MARKETING AND PRODUCTS

The Effect of Extended Holding Time, Temperature, and Dietary Energy on Yields of Broilers[1]

T. C. CHEN and C. D. SCHULTZ

Poultry Science Department, MAFES-Mississippi State University, Mississippi State, Mississippi 39762

F. N. REECE, B. D. LOTT, and J. L. McNAUGHTON

US Department of Agriculture, ARS, South Central Poultry Research Laboratory, Mississippi State Mississippi 39762

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ABSTRACT Feed was withdrawn, but water was available, for 12 hr before 8-week-old broilers were held in crates at 10.0 and 32.2 C for 8 and 16 hr or at 26.7 C for 16 hr. The effects of holding time, holding temperature, and dietary energy on shrinkage and processing yields were investigated.

The rates of live weight loss were linear with holding time and were .219 and .513%/hr for birds held at 10.0 and 32.2 C, respectively. Male birds tended to have higher weight loss than the females. When based on preholding weight, carcass yields decreased significantly for both holding times at both temperatures; however, yields tended to slightly increase with time when based on the postholding weight. Broilers reared on a 3325 kcal/kg ration lost significantly more than those reared on a 3100 kcal/kg ration after 16 hr of holding at 26.7 C. Eviscerated carcass yields were significantly higher for the birds reared on the low energy diet than for those reared on the higher energy diet. Increased holding time reduced viscera weight and the weight of blood and feathers lost during slaughter.

(Key words: holding time, holding temperature, dietary energy, yields)

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INTRODUCTION

In recent years, poultry processing companies have paid close attention to the yields of poultry during processing. Higher processing yields not only mean higher profit but also indicate more efficient labor and better returns on equipment. For a plant processing 100,000 broilers per day, a 1% increase or decrease in processing yields means a gain or loss of $551,250 per year for this company. This figure was obtained on the basis of an average bird weight of 1.6 kg (3.5 lb) and a wholesale price of fresh carcasses at $.99/kg ($.45/lb).

Preslaughter condition is one of the major factors that affects the processing yields of broilers. In normal operations, feed is withdrawn from the birds several hours prior to pick-up by the catching crew in order to complete digestive system cleanout prior to slaughter. The length of starvation time on eviscerated yields of broilers has been studied by several researchers. May and Brunson (1955) reported that broiler chickens starved for 24 hr prior to slaughter yielded significantly lower eviscerated weights than for groups held for 0, 3, 6, and 12 hr prior to slaughter; there was no significant variation between sexes. Brunson (1957) reported significantly lower yields when broilers were fasted for 12 or 24 hr prior to slaughter compared to those fasted 0, 3, and 6 hr. Similar reports were made by Schmidt *et al.* (1964) who indicated that there was no significant loss in dressed weight during fasting periods of 16 hr or less, but the yield was significantly reduced when the fasting period was 24 hr or longer. On the contrary, Wabeck (1972) reported that the loss in weight of live birds was linear with time of feed withdrawal. Veerkamp (1978) reported that the total weight losses of broilers after 4 hr of fasting were .353%/hr, mainly caused by weight losses in the edible parts, which were .24%/hr. Recently, Leeson and Summers (1981) studied feed withdrawal and broiler shrinkage and reported the holding loss as a percentage of live weight of broilers to be 1.65 + (.06 × the number of hours held) for the holding birds in pens without feed; a shrinkage of 2.24 + (.17 × the number of hours held) was derived for broilers held in crates.

[1] Journal Paper No. 5465 of the Mississippi Agricultural and Forestry Experiment Station.

Temperature effects were not reported by Leeson and Summers (1981).

This study was designed to determine the effects of holding time, holding temperature, and dietary energy on shrinkage and processing yields of broilers.

MATERIALS AND METHODS

Commercial broiler chickens (Arbor Acres × Arbor Acres) were reared to 8 weeks of age using conventional management practices. House temperature was maintained at 26.7 C for the 3- to 8-week growing period. Birds were wing-banded prior to the beginning of two experiments. Feed was withdrawn, but water was available, for a 12-hr period before the birds were placed in crates (55 cm long, 81 cm wide, 22 cm high).

Experiment 1 was designed to determine the effects of holding times in crates of 0, 8, and 16 hr and holding temperatures of 10.0 C (60% relative humidity) and 32.2 C (62% relative humidity) on weight loss and processing yields. Birds for this experiment were fed Diet 2 (Table 1) with a calculated metabolizable energy (ME) of 3250 kcal/kg of feed from 3 to 8 weeks.

