UNIVERSITÄT HOHENHEIM

Faculty of Agricultural Sciences

Institute of Farm Animal Ethology and Poultry Science

Prof. Dr. Werner Bessei

Effect of sodium and potassium chloride supplementation in drinking water on performance of laying hens and broilers under high ambient temperature

Dissertation

Submitted in fulfilment of the requirements for the degree

''Doktor der Agrawissenschaften''

(Dr.sc.agr./Ph.D. in Agricultural Sciences)

to the

Faculty of Agricultural Sciences

presented by

NGUYEN VAN DAI

born in Viet Nam

Stuttgart-Hohenheim, June 2008

This thesis was accepted as a doctoral dissertation in fulfilment of the requirements for the degree ''Doktor der Agrawissenschaften'' by Faculty of Agricultural Sciences

At Universität Hohenheim on June 18, 2008

Date of oral examination on July 18, 2008

Examination committee

Supervisor and reviewer: Prof. Dr. Werner Bessei

Co-Reviewer: Prof. Dr. Anne Valle Zárate

Additional examiners: Prof. Dr. Werner Amselgruber

Vice-Dean and Head of the Committee: Prof. Dr. Werner Bessei

DECLARATION

I assure that this doctoral thesis is the result of my personal work and that no other than the indicated aids have been used for its completion. All quotations and statements that have been used are indicated. Furthermore I assure that the work have not been used, neither completely nor in parts, for achieving any other academic degree.

Stuttgart-Hohenheim, June 2008
Nguyen Van Dai

TABLE OF CONTENTS

Table of contents i

List of abbreviations iii

1 Introduction 1

1.1 Background and research objective 1

1.2 Design of the study 3

1.3 Structure of the thesis 5

2 General discussion 6

2.1 Effect of heat stress and NaCl or KCl supplementation in drinking water on water and feed intake, feed conversion ratio and water: feed ratio 6

2.2 Effect of heat stress and NaCl or KCl on body weight 8

2.3 Effect of heat stress and NaCl or KCl on body temperature 9

2.4 Effect of heat stress and NaCl or KCl on egg production and egg quality 10

2.5 Effect of NaCl and KCl on carcass characteristics in broilers 11

2.6 References 12

3 Effect of potassium chloride supplementation in drinking water on water and feed intake and egg quality of laying hens under cyclic heat stress 18

3.1 Abstract 19

4 Effect of sodium chloride supplementation in drinking water on water and feed intake and egg quality of laying hens under cyclic heat stress 20

4.1 Abstract 21

5 Effects of sodium chloride and potassium chloride supplementation in drinking water on performance of broilers under tropical summer conditions 22

5.1 Abstract 23

6 Summary 24

7 Zusammenfassung 27

8 Tóm TẮT **30**

LIST OF ABBREVIATIONS

CFS	Compression fracture strength
FCR	Feed Conversion Ratio
g	gram
hrs	hours
HU	Haugh Units
KCl	Potassium chloride
LH	Leuteinizing hormone
LSM	Least square mean
MJ	Megajoule
ml	milliliter
mm	millimeter
N	Newton
NaCl	Sodium chloride
NRC	National Research Council

1 INTRODUCTION

1.1 Background and research objective

Poultry has an important role amongst agricultural industries in many countries. Poultry products are the major source of animal protein for most people throughout the world. There are many factors which can decrease the performance such as diseases, management, nutritional deficiencies, housing and climate etc. Temperature is a major environment variable that affects poultry production. Under tropical conditions, high temperature especially when coupled with high humidity, imposed severe stress on birds and leads to poor performance, increased mortality (Daghir, 1995), decreased growth rate in broilers (Lin et al, 2005) and reduced egg production and poor eggshell quality in laying hens (Saffar and Rose, 2002). Therefore, keeping chicken in high ambient temperature is a big problem, especially in developing countries where farmers cannot afford air conditions in poultry houses.

Several methods have been suggested for maintaining performance of birds in high temperature. Genetic selection to improve tolerance to high temperature was studied by Arad and Marder (1982), Setter et al. (1999), Gowe and Fairfull (1995). Important genes related to heat tolerance were studied such as the major gene for naked neck (Na) (Yalcin et al., 1997), scaleless (Cahaner, 2007), dwarf (dw) (Gowe and Fairfull, 1995), indicating a genetic component in heat tolerance. Acclimatization of chicken to heat stress was shown by Reece et al. (1972), Deaton et al. (1982), Leeson (1986), Sykes and Fataftah (1986). Chicken house environment management and housing design were considered for chicken in high ambient temperature (Teeter, 1994; Ernst, 1995). However, in general these methods are too expensive and too difficult to be applied by small holders in developing countries. Nutritional strategies for reducing heat load are also very important and may be easier to apply. The use of high density feeds, alternation of the energy: protein ratio, improving the amino acid profile, addition of vitamins, alternation of the anion:cation balance, use of lipids as source of energy supplied, use of time feeding were recommended by Gous and Morris (2005). Water, in addition to being a vital nutrient, is involved in many aspects of poultry metabolism, digestion and absorption of food, transport of nutrients, and the elimination of waste products via urine from the body, and body temperature control (Jafari et al., 2006).

In heat stress, water intake becomes more important for chicken by evaporative cooling through the respiratory system.

The role of water intake on chicken under heat stress was reported by Belay and Teeter (1993), Balnave and Brake (2005), and survival of chicken in hot environment depends on the consumption of large volumes of water (Fox, 1951). Bessei (1998) showed that there is considerable individual variation of water intake within breeds which can not be explained by maintenance and performance. Birds showing high voluntary water intake under moderate temperature seem to better cope with episodic heat stress. This finding was confirmed in a study, which revealed that birds with excess water consumption under moderate conditions, maintained high feed intake and egg production under heat stress while birds with low water intake reduced egg production (Bessei et al., 1999). Wilson (1949) found that White Leghorn hens which voluntary consumed more water under hot environmental temperature than New Hampshire and Rhode Island Red hens, maintained high egg production under these conditions. So, it is not unreasonable to assume that such birds will benefit from an increase in water intake.

