J. King Saud Univ., Vol. 12, *Agric. Sci.* (1), pp. 1-10, Riyadh (1420/2000)

ANIMAL PRODUCTION

Feed Restriction in Broiler Chicks by Dietary *Salicornia bigelovii* Torr Meal Supplementation

H. A. Al-Batshan, F. M. Attia and A. A. Alsobayel
Department of Animal Production, College of Agriculture, King Saud University, P. O. Box 2460, Riyadh 11451, Saudi Arabia

(Received 14/5/1419; accepted for publication 28/10/1419)

Abstract. An experiment was conducted to determine the effect of feed restriction using *Salicornia bigelovii* Torr meal (SM) on performance and abdominal fat deposition in broiler chicks. During the first week of age, all birds were fed a practical starter diet. Treatments then proceeded as follows: treatment 1, continued on the practical starter diet up to four weeks of age (control); treatment 2, as the control but supplemented with 3% SM during the second week of age; treatment 3, as the control but supplemented with 3% SM during the second and third weeks of age; treatment 4, as the control but supplemented with 6% SM during the second week of age; treatment 5, as the control but supplemented with 6% SM during the second and third weeks of age. The results of this experiment showed that the inclusion of 3% SM for one week did no significantly affect feed intake or weight gain during the 2-3 weeks period compared to the control. However, the inclusion of 6% SM for one week significantly reduced feed intake and weight gain compared to the control. The inclusion of 6% SM for two weeks significantly reduced weight gain. Upon release from diets supplemented with SM for one or two weeks, no significant differences were noted in weight gain during the 2-3 or 3-4 weeks period, respectively. However, these birds gained significantly more than the control during the 3-4 and 4-5 week periods, respectively. Cumulative weight gain and body weight at four and seven weeks of age were significantly lower for birds fed 6% SM for two weeks. Feed conversion was adversely affected by SM inclusion in the diet and the effect was more pronounced for bird fed 6% SM for two weeks. Carcass weight was significantly lower for birds fed 6% SM for two weeks. Abdominal fat and percentage abdominal fat were not affected by SM inclusion in the diet. It was concluded that SM was effective in reducing feed intake and hence body weight gain and final body weight. However, neither the addition of SM in the diet nor the duration of feed restriction were effective in reducing abdominal fat deposition in broiler chicks.

Introduction

Producing lean broiler meat is a major objective of the broiler industry. This goal is difficult to achieve as selection for rapid growth in broilers results in increased deposition of abdominal fat at juvenile ages [1-3]. Problems associated with increased fat deposition in broilers increased interest in feed restriction programs designed to reduce both abdominal and carcass fat [4-7]. Several reports indicated that the type of

diet and feeding program during the first days of life might influence the net deposition of fat in broilers [4, 8-10].

Quantitative feed restriction may require extra labor or mechanization. Therefore, a number of reports suggested that feed restriction could be practiced by dietary inclusion of feed additives that have specific inhibitory effects on the appetite of chicks. These feed additives include short and medium chain fatty acids such as propionic and lactic acids [11, 12], and glycolic acid [13]. Using natural compounds present in plants as feed additives is preferable to unnatural compounds as it helps to avoid tissue residue.

Salicornia bigelovii Torr is considered as an oil seed crop tolerant of sea water irrigation in extreme coastal desert environment [14]. Glenn *et al.* [15] reported that *Salicornia bigelovii* Torr seeds contained 26-33% oil, 30-33% protein. These workers reported that the principle product extracted from seeds was an oil rich in linoleic acid. *Salicornia bigelovii* Torr meal (SM) is the by product of oil extraction containing 33% protein. SM also contains an antigrowth factor(s), believed to be saponins, which reduces feed intake and depresses growth. Inclusion of SM that contains saponins in broiler diets at an early age might be a valuable mean to control feed intake and may results in reduced abdominal fat.

In the present experiment, we examined the effects of SM inclusion in broiler diets on performance and abdominal fat deposition.