Experiment 2 was designed to determine the effects of dietary energy and holding time in crates on weight loss and processing yields. Birds were held for 0 and 16 hr at 26.7 C (60% relative humidity). Birds for this experiment were fed Diets 1 and 3 (Table 1), which contained calculated ME values of 3100 and 3325 kcal/kg, respectively.

For each treatment, 48 birds were individu-

TABLE 1. *Composition of diets used between 3 and 8 weeks*

Ingredient	Diet number 1	2	3
	(%)		
Yellow corn	71.798	67.336	64.798
Soybean meal (48.5%)	19.537	20.328	20.778
Animal fat (7716 kcal ME/kg)	.819	4.490	6.445
Dicalcium phosphate (22% Ca, 18.5% P)	1.077	1.091	1.098
Limestone	.788	.775	.750
Iodized salt	.408	.409	.410
Broiler vitamin-mineral premix[1]	.250	.250	.250
MHA-Ca, 93%	.209	.219	.291
Coban (45 g/t)	.100	.100	.100
Animal protein pack (60%)[2]	5.000	5.000	5.000
L-Lysine-HCl	.014	.002	.080
Total	100	100	100
Calculated analysis:			
Protein, %	18.70	18.70	18.70
Metabolizable energy, kcal/kg	3100	3250	3325
per lb	(1406)	(1474)	(1508)
Lysine, Mcal %	.71	.68	.71
Methionine + Cystine, Mcal %	.59	.56	.59
Lysine, %	1.00	1.00	1.07
Methionine + Cystine, %	.83	.83	.89
Calcium, %	.90	.90	.90
Available phosphorus, %	.45	.45	.45
Sodium, %	.20	.20	.20
Calorie:protein ratio	75.2	78.8	80.6

[1] The broiler premix furnished the following amounts of other ingredients per kg of feed: vitamin A, palmitate, gelatin coated, 6614 IU; vitamin D_3, 1654 ICU; vitamin E, 2.2 IU; riboflavin, 4.4 mg; niacin, 27.6 mg; d-pantothenic acid, 8.8 mg; folic acid, 275.6 μg; vitamin B_{12}, 8.8 μg; choline chloride, 551 mg; ethoxyquin, 55 mg; menadione sodium bisulfite complex, 2.8 mg or menadione sodium bisulfite, 1.7 mg; pyridoxine, .55 mg; manganese, 66.25 mg; zinc, 44 mg; iodine, 1.25 mg; iron (in sulfate form), 20 mg; copper (in sulfate form), 2 mg.

[2] Pro-pak, a combination of menhaden fish meal, poultry by-product meal, and poultry offal meal.

TABLE 2. *Live weights of broilers before holding*

Calculated dietary metabolizable energy	Body weight		
	M	F	Overall
(kcal/kg)	(g)		
3100	2375	1969	2172
3250	2348	1971	2160
3325	2478	2025	2252

ally weighed and placed in four plastic crates with 6 males (M) and 6 females (F) per crate. Birds not held were immediately processed. The crates for the 8- and 16-hr treatments were placed in environmental chambers maintained at the indicated temperatures and humidities. Crates were stacked in groups of four (two wide and two high) with major dimensions of the crates adjacent to each other. At the end of the specified holding times, the birds were taken to the plant, reweighed, and processed. During processing, the birds were weighed after bleeding and defeathering (New York dressed), and after viscera, heads and feet were removed (eviscerated).

The percentages for holding losses, New York dressed and eviscerated yields, and percentage ratios of viscera, heads, and feet weights to eviscerated weights, and blood and feather weights as a percentage of preslaughter weights, were calculated. Arcsin $\sqrt{\text{percentage}}$ transformation was performed according to the methods described in Steel and Torrie (1980). Duncan's new multiple range test was used to separate the means of the arcsin $\sqrt{\text{percentage}}$ (Duncan, 1955).

RESULTS AND DISCUSSION

The mean weights of the birds used in this study are shown in Table 2. There was little weight difference between birds fed the 3100 kcal/kg ME diet and those fed the 3250 kcal/kg ME diet; those receiving the 3325 kcal/kg ME diet were about 90 g heavier for sexes combined.

The holding losses in crates are shown in Tables 3 and 4, and the data from Table 3 are plotted in Figure 1. Losses with time were very nearly linear for both 10.0 and 32.2 C. The rate of loss at 32.2 C was slightly more than double the loss rate at 10.0 C (.513% *vs.* .219%/hr). There was little difference between sexes, except that males lost significantly more than females when held 16 hr at 32.2 C. Birds fed the 3325 kcal/kg ME diet (Table 4), lost significantly more weight when held 16 hr at 26.7 C than those fed the 3100 kcal/kg ME diet. The males lost significantly more weight than did the females for both dietary treatments.