There are various methods to increase water intake in chicken. Supplementation of sodium and potassium salts in the diet or in drinking water was reported to increase water intake (Teeter, 1994; Smith, 2001). Furthermore, it is known that mineral salts should be supplemented for chicken under heat stress, because heat stress modifies the extent of mineral excretion leading to mineral unbalance. The negative effect of heat stress on electrolytes balance was reported by Ait-Boulahsen (1989), Deyhim and Teeter (1991b), Brake et al. (1994), Belay and Teeter (1996). Supplementation of minerals, such as NaCl and KCl, is recommended to compensate for the losses of minerals through excretion. It seems better to provide electrolytes through the drinking water than through feed, because in high ambient temperature, water intake is increased while feed intake is reduced. Most of studies have focused on the effects of mineral salts on the performance and egg characteristics in the moderate conditions (Yoselewitz and Balnave, 1989; Khafafalla and Bessei, 1996; Damron B.L., 1998; Richter et al. 2006), studies of mineral supplementation in drinking water for heat stressed laying hens and broilers under tropical field conditions are scare.

The objective of this study is to elucidate the role of high voluntary water intake by supplementation sodium or potassium chloride in drinking water on heat tolerance under high temperature conditions in laying hens and broilers.

1.2 Design of the study

The study including three experiments was conducted in two environmental conditions: controlled temperature conditions and tropical field conditions. Two experiments were carried out with laying hens in controlled temperature conditions at Hohenheim University, Germany. One experiment was conducted with broilers in tropical summer conditions of Viet Nam.

The first experiment was conducted to study the effect of cyclic heat stress and KCl supplementation in drinking water on laying hens. A total of 48 Hisex hens (76 weeks old) were kept in individual laying cages in environmental controlled chambers and were randomly allocated to three experimental groups of 16 hens each. These groups were given 0; 0.2 and 0.4 % KCl in the drinking water for seven consecutive days of heat stress. Before and after heat stress, the birds were given normal drinking water. Water and feed were provided *ad libitum*. The birds were fed a layer diet containing 11.45 MJ/kg Metabolizable Energy (ME), 16.97 % Crude Protein (CP), 3.73% calcium (Ca), 0.62% phosphorus (P), 0.22% sodium (Na) and 0.33% chloride (Cl). The study was done at the research station of Hohenheim University, Germany from 26 March to 16 April 2007 (3 weeks). The room temperature was kept constant at 21±1°C for 7 days, afterwards, it was cycled from 21±1°C to 34±1°C (from 9 to 22 hrs) for 7 days, and then constant at 21±1°C for 7 days. Humidity was not controlled. 14-hours lighting schedule was maintained during the experiment. Water and feed intake, water: feed ratio, body weight, body temperature, egg production, egg weight, eggshell thickness, egg deformation, eggshell strength, yolk colour and Haugh Units (HU) were recorded.

In the second experiment, the effect of NaCl supplementation (0.2 and 0.4%) in drinking water on laying hens was tested under the same temperature program as in the first experiment. A total of 48 Hisex hens (80 weeks old) were used.

In the third experiment, the effect of NaCl or KCl supplementation in drinking water on performance of broilers under tropical summer conditions of Viet Nam was studied. The study was conducted on a commercial chicken farm from 26 June to 14 August 2007 (49 days) in Song Cong Town, Thai Nguyen province situated in mountainous and midland region of northeastern Viet Nam. It lies in the monsoon tropical climate zone with summer season from May to October and winter season from November to April. The average summer temperature is about 29°C and humidity is about 75%. A total of 240, 21-day-old broiler chicks (Lohmann Meat) provided by Viet Nam Japfa Comfeed Indonesia were randomly allocated into 5 treatmental groups. Each treatment group consisted of three replicates of 16 chickens each. NaCl or KCl was supplemented at 0.2% and 0.4% to drinking water, and unsupplemented water was used as control. NaCl or KCl was supplemented from the beginning of the 4^{th} to 7^{th} weeks of age. Birds were vaccinated according to the recommended commercial poultry practices being used in the region. The birds were kept in an open sided poultry house on the rice hull litter. Temperature and humidity of the house were not controlled. The light program was 24 hours light from 1-3 weeks of age, thereafter, 18 hours light per day. Water and feed were provided *ad libitum*. Water was offered by nipple drinkers. Commercial broiler feed (starter, grower and finisher) were used. Water and feed consumption, feed conversion ratio (FCR), body weight, body weight gain, body temperature, carcass traits and mortality were recorded.

The experimental data were statistacally analyzed by JMP 5.0.1 program (SALL et al., 2005). The effect of salt supplementation was tested by the MANOVA analysis with salt concentration as fixed effect and the period (before, during and after heat stress) as the repeated measurement.

Differences between means of salt concentrations within the periods were tested by Student's t-test. using ANOVA procedure. Differences of means between periods with salt concentration were tested by Matched Pairs test. MANOVA and Matched Pairs analysis was not applied for egg quality analysis since hens did not lay every day, and the data contained too many missing values. The two following statistical models were used:

The first model was used for analysis between groups:

$y_{ij} = \mu + S_i + e_{ij}$

y_{ij} = Parameter of j bird in i group

μ = Total mean

S_i = Effect of salt supplementation (NaCl or KCl) (i= 0, 0.2, 0.4%)

e_{ij} = error

The second model was used for analysis the experimental periods:

$(y_{ij})_{p1} + (y_{ij})_{p2} + (y_{ij})_{p3} = \mu + S_i + e_{ij}$

$(y_{ij})_{p1} + (y_{ij})_{p2} + (y_{ij})_{p3}$ = Parameter of period 1, 2, 3 (before, heat stress and after heat stress)

μ = Total mean

S_i = Effect of salt supplementation (NaCl or KCl (i= 0, 0.2, 0.4%)

e_{ij} = error

1.3 Structure of the thesis

Chapter 1 includes introduction and general discussions.