Materials and Methods

Three hundred 1-day-old ISA Vedette broiler chicks were wing banded, individually weighed and randomly allocated to five dietary treatments. Each treatment was represented by three replicates of 20 birds each. Birds were kept in floor pens in an environmentally controlled house and temperature was maintained at 33 C during the first week with the temperature being reduced three C/week until it reached 24 C. Light was provided continually using incandescent lamps. During the first week of age, all groups were fed a practical starter diet containing 22.54% crude protein and 2920 kcal ME/kg (Table 1). Treatments then proceeded as follows: treatment 1, continued on the practical starter diet up to four weeks of age (C-0% SM, control); treatment 2, as the control but supplemented with 3% SM during the 2nd wk of age (3% SM-wk_2); treatment 3, as the control but supplemented with 3% SM during the 2nd and 3rd wk of age (3% SM-$wk_{2\&3}$); treatment 4, as the control but supplemented with 6% SM during the 2nd wk of age (6% SM-wk_2); treatment 5, as the control but supplemented with 6% SM during the 2nd and 3rd wk of age (6% SM-$wk_{2\&3}$). SM was supplemented at the expense of the whole diet. At four weeks of age, all birds were fed a finisher diet until the end of the experiment (Table 1).

Proximate analysis of SM used in this study on dry matter basis [16] showed that it

contained 34% crude protein, 6.45% ether extract, 5.3% crude fiber, and 15% ash. Saponins content of SM used in this study was .05% on dry matter basis [17]. Individual body weights and feed intake by pen were determined weekly, and gain and feed conversion (feed:gain) were calculated.

Table 1. Composition of the basal diets

Ingredient	Starter	Finisher
	g/kg	
Ground yellow corn	603.0	657.5
Soybean meal	340.0	285.0
Vitamins[1] and mineral[2]	25.0	25.0
Limestone	14.5	15.0
Dicalcium phosphate	15.0	15.0
Salt (NaCl)	2.5	2.5
Total	1000.0	1000.0
Calculated composition[3]		
Protein, %	22.54	20.34
ME_n, kcal/kg	2920.00	2967.00
Ether extract, %	2.77	2.64
Ca, %	0.95	0.94
Available phosphorus, %	0.41	0.41

[1]Provided the following per kg of diet: vitamin A, 12,000 IU; vitamin D_3, 7,200 ICU; vitamin E, 20 IU; vitamin B_1, 2.5 mg; vitamin B_2, 5 mg; vitamin K, 3 mg; vitamin B_{12}, 1.5 µg; pyrodoxine, .225 µg; pantothenic acid, 10 mg; niacin, 35 mg; choline chloride, 500 mg; folic acid, 1.5 mg; biotin, 0.1 mg; virginiamycin, 20 mg; ntioxidant, 125 mg.
[2]Provided the following per kg of diet: Mn, 90 mg; Cu, 7.5 mg; Zn, 65 mg; Fe, 50 mg; Se, 0.1 mg.
[3]Based on the National Research Council [18] tables of feed composition.

At seven weeks of age, 24 birds (males and females) per treatment were selected randomly, slaughtered, and sex was confirmed by organs examination. Feed was withdrawn for overnight before processing. Each bird was eviscerated manually and abdominal fat was excised and weighed. Carcass weight was defined as the weight of each dressed carcass without the neck, giblets, and abdominal fat. Abdominal fat was that surrounding the bursa of Fabricus, cloaca and adjacent abdominal muscles.

Data were subjected to statistical analysis using the General Linear Models procedure of SAS® [19] as a completely randomized design. Variable means for treatments showing significant differences in the ANOVA were compared using the Least Squares method. Percentage data were transferred to arc sine prior to analysis;

however, actual percentage data are reported.

Results and Discussion

Data for body weight and body weight gain are shown in Table 2. Treatment significantly ($P < .01$) affected weight gain during all periods except the 5-6 weeks period. Also, treatment significantly ($P < .01$) affected body weight at four and seven weeks of age. Feed intake and feed conversion were also significantly ($P < .05$ and .01) affected by treatment throughout the experiment (Table 3).