There is considerable variation within the poultry processing industry concerning feed withdrawal prior to slaughter. The procedure that we used in this study was patterned after the recommendation of a producer in Mississippi. The withdrawal of feed 12 hr before catching also ensured that the birds that were slaughtered

TABLE 3. *Mean holding loss and eviscerated yields for broilers held at two temperatures*[1]

Treatment	Holding loss (Prehold weight)			Eviscerated carcass yield					
				Prehold weight			Posthold weight		
	M	F	Overall	M	F	Overall	M	F	Overall
	(%)								
Experiment 1									
Control (0 hr)	0	0	0	66.8^{ab}	67.1^{a}	66.9^{a}	66.8^{ef}	67.1^{cdef}	66.9^{b}
8 hr at 10.0 C	1.77^{c}	1.43^{c}	1.60^{c}	66.4^{abc}	65.2^{cd}	65.8^{b}	67.7^{bcde}	66.3^{f}	67.0^{b}
16 hr at 10.0 C	3.48^{b}	3.29^{b}	3.39^{b}	65.9^{abc}	65.7^{bcd}	65.8^{b}	68.5^{ab}	68.1^{abc}	68.3^{a}
8 hr at 32.2 C	3.70^{b}	3.65^{b}	3.67^{b}	65.2^{cd}	64.5^{cde}	64.9^{c}	67.8^{abcde}	67.0^{def}	67.4^{b}
16 hr at 32.2 C	9.42^{a}	7.69^{a}	8.26^{a}	61.5^{f}	63.4^{e}	62.5^{d}	67.9^{abcd}	68.8^{a}	68.5^{a}

^{a,b,c,d,e,f}Means within the male and female columns combined and within the overall columns not followed by the same superscript letter are significantly different ($P<.05$).

[1] Twenty-four each of male (M) and female (F) broilers were used in each treatment.

TABLE 4. *Mean holding loss and eviscerated yield for broilers from two diet energy levels held at 26.7 C for 16 hr*[1]

Treatment	Dietary energy	Holding loss (Prehold weight)			Eviscerated carcass yield					
					Prehold weight			Posthold weight		
		M	F	Overall	M	F	Overall	M	F	Overall
	(kcal/kg)	(%)								
Experiment 2										
Control (0 hr)	3100	0	0	0	66.4^{a}	65.7^{a}	66.1^{a}	66.4^{abcd}	65.7^{cd}	66.1^{a}
Control (0 hr)	3325	0	0	0	66.6^{a}	66.3^{a}	66.4^{a}	66.6^{abcd}	66.3^{bcd}	66.4^{a}
16 hr at 26.7 C	3100	6.32^{b}	5.50^{b}	5.92^{b}	63.6^{bc}	64.2^{b}	63.9^{b}	65.2^{d}	68.0^{ab}	66.6^{a}
16 hr at 26.7 C	3325	8.13^{a}	6.91^{a}	7.49^{a}	62.8^{c}	63.0^{bc}	62.9^{c}	68.4^{a}	67.7^{abc}	68.0^{a}

^{a,b,c,d}Means within the male and female columns combined and within the overall columns not followed by the same superscript letter are significantly different ($P<.05$).

[1]Twenty-four each of male (M) and female (F) broilers were used in each treatment.

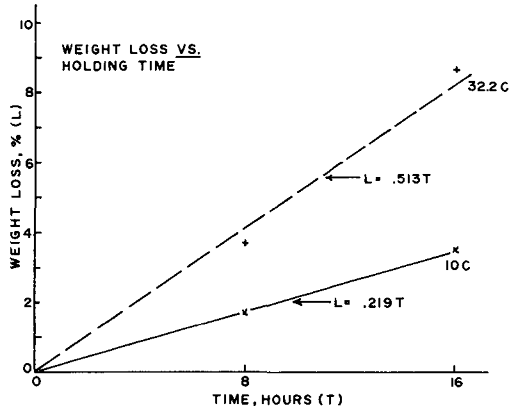

FIG. 1. Weight loss *vs.* time for broilers held in crates in two environmental temperatures.

immediately after crating (zero holding time) would not be contaminated during processing.