Chapter 2 (corresponding to paper 1) describes the effect of heat stress and KCl supplementation in drinking water on water and feed intake, water:feed ratio, body weight, body temperature, egg laying rate, and egg quality of laying in hens in cyclic heat stress under controlled conditions.

Chapter 3 (corresponding to paper 2) describes the effect of heat stress and NaCl supplementation in drinking water on water and feed intake, water: feed ratio, body weight, body temperature, egg laying rate, and egg quality of laying in hens in cyclic heat stress under controlled conditions.

Chapter 4 (corresponding to paper 3) presents the effect of NaCl or KCl supplementation in drinking water on water and feed intake, water: feed ratio, feed conversion, body weight, body temperature, and carcass characteristics of broiler under summer conditions of Viet Nam.

2 GENERAL DISCUSSION

2.1 Effect of heat stress and NaCl or KCl supplementation in drinking water on water and feed intake, feed conversion ratio and water: feed ratio

Water intake in chicken varies with age, breed, ambient temperature, humidity, density and nutritional factors. Ambient temperature is probably an important factor affecting water intake of birds (Daghir, 1995). In the present study, cyclic heat stress significantly increased water consumption of laying hens. Hens increased water consumption by 38.8% to 40.5% in the week of heat stress in comparison with the before and after heat stress period. This finding was in agreement with other studies , they showed that water intake increases by 100% when temperature increases from 21°C to 32°C (Portsmouth, 1979), and by 135% when temperature rises from 26.6°C to 37.8°C (Wilson, 1949). The high level of water intake was maintained for the first two days of heat stress only. With continued exposure to high temperatures water intake by hens returned to normal level (Smith, 2001), however the present result of two experiments with laying hens revealed that birds maintained high water consumption during heat stress (7 days), and it only returned to normal when ambient temperature decreased to a moderate level.

Beside temperature, KCl or NaCl supplementation in drinking water increased water intake of hens in our study. Birds receiving 0.2% and 0.4% KCl in drinking water had higher water consumption (27.9% and 29.6%, respectively) in comparison with the control group under heat stress. Even higher water intake was seen in birds receiving 0.2% and 0.4% NaCl in drinking water (38% and 48.8%, respectively). The different water intake between birds receiving two levels of KCl or NaCl supplementation was not significant.

Heat stress combined with KCl or NaCl supplementation in drinking water a had greater effect on water intake of hens than either factors alone. In heat stress, birds receiving 0.2% and 0.4% KCl increased water consumption by 67.6% and 67%, respectively, than before the heat stress period while birds received 0.2% and 0.4% NaCl in drinking water, it increased by 74.7% and 108%, respectively. Hence, supplementation of NaCl was more efficient in increasing water intake than KCl. This was also found in broilers where water intake in high temperature was affected by 0.2% and 0.4% NaCl or 0.4% KCl in drinking water while 0.2% KCl did not affect water intake.

Heat stress usually decreases feed consumption as reported by Emmans (1974), Bird et al. (1988), Cobb (1991), Li et al. (1992) and May and Lott (1992). This decline of feed intake is shown to be in negative correlation with performance of chicken. Smith and Oliver (1972) loc. cit. Daghir (1995) showed that 40-50% reduction in egg production and egg weight at 38°C is due to reduced feed intake. Dale and Fuller (1979) reported that 63% of reduction in growth rate is due to reduced feed intake in high temperature. This decrease is an important response of chicken to heat stress to reduce the metabolic heat load that requires dissipation (Etches et al., 1995). Feed intake decreases by about 0.12 percent for each degree rise in environmental temperature over 21°C (Smith, 2001), and 5% when temperature increased from 26.5 to 37.8 °C (Wilson, 1949). Feed intake of laying fowl fell when temperature was increased to 30°C, on returning to 20°C it increased to normal (Sykes and Fataftah, 1986). In the present study, feed intake of laying hens showed a tendency to decrease in the first three days of heat stress, thereafter it slowly increased to normal again. However, the average feed intake during and before the heat stress period was not significantly different. This finding is not in agreement with Emmans (1974), May and Lott (1992), Smith (2001), who reported that heat stress reduced feed intake of birds. The different results may be due to different intensity of heat stress. In the cyclic heat stress schedule of our study, the temperature returned to normal for several hours, this allowed birds to dissipate the heat stored during heat stress period. Morris (2004) also concluded that constant temperature (30°C) reduced feed intake, laying rate and egg weight in comparison with at 21°C, however cyclic heat stress (30°C in light and 24°C in dark period) did not affect these parameters.

KCl supplementation in diet or drinking water was believed to reduce negative effects of heat stress on chicken (Teeter, 1994; Deyhim and Teeter, 1995), but can not fully correct them (Daghir, 1995). In our study, NaCl and KCl supplementation with two levels (0.2% and 0.4%) did not affect feed intake of both laying hens and broilers in high ambient temperature. Nevertheless, the highest concentration of KCl or NaCl in drinking water had positive effects on FCR which is very relevant economicallsy. Broilers receiving 0.2% NaCl or 0.2% KCl supplementation did not show differences in FCR. The deterioration of FCR under hot conditions can be caused by the disturbance of physiological processes. Hai et al. (2000) reported that the activities of three kinds of enzymes in the intestinal tract (trysin,

chymotripsin, and amylase) were decreased by hot environment (32°C) compared to normal environmental temperature (21°C).