Table 2. Least square means for weight gain and body weight for non-sexed ISA Vedette broiler chicks during one to seven weeks of age

	Weight gain (g/week)							Body weight (g)		
	Weeks of age									
Source	0-1	2-3	3-4	4-5	5-6	6-7	0-4	0-7	4	7
Treatment[1]	NS	**	**	**	NS	**	**	**	**	**
C-0% SM	80	223^{a}	366^{b}	339^{bc}	431	377^{a}	837^{ab}	1980^{a}	886^{ab}	2030^{a}
3% SM-wk_2	79	232^{a}	399^{a}	323^{c}	423	375^{a}	866^{a}	1948^{a}	917^{a}	1998^{a}
3% SM-$wk_{2\&3}$	79	178^{b}	390^{ab}	357^{ab}	439	327^{ab}	805^{bd}	1892^{a}	855^{b}	1941^{ab}
6% SM-wk_2	79	224^{a}	377^{ab}	347^{bc}	447	327^{ab}	797^{d}	1910^{a}	848^{b}	1959^{a}
6% SM-$wk_{2\&3}$	81	152^{c}	376^{ab}	377^{a}	411	293^{b}	744^{c}	1789^{b}	794^{c}	1825^{b}
SEM[2]	±1	±2	±3	±4	±5	±7	±5	±16	±6	±16

[1]C-0% SM, control; 3% SM-wk_2, diet supplemented with 3% SM during the second week; 3% SM-$wk_{2\&3}$, diet supplemented with 3% SM during the second and third weeks; 6% SM-wk_2, diet supplemented with 6% SM during the second week; 6% SM-$wk_{2\&3}$, diet supplemented with 6% SM during the second and third weeks.

[2]SEM, pooled standard error of the mean.

[a-d]Means within a column without common superscript letter are significantly different ($P < .05$).

NS, not significant; **$P < .01$.

Weight gain and feed intake

The 1-2 week weight gain and feed intake of birds fed 3% SM diet were not significantly different from those of the control, indicating that the 3% SM level for one week had no adverse effect on weight gain and feed intake. However, this was not the case for birds fed the 6% SM diet that differed significantly from the control. During the 2-3 week period and upon release from diets supplemented with SM, no significant differences were noted in weight gain between birds previously fed with 3 or 6% SM for one week and the control. On the other hand, birds fed diets supplemented with 3 or 6% SM for another week showed significantly ($P < .05$) lower weight gain than the control. The reduction in weight gain occurred stepwise with the level of SM in the diet, being more pronounced in birds fed the 6% SM diet.

The smaller weight gain for birds fed the SM diets for two weeks paralleled the reduction in feed intake during the same period (Tables 2 and 3). Weight gain during the 3-4 week of age was comparable for all treatments regardless of prior SM supplementation. However, birds fed the 3% SM diet for one week exhibited significantly ($P < .05$) higher body weight gain relative to the control. During the 4-5 week period, no treatment differences were noted except for birds fed the 6% SM for two weeks, whose weight gain significantly ($P < .05$) exceeded that of the control, indicating a rapid compensatory growth.

The ability of animals to compensate from undernutrition was reported by several investigators [7, 4, 20]. Cumulative weight gain during 0-4 weeks was significantly affected by SM supplementation only when SM was fed for two weeks and/or when birds were fed 6% SM. During the 5-6 week period, weight gain was not significantly different among treatment groups. During the 6-7 week period, birds fed 6% SM for two weeks showed the lowest ($P<.05$) weight gain among treatments. A similar trend was observed for feed intake during the same period. These results might indicate that the duration of feeding the 6% SM diet has a pronounced effect. Cumulative weight gain during the 0-7 weeks of age was significantly ($P < .05$) low only for birds fed 6% SM for two weeks.

Body weight

Body weight of birds fed 6% SM for two weeks at four and seven weeks of age was significantly ($P < .05$) lower than the control. This might indicate that compensatory gain for this group was insufficient to overcome the growth depression caused by feeding 6% SM for two weeks. The results of this study are in agreement with those reported by Plavink and Hurwitz [4] and Attia *et al.* [7] who showed that final body weight was lower in broilers restricted for two or four weeks than in fully fed birds. Plavink and Hurwitz [21] concluded that early feed restriction for more than five days reduced body weight at seven weeks of age. The present data suggest that the ability of birds to compensate for body weight loss depend on the severity and duration of feed restriction and age of the bird.

Feed conversion

Although, differences in feed intake during the 0-4 weeks were similar to those observed during 0-7 weeks of age, weight gain data were different during the same periods resulting in pronounced differences in feed conversion (Tables 2 and 3). Although compensatory adjustment was anticipated in birds fed SM, overall feed conversion for all birds fed SM diets was inferior ($P < .05$) to that of the control group. The findings of the present experiment support the conclusion of Mollison *et al.*[22] and those of Alsobayel *et al.* [6] that feed restriction for short periods caused no improvement in the overall feed conversion. Other workers, however, reported that early feed restriction showed feed conversion advantages over full fed birds [4, 21].

