than control (treatment 1) (P > 0.05). The dressing weight of the organic soybean treatments was lower than control although the weights of those under treatments 2 and 4 were not significantly different from control (P < 0.05). The percentages of legs in the hot carcass from the broilers in the organic soybeans group were higher than that of the control, while pectoralis minor and pectoralis major were lower than those of the control. The visceral fat was also not significantly different among the various experimental groups although that of group 5 was higher than that of the control (P < 0.05).

As for the hot carcass, the percentages of head and neck, wings, drumsticks, thighs, and skeleton frame from all treatments were not significantly different (P > 0.05). Nevertheless, the percentages of the legs, loins, and tenderloins of the warm carcass were significantly different (P < 0.05). Interestingly, the leg percentages of the warm carcass from broilers fed with boiled organic soybeans and those fed with fermented boiled organic soybeans were higher than that of the control. In contrast, the percentages of loins and tenderloins from broilers fed with soybeans (25, 50, 75, and 100%) were lower than that of the control.

The examination of internal organ weights showed that the percentages (% live weight) of visceral organs, heart, liver, proventriculus gizzard, and spleen of broilers from all experimental groups were not significantly different (P > 0.05). However, the visceral fat percentages of broiler chickens fed with boiled organic soybeans and fermented boiled organic soybeans were higher than that of the control (Table III).

TABLE III

THE EFFECT FERMENTED OF BOILED ORGANIC SOYBEAN LEVEL ON CARCASS COMPOSITION IN BROILER CHICKEN

Items	**Groups**					
	1	**2**	**3**	**4**	**5**	**6**
Live weight (g)	1743.9	1558.2	1554.2	1560.6	1599.9	1624.8
Hot carcass weight (g)	1641.5	1292.7	1266.9	1289.4	1278.7	1322.3
Dressing weight (g)	1296.4	1136.7	1104.1	1131.0	1105.4	1157.2
Hot carcass (%)	83.58^{a}	81.68^{a}	75.85^{b}	81.08^{a}	79.59^{ab}	79.48^{ab}
Dressing (%)	74.00^{a}	70.92^{ab}	64.69^{c}	70.14^{ab}	68.74^{bc}	68.68^{bc}
Carcass percentage (Hot carcass %)						
Head and Neck	5.53	6.10	6.20	6.19	6.11	6.08
Legs	4.05^{b}	4.59^{a}	4.77^{a}	4.89^{a}	4.74^{a}	4.72^{a}
Wings	8.17	7.84	8.06	8.15	7.78	7.96
Drumsticks	11.18	11.48	10.91	10.96	11.13	10.96
Thighs	12.96	14.01	12.45	12.04	13.20	12.98
Loins	15.2^{a}	11.22^{c}	10.07^{c}	10.3^{c}	12.97^{b}	11.55^{bc}
Tenderloins	3.43^{a}	$2.74b^{c}$	$2.71b^{c}$	2.55^{c}	3.01^{b}	2.81^{bc}
Skeleton frame	17.40	18.99	18.14	18.37	17.89	18.59
Internal organ (Live weight %)						
Visceral organs	9.91	11.37	11.21	10.86	12.02	11.62
Heart	0.45	0.49	0.50	0.49	0.56	0.54
Liver	2.12	2.3	2.15	2.20	2.36	2.40
Proventriculus Gizzard	2.28	2.76	2.73	2.78	2.76	2.77
Spleen	0.24	0.11	0.14	0.14	0.17	0.16
Visceral fat	0.36^{b}	0.73^{ab}	0.49^{ab}	0.47^{ab}	0.85^{a}	0.67^{ab}

[a, b, c] The different letters in the same row represent statistically significant differences (P<0.05)

We then examine the meat quality by measuring the pH and color of the meat. We found the pH of the 24 hour postmortem thighs, the brightness of loin and the redness of drumsticks at 45 minutes postmortem, and the brightness of loin at 24 hours postmortem of the control were significantly different (P < 0.05) (Table IV). The pH of thighs at 24 hours postmortem and the brightness of loin at 45 minutes postmortem were highest in the broilers fed with the boiled organic soybeans and fermented boiled organic soybeans (25, 50, 75, and 100% compositions; see Materials and Methods). The drumstick meat of broiler chickens fed with 100% boiled organic soybeans showed the highest degree of redness at 45 minutes postmortem. Moreover, the brightness of drumsticks at 24 hours postmortem of the control and that of the 50% fermented organic boiled soybeans group were considerably high (Table IV).