Under temperate conditions, the water: feed intake ratio ranges from about 1.5 to 2.5, and at extremely high temperatures, an even higher ratio may be seen. Interestingly, both meat and egg-type chickens have similar water: feed ratios (Bell, 2002). In the present study, water: feed ratio was from 2 to 2.18 in laying hens before heat stress and it increased to about 2.8 during heat stress. For birds receiving 0.2% and 0.4% KCl in heat stress, water: feed ratio further increased to 3.65 and 3.59, respectively, while in the birds receiving 0.2% and 0.4% NaCl, it increased to 4.52 and 4.56, respectively. The average of water: feed ratio in broilers from 4-7 weeks of age was 2.15 in tropical summer conditions. It increased significantly to 2.78 and 2.93 when broilers received 0.4% KCl and 0.4% NaCl added in drinking water, respectively. The increase in water: feed ratio responding to increasing ambient temperature reflected the extra water requirement for maintaining body temperature. Addition of 0.2% NaCl or KCl did not affect the water: feed ratio.

2.2 Effect of heat stress and NaCl or KCl on body weight

In both experiments with laying hens under cyclic heat stress, body weight had a decreasing tendency when ambient temperature rose. In heat stress, birds responded differently towards KCl or NaCl supplementation. Birds receiving KCl in drinking water maintained body weight during heat stress and thereafter, while birds receiving 0.4% NaCl in drinking water decreased body weight. This decline may not be due to effect of NaCl, because in normal temperature, 0.2% NaCl added in drinking water improved body weight of birds in first laying period (2-3 months of laying age) (Khalafalla, 1996). At high temperature (35°C), broilers receiving 0.39% NaCl in drinking water had better weight gain (Deyhim and Teeter, 1991a). The decline of body weight in the present case may be due to heat stress, and it reveals that NaCl added in drinking water failed to maintain body weight. However, in tropical conditions, broilers receiving 0.4% NaCl added in drinking water had better final weight and body weight gain than birds receiving normal water while KCl supplementation in drinking water did not affect final body weight and body weight gain. The positive effect of NaCl on weight gain in heat stressed broilers is in agreement with Smith (1994), Ross (1979), Balnave et al. (1989), Smith and Teeter (1989), and Ahmad et al. (2004)

2.3 Effect of heat stress and NaCl or KCl on body temperature

The potential of heat loss is a major factor of adaptation to high ambient temperature. Chicken produce heat through metabolic processes and muscular activity. Body temperature increases when the production of metabolic heat exceeds the potential of heat dissipation. When body temperature reaches a critical point (about 47°C), birds will die from heat prostration (Weaver, 2002). In the present study, body temperature of laying hens increased from about 40.8°C at normal ambient temperature to about 41.4°C on the first day of heat stress, in the following days body temperature was tendentiously lower. Body temperature of broilers in tropical conditions (34-35°C and 60-62% humidity) was about 42°C at 23 days of age. When broilers were heavier, body temperature increased to about 43°C. It reveals that heat dissipation in the early age is not a problem since the body surface relative to the body mass is high, and the birds are not fully feathered. Body temperature of broilers in this case may also have been influenced by high humidity which reduces evaporative heat loss from the respiratory tract. The increase in body temperature due to heat stress was reported by Boone and Hughes (1971), who concluded that if the ambient temperature rose slowly, the birds maintained their normal body temperature until the ambient temperature reached 33°C. The increasing water intake may delay the rise in body temperature. Under hot conditions, the immediate increase in water consumption meets the demand for evaporative cooling from respiratory surfaces (Etches et al., 1995). Smith (2001) showed that water is essential for the control of body temperature by the birds in hot environments. Panting is an essential heat loss mechanism under these conditions and lack of water quickly leads to death by hyperthermia. In our study, 0.4% KCl or 0.4% NaCl added in drinking water increased water intake of laying hens, therefore it helped birds to reduce tendentiously body temperature from 0.1 to 0.2°C. At a level of 0.2%, NaCl or KCl had no effect on body temperature. At 40 days of age, the positive effect of increasing water intake on body temperature of broilers was noted in groups receiving 0.4% NaCl or 0.4% KCl in drinking water in comparison with a group receiving 0.2% KCl. Body temperature of birds in these groups was reduced from 0.2 to 0.3°C in comparison with the control group, but it was not significantly different. The results showed that the response of body temperature to mineral supplementation was in agreement

with the above mentioned responses of feed intake and growth rate. Hence change in body temperature is a good criteria to appraise heat stress in chicken.

2.4 Effect of heat stress and NaCl or KCl on egg production and egg quality

The effect of high ambient temperature on egg production appears to be progressive and consequently hens kept at ambient temperature above 32°C show a decline in egg production (Smith, 2001). In the present results, egg production of birds receiving normal drinking water was declined during the first four days of heat stress only, thereafter it increased to normal rate. Mean laying rate during heat stress was not significantly different from the before and after heat stress period. The decrease in laying rate was parallel with the decline of feed intake in heat stress. Etches et al. (1995) reported that the diminished egg production under heat stress is suspected to be at least partly influenced by the ovulatory hormones. Donoghue et al. (1989) showed that reproductive decline in the acute heat stressed hen is mediated by reduced luteinizing hormone (LH) releasing ability of the hypothalamus. The direct physiological effect on egg production can be explained by increased body temperature and reduced blood flow to the uterus in high temperature (Wolfenson et al., 1981).

