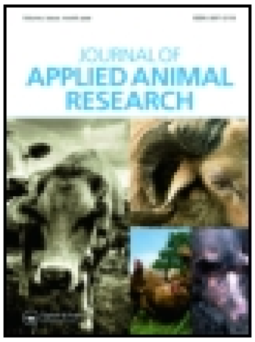

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Which is the best alternative for ascites syndrome prevention in broiler chickens? Effect of feed form and rearing temperature conditions

Alireza Hasani[a], Mehrdad Bouyeh[a], Mliheh Rahati[a], Alireza Seidavi [a], Peter Makovicky[b], Vito Laudadio [c] and Vincenzo Tufarelli [c]

[a]Department of Animal Science, Rasht Branch, Islamic Azad University, Rasht, Iran; [b]Laboratory of Veterinary Histopathology in Komarno, Komarno, Slovak Republic; [c]Department of Emergency and Organ Transplantation (DETO), Section of Veterinary Science and Animal Production, University of Bari 'Aldo Moro', Valenzano, Italy

ABSTRACT

Ascites syndrome (AS) is a metabolic disorder in fast-growing broilers that is characterized by non-tumult fluid collection in the abdomen. The objective of this study was to evaluate the effects of variable feeding and rearing temperature on AS occurrence in broilers. A total of 360 one-day-old male Ross-308 chicks were assigned to three equal groups ($n = 120$) fed pellet, crumble or mash diets and within each group, half of birds ($n = 60$, starting from the 22nd day of age) were reared under two different temperatures: at 23°C (comfort) or at 14°C (cold), respectively. There were six treatments and four replicates including 15 broilers per replicate per treatment. Birds' growth performances and blood parameters as well the incidence of ascites were assessed. The haematocrit percentage, T3 and T4 hormones activity in pellet-fed group under cold temperature conditions were significantly higher ($P < .05$) than the other groups. Based on the results, the occurrence of AS under mash-fed regime was less than pellet and crumble dietary groups ($P > .05$). Further, feeding of mash diet reduced broilers' feed consumption per unit of time, especially by level of achieving energy that is reducing the growth and AS.

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Ascites syndrome; diet form; rearing temperature; broiler

1. Introduction

Ascites syndrome (AS) is one of the serious health and economic problems in commercial broilers' breeding practice. Ascites (pulmonary hypertension syndrome or 'water belly diseases') is a metabolic disorder, characterized by hypoxaemia, increased workload of the cardiopulmonary system, central venous congestion, an excessive accumulation of fluid in body coelomic cavities, hypertrophy of the right ventricle and flaccid heart and finally death (Riddell 1991; Olkowski et al. 1999; Luger et al. 2003; Baghbanzadeh & Decuypere 2008). The causes of AS are multifactorial and mainly induced by exogenous and/or endogenous factors (i.e. interaction between physiological, environmental and management factors) (Wideman et al. 2013). The increased haemodynamic burden and reduced structural density of the venous wall constitute various conditions conducive for seepage and accumulation of fluid (Chen et al. 2014). It has been reported that feeding regime has a significant impact on the incidence of AS in broilers. The work of Maxwell et al. (1991) shows that feed overconsumption, resulting in fat deposition, is a possible cause of the triggering of AS. Jantosovic (2001) and Baghbanzadeh and Decuypere (2008) showed that AS is caused by a primary pulmonary hypertension, which is the result of lack of vascular capacity.

Selection for fast-growing broilers with continual effort to reduce the interval between tissue growth and feed conversion caused an increase in the incidence of AS (Van As et al. 2010; Kalmar et al. 2013).

Kalmar et al. (2013) found that birds selected for low feed conversion ratio (FCR) with low rates of heat production that were stimulated to a higher heat production by a low ambient temperature had difficulties in adapting to environmental changes. Moreover, it has been shown that the highest incidence of ascites occurs in broilers that combined low FCR with fast growth rate, whereas in broilers with either slower growth or higher FCR, the incidence of ascites was much lower. A low FCR in fast-growing birds was attributed to low values of heat production. Furthermore, birds selected for a combination of both fast growth and low FCR had low pO_2 and high pCO_2 in venous blood at low ambient temperature compared with the slower growing birds (Decuypere et al. 2005).

By increasing the amount of fat, muscle and connective tissue, the heart is unable to push sufficient blood through the lungs, determining ventricular hypertrophy. Recent literature showed that some management practices may prevent AS; in fact it was found that feed restriction can reduce the syndrome incidence (Teimouri et al. 2005). Tumova et al. (2007) showed that feed restriction resulted in compensatory accelerated growth and did not affect mortality of broilers. McGovern et al. (1999) also assessed that feed restriction reduced the incidence of AS, even if Singh et al. (2011) reported that feed restriction is not always an advantage.