TABLE IV
THE EFFECT OF FERMENTED BOILED ORGANIC SOYBEAN LEVEL ON PH AND COLOR OF THE PECTORALIS AND THIGH MEAT IN BROILER CHICKENS

Item	Groups					
	1	2	3	4	5	6
pH of pectoralis major						
pH 45 min.	6.20	6.03	6.02	6.07	6.00	6.04
pH 24 hour	5.86	5.99	5.87	5.93	5.72	6.08
pH of thigh						
pH 45 min.	6.27	6.41	6.36	6.40	6.25	6.35
pH 24 hour	6.30^{a}	6.25^{a}	6.17^{abc}	6.20^{ab}	6.04^{c}	6.07^{bc}
Color of loin at 45 min. postmortem						
L*	60.82^{a}	58.59^{ab}	57.10^{bc}	55.53^{c}	59.33^{ab}	58.34^{abc}
a*	15.25	16.86	14.23	15.26	14.56	13.22
b*	8.40	6.69	5.16	5.82	6.47	7.86
Color of thigh at 24-hour postmortem						
L*	58.19	55.98	56.32	54.46	55.56	55.74
a*	16.55^{ab}	18.12^{a}	15.55^{b}	16.03^{b}	16.74^{ab}	15.56^{b}
b*	8.40	6.69	5.16	5.82	6.74	7.89
Color of loin at 45 min. postmortem						
L*	60.06	61.03	59.29	57.70	60.34	59.01
a*	12.91	13.96	13.35	14.83	14.37	14.16
b*	7.00	7.91	8.29	7.04	8.32	8.08
Color of thigh at 24 hour postmortem						
L*	58.03^{ab}	57.44^{ab}	56.70^{bc}	58.30^{a}	55.39^{ab}	54.90^{c}
a*	14.82	15.83	15.43	14.84	16.65	16.25
b*	7.68	8.25	9.22	7.17	8.36	8.47

^{a,b,c}The different letters in the same row represent statistically significant differences (P<0.05)

The meat quality of the chickens fed with fermented organic boiled soybeans was determined by the level of drip loss, cooking loss, shear force, and TBARS of the meat. We found that the drip loss from chilling and cooking the loin and thigh as well as the meat oxidation were not statistically different. (P > 0.05) Nevertheless, shear force value of the thigh was significantly different (P < 0.05). The shear force values of the thighs of the broilers in the 100% boiled organic soybeans group and those in the 25% fermented boiled organic soybeans group were lower than that of the control and the rest of the experimental groups (P<0.05). Intriguingly, the shear force seemed to increase as the fermented boiled organic soybean percentage in the feeding composition increased (50% fermented boiled organic soybean in treatment 4, 75% in treatment 5, and 100% in treatment 6, respectively; Table V).

TABLE V
THE EFFECT OF FERMENTED BOILED ORGANIC SOYBEAN LEVEL ON DRIP LOSS, COOKING LOSS, SHEAR FORCE, AND TBARS OF THE LOIN AND THIGH MEAT OF BROILER CHICKENS

Item	Groups					
	1	2	3	4	5	6
Drip loss (%)						
Pectoralis major	7.33	6.96	6.81	7.72	7.05	7.61
Thigh	6.96	7.77	6.11	5.70	5.36	5.14
Cooking loss (%)						
Pectoralis major	15.57	16.68	14.88	23.66	22.16	18.56
Thigh	17.66	15.40	21.93	19.72	19.72	17.73
Shear force (Kg/cm^{3})						
Pectoralis major	1.23	0.66	0.97	1.00	1.56	1.50
Thigh	1.49^{ab}	0.97^{b}	0.74^{b}	1.11^{ab}	1.67^{a}	1.80^{a}
TBARS of loin						
Day 0	0.02	0.03	0.02	0.03	0.03	0.03
Day 3	0.04	0.04	0.04	0.03	0.05	0.04
Day 7	0.05	0.05	0.04	0.05	0.06	0.06

^{a,b,c} The different letters in the same row represent statistically significant differences (P<0.05)

IV. DISCUSSION

The fermented boiled organic soybean was used as ingredient of animal feed that decreased the percentages of hot carcass, dressing, loin and tenderloin. The live weight of broiler chicken fed with the fermented boiled organic soybean was low. The fermented boiled organic soybean increased the percentages of visceral organs and visceral fat. Ken-ichiro et al. [14] found that the fermented boiled organic soybean did not increase the hot carcass, thighs, and drumsticks. Kim et al. [15] reported that the fermented soybean meal did not increase the organ weight of grower chickens. Conversely the boiled organic soybean and fermented boiled organic soybean increased the percentage of visceral fat. The boiled organic soybean and fermented boiled organic soybean have high fat content that was reflected in the visceral organs and fat [16]. However, they barely affected the carcass composition in our experiments.

The fermented, boiled organic soybean in diet affected the meat quality, pH, color and shear force of broiler chickens. Similar to our observations, Lee et al. [17] reported that the fermented sprout soybean has an effect on the meat quality. The soybean contains isoflavone compounds such as genistein, daidzein, and glycitein. Isoflavone influences the meat color [18]. The accumulation of lactic acid from anaerobic respiration leads to low pH of the meat. The killing management, transportation, and timing also reduce a pH value [19]. The 25% fermented boiled organic soybean in broiler diet led to the low shear force value that indicated the softness/tenderness of the meat [20]. However, the boiled organic soybean and fermented boiled organic soybean had no effects on meat oxidation. Nonetheless, Baranski et al. [21] reported that the organic materials in diet are composed of more antioxidants than the common materials. The antioxidant agents decrease the oxidation of fat in the loins and increase shelf life of the meat.

V. CONCLUSION

The present study used fermented boiled organic soybeans in the broiler diet to evaluate the carcass composition and meat quality of a commercial broiler. This research found that the fermented boiled organic soybeans decreased the percentage of carcass, dressing, loin, and tenderloin. In addition, the percentage of visceral fat was increased. They affected the quality of the chicken meat in terms of pH, color, and shear force.

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