The negative effect of heat stress on eggshell defects was found in the experiment 1, but it was not significant in the experiment 2. This difference may be due to body temperature of birds in heat stress. It can be seen that hens in experiment 2 had lower body temperature (about 0.1°C) than hens in experiment 1, though the ambient temperature was similar. Ernst (1995) reported that panting due to heat stress increases water evaporation from the respiratory surfaces, but it also results in a loss of carbon dioxide from the blood via the lungs. This results in alkalosis, which interferes with eggshell calcification. This can cause egg shell defects due to poor eggshell formation. In the present study, heat stress decreased eggshell thickness and egg weight and increased eggshell defects. This finding is in agreement with Tyler and Geake (1958), Belyavin et al. (1987) and Zeidler (2002), who reported that ambient temperature above 32°C results in decease in eggshell thickness and shell strength, resulting in increase in percentage of cracked eggs.

The effect of KCl added in diet or drinking water on performance of broilers in heat stress and NaCl added in diet or drinking water on performance of laying hens in moderate conditions have been the subject of several researches, but there is not much information about the effect

of them on performance of laying hens under heat tress. In normal ambient temperature, supplementation of 2g NaCl/l in drinking water (Yoselewitz and Balnave, 1989; Khafaflla and Bessei, 1996) for laying hens increased eggshell defects. However, in Leghorn hens fed diets with no added salt, feed consumption and body weight was declined. After 14 days, there were no ova in the rapidly maturing stage. After 17-21 days, egg production dropped to 0% (Nesbeth et al., 1976). The positive effect of KCl supplementation on broilers under high ambient temperature was reported by Teeter and Smith (1986), Smith and Teeter (1987) and Teeter (1994), however the effect of KCl supplementation in drinking water on laying hens in high ambient temperature has not been documented yet. In the present study, 0.2% or 0.4% KCl added in drinking water supported to maintain the laying rate during the time of heat stress. But this maintenance of laying rate was found with 0.4% NaCl supplementation only. During heat stress, egg weight of birds receiving normal water decreased continuously while birds receiving KCl added in drinking water laid eggs with constant weight. This effect was not seen in the birds receiving NaCl supplementation. Shell thickness was also better when birds received drinking water with 0.4% KCl. However, birds receiving drinking water with NaCl had a tendency of thinner eggshell thickness. Egg shell strength, shell deformation, yolk color and HU were not affected by KCl or NaCl supplementation. Khalafalla (1996) reported that in moderate temperature, 0.2% NaCl supplementation in drinking water did not affect shell deformation, shell strength, HU and yolk color, but decreased shell thickness.

2.5 Effect of NaCl and KCl on carcass characteristics in broilers

Dressing percentage of birds receiving normal water was similar to birds receiving drinking water with 0.4% NaCl and higher than birds receiving water with two levels of KCl and 0.2% NaCl. Abdominal fat increases under high continuous high temperature (32°C) in comparison with 22°C (Ain et al., 1996). This increase was about 1.6 percent with each degree rise in temperature (Smith, 2001). A similar result was shown by Lu et al. (2007) when broilers were kept at high ambient temperature (34°C). In the present study, the control birds under summer conditions in Viet Nam had high abdominal fat (3.05%). Addition of 0.4% NaCl in drinking water reduced the abdominal fat in comparison with birds in the control and 0.2% NaCl group. The lower abdominal fat may be related to better FCR (Buyse et al., 1998). This finding was in agreement with Marks and Washburn (1983), who reported that abdominal fat

was reduced by 2.4% NaCl supplementation in diets under normal conditions. They indicated that high water to feed ratio may be associated with reduced abdominal fat. A lower abdominal fat of broiler receiving 0.3% Na in diets under summer conditions (35°C temperature and 58.2% humidity) was found by Mushtag et al. (2005). He showed that the better use of energy of broilers may reduce abdominal fat. In our study, lower abdominal fat is related with both better FCR and higher water to feed ratio.

2.6 References

Ahmad, T., M. Sarwar, Mahr-un-Nisa; Ahsan-ul-Haq and Zia-ul-Hasan, 2005: Influence of varying sources of dietary electrolytes on the performance of broilers reared in a high temperature. Animal Feed Sci. and Technology 120, Issue 3-4, 277-298.

Ain B. H., P. A. Geraert, J. C. Padilha, S. Guillaumin, 1996: Chronic heat exposure enhances fat deposition and modifies muscle and fat partition in broiler carcasses. Poultry Sci. 75, 503-513.

Ait-Boulashen, Jim D. Garlich, F. W. Edens, 1989: Effect of fasting and acute heat stress on body temperature, blood acid base balance and electrolytes status in chickens. Comp. Biochem. Physio. 94, 683-687.

Arad, Z., J. Marder, 1982: Comparison of the productive performances of the Sinai Bedouin fowl, the White Leghorn and their crossbreds: study under natural desert conditions. British Poultry Sci. 23, 333-338.

Balnave D., J. Brake, 2005: Nutrition and management of heat-stressed pullets and laying hens. Worl's Poultry Science Journal, 61, 339-406.

Balnave D., I. Yoselewitz, R. J. Dixon, 1989: Physiological changes associated with the production of defective eggshells by hens receiving sodium chloride in the drinking water. British Journal of Nutrition 64, 35.

Belay, T., R. G. Teeter, 1993: Broiler water balance and thermobalance during thermoneutral and high ambient temperature exposure. Poultry Sci. 72, 116-124.

Belay, T., R. G. Teeter, 1996: Effects of ambient temperature on broiler mineral balance partitioned in to urinary and faecal loss. British Poultry Sci. 37, 423-433.

Bell D. D., 2002: Consumption and quality of water. Commercial chicken meat and egg production, 5th ed; Kluwer Academic Publishers, Massachusetts, USA, 411-431.

Belyavin, C. G., K. N. Boorman and J. Volynchook, 1987: Egg quality in individual birds. Egg quality – current problems and recent advances. Butterworths, London, UK, 105-121.