CONTACT Vincenzo Tufarelli vincenzo.tufarelli@uniba.it; Alireza Seidavi alirezaseidavi@iaurasht.ac.ir

Other factors affecting AS occurrence were ascribed to environmental conditions such as temperature, oxygen and dust percentage in air, as well as microorganisms, toxins, disbalance of nitric oxide metabolism, vitamin E and/or selenium. However, there are few available literatures evaluating this topic.

Therefore, the objective of this study was to determine the effect of feed form (mash, pellet and crumble) in commercial-type broilers reared under comfort or cold environmental conditions on growth performance, blood biochemistry and AS occurrence.

2. Materials and methods

2.1. Ethical rules

The experiment has been approved by the Institution's Ethic Committee of Rasht Branch, Islamic Azad University, Rasht, Iran, and care was taken to minimize the number of animals used.

2.2. Animals, management and treatments

The trial was conducted in a poultry facility at Khorramdarreh, Iran, and Rasht Branch (Islamic Azad University, Rasht, Iran). Three-hundred and sixty male Ross-308 (Aviagen, Newbridge, Scotland, UK) broilers (42 ± 4.0 g BW) were purchased, then transferred into the rearing area and divided into six groups including 60 broiler chicks each. On the first day, a 24-h lighting was provided, which was followed by 23-h lighting per day for the remainder of the experimental feeding period. The feeding trial lasted 42 days. The different dietary treatments were applied and included mash, pellet and crumble diets (Chineh Co, Tehran, Iran) and two different rearing temperature conditions (comfort at 23°C and cold at 14°C) as follows:

Treatment 1: Mash diet from 1 to 42 days of age under comfort temperature conditions (23°C from 15 to 42 days of age);
Treatment 2: Mash diet from 1 to 42 days of age under cold temperature conditions (14°C from 15 to 42 days of age);
Treatment 3: Pellet diet from 1 to 42 days of age under comfort temperature conditions (23°C from 15 to 42 days of age);
Treatment 4: Pellet diet from 1 to 42 days of age under cold temperature conditions (14°C from 15 to 42days of age);
Treatment 5: Crumble diet from 1 to 42 days of age under comfort temperature conditions (23°C from 15 to 42 days of age);
Treatment 6: Crumble diet from 1 to 42 days of age under cold temperature conditions (14°C from 15 to 42 days of age).

The ingredient composition of the diets used as well as the nutrient composition is presented in Table 1. Feed and water were supplied *ad libitum* throughout the experimental period and the consumption recorded weekly. Birds' mortality rate, feed intake and refusals and body weight and body weight gain were weekly recorded and FCR was calculated accordingly.

Table 1. Ingredients and nutrient analysis of diets fed to broilers.

Ingredients (%)	Starter period	Finisher period
Corn	44.29	47.95
Soybean meal, 44% CP	34.85	26.99
Wheat	10.0	10.0
Meat meal	5.00	5.00
Sunflower oil	2.17	6.25
Dicalcium phosphate	0.78	0.54
Calcium carbonate	0.86	1.05
Sodium bicarbonate	0.12	0.12
Sodium chloride	0.25	0.25
DL-Methionine	0.07	0.22
Enzymes	1.00	1.00
Antioxidants	0.02	0.02
Vitamin-mineral mixture[a]	0.50	0.50
Nutrient analysis		
ME (kcal/kg)	2900	3200
Crude protein (%)	22.0	19.0
Calcium (%)	1.0	1.0
Available phosphorus (%)	0.48	0.42
Lysine (%)	1.28	1.06
Methionine (%)	0.40	0.48
Methionine + cysteine (%)	0.73	0.76
Threonine (%)	0.84	0.71

[a]Vitamin A: 5000 IU/g; Vitamin D3: 500 IU/g; Vitamin E: 3 mg/g; Vitamin K3: 1.5 mg/g; Vitamin B2: 1 mg/g; Calcium Pantothenate: 4 mg/g; Niacin: 15 mg/g; Vitamin B6: 13 mg/g; Cu: 3 mg/g; Zn: 15 mg/g; Mn: 20 mg/g; Fe: 10 mg/g; K: 0.3 mg/g.