Table 3. Least squares means for feed intake and conversion for non-sexed ISA Vedette broiler chicks during one to seven weeks of age

	Feed intake (g/week)								Conversion (g/g)		
	Weeks of age										
Source	**0-1**	**1-2**	**2-3**	**3-4**	**4-5**	**5-6**	**6-7**	**0-4**	**0-7**	**0-4**	**0-7**
Treatment[1]	NS	*	**	**	**	**	**	**	**	**	**
C-0% SM	160	237[a]	428[c]	595[de]	781[b]	929[c]	965[b]	1420[b]	4097[b]	1.72[a]	2.10[a]
3% SM-wk_2	159	234[a]	506[a]	689[a]	851[a]	978[a]	1041[a]	1588[a]	4461[a]	1.85[bc]	2.31[b]
3% SM-$wk_{2\&3}$	158	244[a]	377[d]	632[bc]	788[b]	943[bc]	987[b]	1411[b]	4131[b]	1.78[ab]	2.19[ab]
6% SM-wk_2	158	199[c]	451[b]	614[cd]	780[b]	948[b]	976[b]	1421[b]	4126[b]	1.81[bc]	2.19[ab]
6% SM-$wk_{2\&3}$	157	221[b]	355[e]	648[b]	760[c]	898[d]	877[c]	1379[c]	3917[c]	1.88[c]	2.22[b]
SEM[2]	±1.0	±1.0	±1.1	±3.1	±1.8	±2.1	±6.1	±3.8	±12.1	±0.01	±0.02

[1]C-0% SM, control; 3% SM-wk_2, diet supplemented with 3% SM during the second week; 3% SM-$wk_{2\&3}$, diet supplemented with 3% SM during the second and third weeks; 6% SM-wk_2, diet supplemented with 6% SM during the second week; 6% SM-$wk_{2\&3}$, diet supplemented with [2]SEM, pooled standard error of the mean.

6% SM during the second and third weeks.

[a-e]Means within column without common superscript letter are significantly different ($P < .05$).

NS, not significant; *$P < .05$; **$P < .01$.

Carcass composition

Data for carcass composition obtained at seven weeks of age are presented in Table 4. Body weight and carcass weight of birds fed the 6% SM for two weeks were significantly ($P < .05$) lower than those of control and other treatments.

Table 4. Least squares means of body characteristics of male and female ISA Vedette broiler chicks slaughtered at seven weeks of age

Source	Carcass weight (g)	Abdominal fat (g)	AF/BW[1] (%)
Treatment[2]	**	NS	NS
C-0% SM	1463[a]	25.8	1.25
3% SM-wk_2	1462[a]	27.9	1.37
3% SM-$wk_{2\&3}$	1433[a]	23.3	1.25
6% SM-wk_2	1397[ab]	25.8	1.30
6% SM-$wk_{2\&3}$	1314[b]	23.2	1.23
Sex	**	**	**
Male	1494[a]	21.7[a]	1.06[a]
Female	1333[b]	28.7[b]	1.50[b]
SEM[3]	±12.24	±0.99	±0.047

[1]Percentage abdominal fat/body weight.

[2]C-0% SM, control; 3% SM-wk_2, diet supplemented with 3% SM during the second week; 3% SM-$wk_{2\&3}$, diet supplemented with 3% SM during the second and third weeks; 6% SM-wk_2, diet supplemented with 6% SM during the second week; 6% SM-$wk_{2\&3}$, diet supplemented with 6% SM during the second and third weeks.

[3]SEM, pooled standard error of the mean.

[a-b]Means within a column without common superscript letter (a-b) are significantly different ($P < .05$).

NS, not significant; *$P < .05$; **$P < .01$.

Sex significantly ($P < .01$) affected carcass weight, abdominal fat, and percent abdominal fat/body weight. Males were heavier ($P < .05$) and showed less abdominal fat than females. Similar findings have been documented previously [6, 23].