Bessei,W., K. Reiter, H. Feile, 1999: Zur Variation des Wasseraufnahmeverhaltens bei zwei verschiedenen Legehennenlinnen. Arch. Geflügelk. 63, 115-121.

Bessei W., 1998: Water intake in the domestic fowl – behavioural and welfare aspects. In: Proceeding of World's Poultry Science Association, 10th European Poultry Conference, Jerusalem, Israel, 513-515.

Bird, N. A., P. Hunton, W. D. Morrison, L. J. Weber, 1988: Heat stress in caged layers. In website: http://www.omafra.gov.on.ca/english/livestock/poultry/facts/88-111.htm#top. Accessed: 26.12.2006.

Boone, M.A., B. L. Hughes, 1971: Wind velocity as it affects body temperature, water consumption and feed consumption during heat stress of roosters. Poultry Sci. 50, 1535-1537.

Brake, J., P. Ferket, J.Grimes, D. Balnave, J. Gorman, J. J. Dibner, 1994: Optimum arginine: lysine ratio changes in hot weather. In: Proceedings of the 21st Carolina. Poult. Nutr. Conference, Charlotte, NC, 82-104.

Buyse, J., H. Michels, J. Vloeberghs, P. Saevels, J. M. Aerts, B. Ducro, D. Berckmans, Decuypere, 1998: Energy and protein metabolism between 3 to 6 weeks of age in male broiler chickens selected for growth rate or for improved feed efficiency. British Poultry Sci. 39, 264-272.

Cahaner, A., 2007: Featherless broilers may facilitate industrial production of quality meat under hot conditions.

http://www.fao.org/ag/AGAInfo/home/events/bangkok2007/docs/Cahaner_poster.pdf.

Accessed 15 May 08.

Cobb, R., 1991: Managing chickens in tropics. Poultry international, April: 24-28.

Daghir N. J., 1995: Present status and future of the poultry industry in hot regions. Poultry production in hot climates. CAB International, Wallingford, UK, 1-9, 101-119.

Dale, N. M., H. L. Fuller, 1979: Effect of diet composition on feed intake and growth of chicks under heat stress. I. Dietary levels. Poultry Sci. 58, 1529-1534.

Damron B.L., 1998: Sodium chloride concentration in drinking water and eggshell quality. Poultry Sci. 77, 1488-91.

Deaton, J. W., F. N. Reece, J. L. Mcnaughton, B. D. Lott, 1982: Effect of heat stress on laying hens acclimated to cyclic vs. Constant temperature. Poultry Sci. 61, 11-29

Deyhim, F., R. G. Teeter, 1991a: Research note: Sodium and potassium chloride drinking water supplementation on acid-base balance and plasma corticosterone in broilers reared in thermoneutral and heat-distressed environments. Poultry Sci.70, 2551-2553.

Deyhim, F., R. G. Teeter,1991b: The effect of heat distress on blood gas, plasma and urine concentration of Na, K, Cl of broiler chicks. Poultry Sci. 69: 42.

Deyhim, F., R. G. Teeter, 1995: Effect of heat stress and drinking water salt supplements on plasma electrolytes and aldosterone concentration in broiler chickens. Int. Jour. of Biometeorol. 38, 216-217.

Donoghue, D., B. F. Krueger, B. M. Hargis, A. M., Miller, M. E. El Halawani, 1989: Thermal stress reduces serum luteinizing hormone and bioassayable hypothalamic content of luteinizining hormone releasing hormone in the hen. Biology and Reproduction 41, 419-424.

Emmans, G. C., 1974: The effect of temperature on performance of laying hens. In: Energy requirements of poultry. Morris,T.R. and R.B.Freemann, edts. British Poultry Sci., LTD., Edinburgh, UK, 79-90.

Ernst, R. A., 1995: Housing for improved performance in hot climate. In: Poultry Production in Hot Climates. Daghir N. J.edts. CAB International, Wallingford, Oxon, UK, 68-98.

Etches, R. J., T. M. John, A. M. Verrinder Gibbins, 1995: Behavioural, physiological, Neuroendocrine and Molecular Responses to heat stress. In: Poultry Production in Hot Climates. Daghir N. J.edts. CAB International, Wallingford, Oxon, UK, 32-37.

Fox, T. W., 1951: Study on heat tolerance in domestic fowl. Poultry Sci. 30, 477-483.

Gowe, R. S., R. W. Fairfull, 1995: Breeding for resistance to heat stress. In: Poultry Production in Hot Climates. Daghir N. J. edts. CAB International, Wallingford, UK,11-29.

Gous, R. M., T. R. Morris, 2005: Nutritional interventions in alleviating the effects of high temperature in broiler production. Wold's Poultry Science Journal 61, 463-475.

Hai, L., D. Rong, Z. Y. Zhang, 2000: The effect of thermal environment on the digestion of broilers. Journal of Animal Physiology and Animal Nutrition 83, 57-64.

Jafari, R. A., A. Fazlara, M. Govahi, 2006: An investigation into Salmonella and fecal coliform contamination of drinking water in broiler farm in Iran. International Journal of Poultry Science 5, 491-493.

Khalafalla, M. K., 1996: Effects of supplemental ascorbic acid and sodium chloride on the performance and egg quality of laying hens receiving saline drinking water. Doctoral thesis. Verlag Ulrich E. Grauer Stuttgart, Germany, 69-71, 89-91.

Khafafalla, M. K., W. Bessei, 1996: The effect of ascorbic acid supplementation on egg shell quality of laying hens receiving saline drinking water. Arch. Geflügelk., 61, 1997, 172-175.

Leeson S., 1986: Nutritional considerations of poultry during heat stress. World Poultry Science Journal 42, 69-81.