2.3. Blood biochemistry and haematology and heart parameter

At the end of the feeding period (42nd day of age), one broiler per replicate was selected for blood sampling. Blood samples were collected into EDTA tubes from the wing veins. Samples were transferred to the biochemical and haematological laboratory for analysis within two hours after collection. Biochemical analysis was made according to the standard protocols of commercial laboratory kits. The levels of plasma total cholesterol (TCH) and high-density lipoprotein (HDL)-cholesterol, triglycerides (TG), uric acid (UA), globulin (G), triiodothyronine (T3), thyroxine (T4), white blood cell (WBC), heterophils, lymphocytes, monocytes and haematocrit were determined using standard methodology according to the diagnostic kits (TeifAzmoon Pars Co, Tehran, Iran). Right ventricle/total ventricle was measured in broilers on the 42nd day of age according to Julian et al. (1987).

2.4. Statistical analysis

This study was based on a factorial design with six treatments and four replicates including 15 broilers per replicate per treatment. Data were analysed by Statistical Package for the Social Sciences (SPSS 1997) using the generalized linear model (GLM) procedure and the statistical comparison was made by Duncan's test at $P < .05$. All percentage data were converted to arc sine and mortality data were transformed to square root of $n + 1$ prior to analysis. The data recorded as ratio or percentage were adjusted within the range between 0 and 30% into their square root.

3. Results and discussion

The results on broilers' feed intake, body weight gain and FCR are reported in Table 2. In a recent study, Shahir et al. (2012)

Table 2. Performance traits of broilers fed the different forms of diet under different temperature conditions.

Treatment	Feed intake (g)	BW gain (g/day)	FCR
Starter period (1–21 days)			
Diet form (Mash) – Temperature (Comfort)	1181.12[b]	38.02[a]	1.47[b]
Diet form (Mash) – Temperature (Cold)	–	–	–
Diet form (Pellet) – Temperature (Comfort)	1196.50[a]	37.82[a]	1.50[a]
Diet form (Pellet) – Temperature (Cold)	–	–	–
Diet form (Crumble) – Temperature (Comfort)	1187.87[ab]	37.42[b]	1.51[a]
Diet form (Crumble) – Temperature (Cold)	–	–	–
P-value	*	**	*
SEM	3.38	0.10	0.005
Finisher period (22–42 days)			
Diet form (Mash) – Temperature (Comfort)	3440.00[c]	84.76[d]	1.93[ab]
Diet form (Mash) – Temperature (Cold)	3677.75[a]	89.47[b]	1.95[a]
Diet form (Pellet) – Temperature (Comfort)	3490.25[b]	86.66[c]	1.91[b]
Diet form (Pellet) – Temperature (Cold)	3702.75[a]	91.67[a]	1.92[b]
Diet form (Crumble) – Temperature (Comfort)	3490.00[b]	86.78[c]	1.91[b]
Diet form (Crumble) – Temperature (Cold)	3658.33[a]	91.38[a]	1.90[b]
P-value	**	**	*
SEM	15.39	0.23	0.010
Total period (1–42 days)			
Diet form (Mash) – Temperature (Comfort)	4610.00[c]	61.38[d]	1.78[b]
Diet form (Mash) – Temperature (Cold)	4870.00[a]	63.76[b]	1.81[a]
Diet form (Pellet) – Temperature (Comfort)	4684.00[b]	62.33[c]	1.78[b]
Diet form (Pellet) – Temperature (Cold)	4902.00[a]	64.66[a]	1.80[ab]
Diet form (Crumble) – Temperature (Comfort)	4670.00[b]	62.09[c]	1.79[b]
Diet form (Crumble) – Temperature (Cold)	4854.33[a]	64.41[a]	1.79[b]
P-value	**	**	*
SEM	15.41	0.11	0.007

Note: Means within each column with no common superscript differ significantly (*$P < .05$, **$P < .01$).

found that in broilers the performances (body weight gain and feed efficiency) were improved under cold condition at the end of the rearing period. According to their research, it seems that the cold condition at early age reduces AS in broilers through altered thyroid hormones metabolism and leukocyte function. Another work showed that AS incidence was clearly higher in cold-exposing chickens compared with normal rearing chickens

Table 3. Water intake (cc/bird/wk) of broilers fed the different forms of diet under different temperature conditions.