Abdominal fat and its percentage of body weight were not significantly different among groups. This observation supports the finding of Deaton et al. [24] who noted comparable percentage abdominal fat for broilers weighing 1580 or 2300 g. Similarly, Cable and Waldroup [25] reported that feed restriction for six or 12 days had no effect on abdominal fat at 49 days. However, Cherry et al. [26] found that early feed restriction increased abdominal fat deposition in two of four broiler strains studied and decreased in the other two strains. Conflicting results of this kind could result from differences in the experimental procedure used such as the level and duration of feed restriction, age at which feed restriction was imposed, and strain of the bird. The nonsignificant effect of feed restriction on abdominal fat, due to SM supplementation, might suggest that the level of SM in the starter diets or the duration of feeding SM supplemented diets was insufficient to reduce adipocyte proliferation or that if such effect did occur was nillified by adipocyte hypertrophy when adequate feed was offered during the realimenation period. Cartwright *et al.* [2] noted that the problem of fat deposition in broilers was apparently related to factors that affected adipocyte hypertrophy or body composition and not adipocyte hyperplasia.

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تقنين غذاء دجاج اللحم بإضافة كسب الساليكورنيا

حمد عبدالعزيز البطشان، فؤاد محمد عطية، و عبدالله علي السبيل

قسم الإنتاج الحيواني، كلية الزراعة، جامعة الملك سعود،

ص. ب. ٢٤٦٠، الرياض ١١٤٥١، المملكة العربية السعودية

(قدم للنشر في ١٤١٩/٥/١٤هـ؛ وقبل للنشر في ٢٨/ ١٠/ ١٤١٩هـ)

ملخص البحث. أجريت هذه التجربة لدراسة تأثير التقنين المبكر للغذاء باستخدام كسب الساليكورنيا في أداء ونسبة دهن البطن لدجاج اللحم. غذيت جميع الكتاكيت خلال الأسبوع الأول على عليقة بادئ. ثم بعد ذلك تبعت المعاملات كما يلي: المعاملة ١، استمرت على عليقة البادئ حتى عمر أربعة أسابيع (الشاهد)؛ المعاملة ٢، كما في المعاملة الشاهد مع إضافة نسبة ٣٪ كسب الساليكورنيا خلال الأسبوع الاول؛ المعاملة ٣، كما في المعاملة الشاهد مع إضافة نسبة ٣٪ كسب الساليكورنيا خلال الأسبوع الأول والثاني؛ المعاملة ٤، كما في المعاملة الشاهد مع إضافة نسبة ٦٪ كسب الساليكورنيا خلال الأسبوع الاول؛ المعاملة ٥، كما في المعاملة الشاهد مع إضافة نسبة ٦٪ كسب الساليكورنيا خلال الأسبوع الأول و الثاني. دلت نتائج هذه التجربة على أن إضافة ٣٪ كسب ساليكورنيا لمدة أسبوع لم تؤثر معنويا على كمية العلف المستهلك ولا على الزيادة في الوزن خلال الفترة ٢-٣ أسابيع مقارنة بالشاهد. إضافة ٦٪ كسب ساليكورنيا لمدة أسبوع قللت معنويا من كمية العلف المستهلك و الزيادة في الوزن مقارنة بالشاهد. إضافة ٦٪ كسب ساليكورنيا لمدة أسبوعين قللت معنويا الزيادة في الوزن. عند التحرر من إضافة كسب الساليكورنيا لمدة أسبوع أو أسبوعين، لم تكن هناك فروق معنوية في الزيادة في الوزن خلال الفترة ٢-٣ و٣-٤ أسابيع، على التوالي. ولكن، هذه الطيور نمت أكثر معنويا من الشاهد خلال الفترة ٣-٤

و٤-٥ أسابيع ، على التوالي. الزيادة التجميعية في الوزن ووزن الجسم عند عمر ٤ و٧ أسابيع كانت الأقل معنويًا للطيور المغذاة على ٦٪ كسب الساليكورنيا لمدة أسبوعين. كذلك كان وزن الذبيحة الأقل معنويًا للطيور المغذاة على ٦٪ كسب الساليكورنيا لمدة أسبوعين. إضافة كسب الساليكورنيا لم تؤثر معنويًا على كمية ونسبة دهن البطن. نستنتج من هذه الدراسة أن كسب الساليكورنيا قلل من كمية العلف المستهلك و الزيادة في الوزن ووزن الجسم. ولكن ، لم تكن إضافة كسب الساليكورنيا ولا مدة تقنين الغذاء فاعلةً في خفض دهن البطن.