Li, Y., T. Ito, M. Nishibori, Yamamoto, 1992: Effects of environmental temperature on heat production associated with food intake and on abdominal temperature in laying hens, British Poultry Sci. 33, 113-122.

Lin, H., Jiao H.C., J. Buyse, E. Decuypere, 2005: Strategies for preventing heat stress in poultry. World's Poultry Science Journal 62, 76-77.

Lu, Q., J. Wen, H. Zhang, 2007: Effect of chronic heat exposure on fat deposition and meat quality in two genetic types of chicken. Poultry Sci. 86, 1059-1064.

May, J. D., B.D. Lott, 1992: Feed and water consumption patterns of broilers at high environmental temperature. Poultry Sci. 71, 331-336.

Morris, 2004: Environmental control for layers. World's Poultry Science Journal 60, 163-175.

Mushtag, T., M. Sarwar, H. Nawaz, M. A. Mirza, T. Ahmad, 2005: Effects and interactions of sodium and chloride on broiler starter performance (one to twenty eight days) under subtropical summer condition. Poultry Sci. 84, 1716-1722.

Nesbeth, W. G., C. R. Douglas, R. H. Harms, 1976: Response of laying hens to a low salt diet. Poultry Sci. 55, 2128-2133.

Portsmouth J., 1979: Food and water. In: The complete handbook of poultry keeping. Stuart Banks edts., Van Nostrand Reinhold Company, New Jork , USA, 136-137.

Richter, G., J. Bargholz, W. Arnhold, 2006: The effect of sodium chloride in laying hens. Tierartzliche Umschau 61, 493-496.

Reece, F.N., J. W. Deaton, L. F. Kubena, 1972: Effect of high temperature and humidity on heat prostration of broiler chickens. Poultry Sci. 51, 2021-2025.

Ross, E., 1979: The effect of water sodium on chick requirement for dietary sodium. Poultry Sci. 58, 626-630.

Saaffar, A. A. AL., S. P. Rose, 2002: Ambient temperature and the egg laying characteristics of laying fowl. World Poultry Science Journal 58: 317-331.

Setter, P., S. Yalcin, L. Turkmut, S. Ozkan, A. Cahaner, 1999: Season by genotype interaction related to broiler growth rate and heat tolerance. Poultry Sci. 78:1353–1358.

Smith, M. O., 1994: Effect of electrolytes and lighting regimen on growth of heat distressed broilers. Poultry Sci. 73, 350-353.

Smith A. J., 2001: The tropical Agriculturalist–Poultry (Revised Edition). Macmillan Education LTD, London and Oxford, UK, 58, 63, 72-73, 85.

Smith, M. O., R. G. Teeter, 1987: Potassium balance of the 5-8 week old broiler exposed to constant heat or cycling high temperature stress and the effect of supplemental potassium chloride on body weight gain and feed efficiency. Poultry Sci. 66, 487-92.

Smith, M. O., R. G. Teeter, 1989: The effect of sodium and potassium salts on gain, water consumption and body temperature of 4-7 week old heat stressed broiler. Nutrition Reports International 40, 161-169.

Sykes, A. H., R. A. Fatagtah, 1986: Effect of a change in environmental temperature on heat tolerance in laying fowl. British Poultry Sci. 27, 307-316.

Teeter, R. G., 1994: Optimizing production of heat stressed broilers. Poultry Digest 53, 10-27.

Teeter, R. G., M. O. Smith, 1986: High chronic ambient temperature stress effects on broiler acid-base balance and their response to supplemental ammonium chloride, potassium chloride and potassium carbonate. Poultry Sci. 65, 1777-1781.

Tyler, C., F. H., Geake, 1958: Studies on egg shells. IX. –Influence of individuality, breed and season on certain characteristics of egg shells from pullets. Journal of the Science of Food and Agriculture 9, 375.

Wilson, W.O., 1949: High environmental temperature as affecting the reaction of laying hens to Iodized Casein. Poultry Sci. 28, 581-592.

Weaver, Jr. William D., 2002: Poultry housing. Commercial chicken meat and egg production, 5th edts; Kluwer Academic Publishers, Massachusetts, USA, 101-112.

Wolfenson, D., Yael, F. Frei, N. Snapir, A. Bernman, 1981: Heat stress effects on capillary blood flow and its redistribution in the laying hen. European Journal of Physiology 390, 86-93.

Yalcin, S., A. Testik, S. Ozkan, P. Settar, F. Celen, A. Cahaner, 1997: Performance of naked neck and normal broilers in hot, warm and temperate climates. Poultry Sci. 76, 930-93.

Yoselewitz, I., D. Balnave, 1989: Response in egg shell quality to sodium chloride supplementation of the diet and/or drinking water. British Poultry Sci. 30, 273-281.

Zeidler, G., 2002: Shell egg quality and preservation. Commercial chicken meat and egg production, 5th ed; Kluwer Academic Publishers, Massachusetts, USA, 1199-1218.

Arch.Geflügelk., 73 (xxx). S. xxx-xxx, 2009, ISSB 0003-9098. © Verlag Eugen Ulmer, Stuttgart

3 EFFECT OF POTASSIUM CHLORIDE SUPPLEMENTATION IN DRINKING WATER ON WATER AND FEED INTAKE AND EGG QUALITY OF LAYING HENS UNDER CYCLIC HEAT STRESS