Treatment	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Diet form (Mash) – Temperature (Comfort)	58.75[b]	100.00	200.00	250.00[a]	310.00[a]	340.00[b]
Diet form (Mash) – Temperature (Cold)	–	–	–	202.50[c]	220.00[d]	240.00[d]
Diet form (Pellet) – Temperature (Comfort)	66.50[a]	103.75	205.00	252.50[a]	302.50[b]	352.50[a]
Diet form (Pellet) – Temperature (Cold)	–	–	–	211.25[b]	230.00[c]	252.50[c]
Diet form (Crumble) – Temperature (Comfort)	59.50[b]	101.25	200.00	250.00[a]	310.00[a]	345.00[b]
Diet form (Crumble) – Temperature (Cold)	–	–	–	206.66[bc]	218.33[d]	241.66[d]
P-value	*	ns	ns	**	**	**
SEM	0.85	2.11	2.04	2.04	1.88	1.98

Note: Means within each column with no common superscript differ significantly (*$P < .05$, **$P < .01$, ns: not significant).

Table 4. Mortality rate (%) of broilers fed the different forms of diet under different temperature conditions.

Treatment	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Diet form (Mash) – Temperature (Comfort)	0.00	0.00	0.25	0.25	0.00	0.00
Diet form (Mash) – Temperature (Cold)	0.00	0.00	0.25	0.50	0.50	0.00
Diet form (Pellet) – Temperature (Comfort)	0.00	0.00	0.25	0.25	1.00	0.00
Diet form (Pellet) – Temperature (Cold)	0.00	0.00	0.25	1.25	0.75	0.00
Diet form (Crumble) – Temperature (Comfort)	0.00	0.00	0.50	0.50	0.25	0.00
Diet form (Crumble) – Temperature (Cold)	0.00	0.00	0.66	1.00	0.66	0.00
P-value	ns	ns	ns	*	*	ns
SEM	0.00	0.00	0.31	0.54	0.53	0.00

Note: Means within each column with no common superscript differ significantly (*$P < .05$, ns: not significant).

(Moayyedian et al. 2011). Further, the results of Namakparvar et al. (2014) show that AS was not correlated with body weight gain and FCR in commercial broiler chickens.

The results related to the broiler water intake, mortality rate and AS occurrence are reported in Tables 3, 4 and 5, respectively. In broilers, the first AS observations were recorded at 3 weeks of age and the best results were detected in birds under Treatments 1 and 2. The values of blood biochemistry in broilers are reported in Table 6, whereas the haematology parameters in Table 7. The findings of Druyan et al. (2009) dealing with AS-susceptible and -resistant broilers showed no differences in haemoglobin concentrations, and the same authors reported no significant differences between haematocrit, red blood cell count, haemoglobin concentration, haemoglobin count and blood oxygen saturation. In the present trial, we have obtained the same trend of results. Moreover, our results showed that T3 and T4 hormones' activity in the pellet-fed group under cold rearing condition was significantly higher than the other dietary groups. In a recent study, Wang

Table 5. AS (%) occurrence in broilers fed the different forms of diet under different temperature conditions.

Treatment	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Diet form (Mash) – Temperature (Comfort)	0.00	0.00	0.00	0.00	0.00	0.00
Diet form (Mash) – Temperature (Cold)	0.00	0.00	0.00	0.25	0.25	0.00
Diet form (Pellet) – Temperature (Comfort)	0.00	0.00	0.25	0.25	0.75	0.00
Diet form (Pellet) – Temperature (Cold)	0.00	0.00	0.25	1.00	0.50	0.00
Diet form (Crumble) – Temperature (Comfort)	0.00	0.00	0.50	0.25	0.25	0.00
Diet form (Crumble) – Temperature (Cold)	0.00	0.00	0.66	0.66	0.66	0.00
P-value	ns	ns	*	*	*	ns
SEM	0.00	0.00	0.27	0.36	0.38	0.00

Note: Means within each column with no common superscript differ significantly (*$P < .05$, ns: not significant).

Table 6. Blood biochemistry parameters in broilers fed the different forms of diet under different temperature conditions.

Treatment	G (mg/dl)	TCH (mg/dl)	TG (mg/dl)	UA (mg/dl)	HDL (mg/dl)	T3 (ng/mg)	T4 (ng/mg)
Diet form (Mash) – Temperature (Comfort)	178.12^{b}	145.14^{a}	112.07^{a}	4.20^{ab}	44.39^{e}	2.60^{d}	31.10^{b}
Diet form (Mash) – Temperature (Cold)	102.18^{f}	119.00^{d}	98.14^{c}	2.41^{c}	71.03^{a}	3.22^{b}	35.07^{a}
Diet form (Pellet) – Temperature (Comfort)	180.12^{a}	127.43^{b}	102.16^{b}	3.95^{ab}	50.50^{d}	2.80^{c}	32.02^{b}
Diet form (Pellet) – Temperature (Cold)	125.25^{d}	126.43^{b}	97.00^{c}	4.37^{a}	51.57^{c}	3.52^{a}	35.17^{a}
Diet form (Crumble) – Temperature (Comfort)	173.27^{c}	122.75^{c}	104.12^{b}	4.05^{ab}	57.32^{b}	2.70^{cd}	31.50^{b}
Diet form (Crumble) – Temperature (Cold)	115.06^{e}	112.66^{e}	102.16^{b}	3.23^{b}	57.23^{b}	3.30^{b}	34.73^{a}
P-value	**	**	**	**	**	**	**
SEM	0.30	0.49	0.63	2.93	0.21	0.06	0.38