The eviscerated carcass yield data for holding times of 0, 8, and 16 hr and the two temperatures of 10.0 and 32.2 C (Experiment 1) are shown in Table 3. Contrasting trends are exhibited, depending on whether the yield was based on the preholding or postholding live weights. When based on preholding live weights, carcass yield percentage decreased significantly for both holding times at both temperatures. At 10.0 C, there was a decrease in yield during the first 8 hr but no further decrease during the next 8 hr; at 32.2 C, the decrease was greater than for 10.0 C, and yield continued to decrease through the full 16 hr. When based on postholding weights, yields tended to increase with time for both holding temperatures; however, the increases were less than the decreases that occurred when yields were based on preholding weights. There was no difference in yield based on postholding weights between the two holding temperatures.

The yields for Experiment 2 where the birds were fed the high and low energy diets (Table 4) exhibited the same trends as in Experiment 1. Based on preholding weights, yields decreased after 16 hr holding at 26.7 C; yields for the birds reared on the high-energy diet decreased significantly more than for those reared on the low-energy diet. When based on postholding weights, yields tended to increase for the 16-hr holding period, but differences both for time and for dietary energy, were not significant.

The data on holding losses and eviscerated yields based on preholding weights are as

TABLE 5. *Mean weight ratio of viscera to eviscerated carcass for broilers held at various conditions*

Treatment	Dietary energy	Viscera + head + feet wt/eviscerated carcass wt × 100		
		M	F	Overall
	(kcal/kg)			
Experiment 1				
Control (0 hr)	3250	36.0^{abcd}	35.9^{abcde}	36.0^{ab}
8 hr at 10.0 C	3250	35.4^{bcdef}	37.9^{a}	36.6^{a}
16 hr at 10.0 C	3250	32.7^{f}	33.8^{def}	33.2^{c}
8 hr at 32.2 C	3250	34.1^{cdef}	36.6^{ab}	35.4^{ab}
16 hr at 32.2 C	3250	36.1^{abc}	33.5^{ef}	34.4^{bc}
Experiment 2				
Control (0 hr)	3100	36.5^{ab}	37.7^{a}	37.1^{a}
Control (0 hr)	3325	36.3^{abc}	35.9^{abcd}	36.1^{ab}
16 hr at 26.7 C	3100	35.0^{cd}	33.3^{d}	34.2^{b}
16 hr at 26.7 C	3325	35.4^{bcd}	35.8^{abcd}	35.6^{ab}

^{a,b,c,d,e,f}Means within the male and female columns combined and within the overall column not followed by the same superscript letter are significantly different ($P<.05$).

expected—weight losses due to respiration and defecation occur in the total body, including the carcass, which is retained as the final product. However, the yield data based on postholding weights that increased after holding indicates that the eviscerated carcass shrinks at a different rate than the waste portions (viscera, blood, feathers, head, and feed). Table 5 shows the ratio of the weight of viscera, head, and feet to the eviscerated carcass weight. The ratio changed little during the first 8 hr of holding time but decreased during the second 8 hr of holding time, indicating there was more shrinkage in the viscera than in the carcass during the 8 to 16 hr holding period.

Table 6 shows the weight of blood and

TABLE 6. *Blood and feather loss as a percentage of preslaughter weight*

Treatment	Dietary energy	Blood and feathers, percentage of preslaughter weight		
		M	F	Overall
	(kcal/kg)			
Experiment 1				
Control (0 hr)	3250	9.16^{ab}	9.23^{a}	9.19^{a}
8 hr at 10.0 C	3250	8.49^{bcd}	8.57^{abcd}	8.53^{b}
16 hr at 10.0 C	3250	9.05^{ab}	8.93^{abc}	8.99^{ab}
8 hr at 32.2 C	3250	7.75^{ef}	8.13^{def}	7.95^{c}
16 hr at 32.2 C	3250	7.51^{f}	8.32^{cde}	8.05^{c}
Experiment 2				
Control (0 hr)	3100	9.44^{a}	9.18^{a}	9.31^{a}
Control (0 hr)	3325	8.94^{ab}	9.05^{ab}	8.99^{ab}
16 hr at 26.7 C	3100	8.39^{b}	9.26^{a}	8.79^{b}
16 hr at 26.7 C	3325	7.70^{c}	8.38^{b}	8.02^{c}

$^{a-f}$Means within the male and female columns combined and within the overall column not followed by the same superscript letter are significantly different ($P<.05$).

feathers lost during processing as a percentage of body weight. Extended holding time tended to decrease these percentages. Mortality in the crates was 25% for the birds held for 16 hr at 32.2 C and 2% for those held for 16 hr at 26.7 C. No mortality occurred in the other treatments.

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