Notes: Means within each column with no common superscript differ significantly (*$P < .05$, **$P < .01$).
G, globulin; TCH, total cholesterol; TG, triglycerides; UA, uric acid; HDL, high-density lipoprotein cholesterol; T3, triiodothyronine; T4, thyroxine.

Table 7. Haematology parameters of broilers fed the different forms of diet under different temperature conditions.

Treatment	WBC ($n \times 10^3$/mL)	Heterophils (%)	Lymphocytes (%)	Monocytes (%)	Haematocrit (%)
Diet form (Mash) – Temperature (Comfort)	30.72^{f}	38.25^{c}	58.75^{d}	3.00^{b}	33.40^{d}
Diet form (Mash) – Temperature (Cold)	34.12^{e}	46.00^{a}	50.51^{f}	3.23^{a}	34.05^{c}
Diet form (Pellet) – Temperature (Comfort)	42.14^{c}	41.75^{b}	56.75^{e}	1.50^{e}	34.90^{b}
Diet form (Pellet) – Temperature (Cold)	51.50^{a}	32.75^{e}	64.51^{b}	2.75^{c}	35.70^{a}
Diet form (Crumble) – Temperature (Comfort)	38.70^{d}	37.74^{d}	59.52^{c}	2.76^{c}	34.09^{c}
Diet form (Crumble) – Temperature (Cold)	44.33^{b}	32.74^{e}	65.12^{a}	2.25^{d}	35.00^{b}
P-value	**	**	**	**	**
SEM	0.008	0.964	0.032	0.024	0.500

Notes: Means within each column with no common superscript differ significantly (*$P < .05$, **$P < .01$).
WBC, white blood cells.

et al. (2012) dealing with some biochemical parameters in cold-induced AS in broilers showed that serum glucose and cholesterol level in AS broilers were significantly increased and there was no significant difference in triglyceride and blood urea nitrogen levels. Our results did not show differences in serum glucose of broilers.

The heart parameter (right ventricle/total ventricle) in broilers is reported in Table 8. In a previous trial from Olkowski et al. (1998), it was found that hearts from healthy broilers had quite normal right and left ventricles, but overall 30% of AS broilers had a normal left ventricle, but a right ventricular dilation was found in all AS broilers. From our findings it was possible to observe an association between heart morphology and AS development. Accordingly, Al-Masri and Hassanzadeh (2010) demonstrated that there is an association between the insufficiency of the cardiopulmonary system with the function of the venous blood gas parameters and the development of AS in fast-growing broiler chickens. Moreover, recently Wideman et al. (2013) stated that AS is an inflammatory disease involving both environmental and immune system components.

In conclusion, our study showed that in broilers the occurrence of AS under mash-fed regime was less than in pellet- and crumble-fed groups. Moreover, feeding of mash diet reduced broilers' feed consumption per unit of time, especially by level of achieving energy that is reducing the growth and AS.

Table 8. Heart parameter (%) ratio of broilers fed the different forms of diet under different temperature conditions.

Treatment	Right ventricle/Total ventricle
Diet form (Mash) – Temperature (Comfort)	26.12^{d}
Diet form (Mash) – Temperature (Cold)	32.00^{b}
Diet form (Pellet) – Temperature (Comfort)	31.00^{b}
Diet form (Pellet) – Temperature (Cold)	33.87^{a}
Diet form (Crumble) – Temperature (Comfort)	28.00^{c}
Diet form (Crumble) – Temperature (Cold)	33.12^{a}
P-value	**
SEM	0.37

Note: Means within each column with no common superscript differ significantly (**$P < .01$).

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Disclosure statement

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ORCID

Alireza Seidavi http://orcid.org/0000-0002-1903-2753
Vito Laudadio http://orcid.org/0000-0003-3306-0205
Vincenzo Tufarelli http://orcid.org/0000-0003-0089-4393

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