DAI* N. V., W. BESSEI* and Z. NASIR*

*Dept. of Poultry Science (470c), University of Hohenheim, Stuttgart, Germany

Corresponding Author address: NGUYEN VAN DAI

Dept. of Poultry Science (470c), University of Hohenheim, Stuttgart, Germany

Email address: vandai75@uni-hohenheim.de

3.1 Abstract

This experiment was carried out to study the responses of laying hens to cyclic heat stress and the effects of potassium chloride supplementation in the drinking water on water intake, feed intake and productivity traits under heat challenge. A total of 48 hens were kept in environmental controlled chambers and randomly allocated to three experimental groups of 16 hens each. These groups were given 0, 0.2 and 0.4% KCl in drinking water for seven consecutive days. The room temperature was constant at 21±1°C for one week and cycled from 21±1°C to 34±1°C (from 9 to 22 o'clock) for following week, then returned to constant at 21±1°C for one week. Water and feed intake, egg production and egg quality of the individual hens were recorded throughout the experimental period. Body temperature was recorded at one day before, and 1st, 3rd, 5th and 7th day of experiment. Heat stress increased water intake, water: feed ratio, body temperature, eggshell defects in comparison with pre-heat stress. Feed intake of control and 0.2% KCl group decreased on first 3 days of heat tress. Laying rate decreased on 2nd, 3rd and 4th day and egg weight and body weight of control group decreased during heat stress. Eggshell thickness, eggshell strength, egg deformation, yolk color and HU seem to be not affected by heat stress. In heat stress, supplementation of KCl in drinking water increased water intake, maintained body weight, egg weight and egg production, and had less eggshell defects. There was a tendency towards lower body temperature and thicker eggshell with 0.4% KCl solution. Feed intake, egg deformation, yolk color and HU were not significantly affected by KCl supplementation. These results showed that KCl supplementation through drinking water may be a means to maintain egg production and egg quality which usually occurs when the temperature in the layer house increases.

Key words: Egg quality, feed intake, heat stress, potassium chloride, water intake.

Arch.Geflügelk., **74** (xxx). S. xxx-xxx, 2009, ISSB 0003-9098. © Verlag Eugen Ulmer, Stuttgart

4 EFFECT OF SODIUM CHLORIDE SUPPLEMENTATION IN DRINKING WATER ON WATER AND FEED INTAKE AND EGG QUALITY OF LAYING HENS UNDER CYCLIC HEAT STRESS

DAI* N. V., W. BESSEI* and Z. NASIR*

*Dept. of Poultry Science (470c), University of Hohenheim, Stuttgart, Germany

Corresponding Author address: NGUYEN VAN DAI

Dept. of Poultry Science (470c), University of Hohenheim, Stuttgart, Germany

Email address: vandai75@uni-hohenheim.de

4.1 Abstract

The objective of this study was to study the responses of laying hens to cyclic heat stress and effect of increasing water intake of laying hens through NaCl supplementation in the drinking water on body weight, body temperature and productivity traits under heat challenge. A total of 48 hens were kept in environmental controlled chambers and randomly allocated to three experimental groups of 16 hens each. These groups were given 0, 0.2 and 0.4% NaCl in the drinking water during cyclic heat stress. The room temperature was constant at 21±1°C for one week before heat stress. During heat stress, temperature was cycled from 21±1°C to 34±1°C (from 9 to 22 o'clock) for 7 days, then returned to 21±1°C for one week. The result showed that heat stress increased water consumption, water: feed ratio and body temperature of laying hens while feed intake, egg production, egg weight, body weight, eggshell thickness, eggshell strength, egg deformation, yolk color and HU were not affected. NaCl supplementation significantly increased water intake and water: feed ratio as compared to control group. NaCl supplementation reduced feed intake and tendentiously decreased egg out put during heat stress period, but after heat stress the laying rate reached to the pre-heat stress level in the both treatments. The control birds did not reduce laying rate and feed consumption during heat stress, but laying rate declined in the period after heat stress. This effect was explained by a delayed response to the heat stress due to inadequate increase of water consumption. The effect of NaCl supplementation on the performance of laying hens was not clear, the positive effects may be produced by NaCl application under higher temperature or constant high temperature schedule.

Key words: Egg quality, feed intake, heat stress, sodium chloride, water intake.

Arch.Geflügelk., 72 (xxx). S. xxx-xxx, 2008, ISSB 0003-9098. © Verlag Eugen Ulmer, Stuttgart

5 EFFECTS OF SODIUM CHLORIDE AND POTASSIUM CHLORIDE SUPPLEMENTATION IN DRINKING WATER ON PERFORMANCE OF BROILERS UNDER TROPICAL SUMMER CONDITIONS

DAI* N. V., W.BESSEI* and N.H.QUANG**

*Dept. of Poultry Science (470c), University of Hohenheim, Stuttgart, Germany

**Dept. of Animal and Vet. Science, Thai Nguyen Uni. of Agriculture and Forestry, Thai Nguyen, Viet Nam

Corresponding Author address: NGUYEN VAN DAI

Dept. of Poultry Science (470c), University of Hohenheim, Stuttgart, Germany

Email address: vandai75@uni-hohenheim.de

5.1 Abstract

It is well known that water intake has a vital role in resistance of chicken to high temperature and maintenance of electrolyte balance is very important to maintain the performance in high temperature conditions. This experiment was carried out to study the effects of sodium chloride (NaCl) and potassium chloride (KCl) in the drinking water on water intake, feed intake, productivity traits and carcass quality of broilers under tropical summer conditions. At the age of 21 days, a total of 240 chicks of Lohmann meat breed were randomly assigned into 5 groups. Each treatment group consisted of three replicates of 16 birds each in a open sided poultry house. Three different levels (0, 0.2, and 0.4%) of sodium and potassium chloride were added in drinking water. Weekly water and feed intake were measured. Body temperature of 15 birds per treatment was measured at 23, 33 and 40 day of age. Body weight of all birds was individually weighed on day of hatching and afterwards at weekly intervals up to 7 weeks of age. At 49 days of age, one male and one female bird from each replicate (a total of 30 birds) were slaughtered to determine carcass characteristics. The results showed that addition of KCl and NaCl in drinking water enhanced water intake and water: feed ratio. The addition of 0.4% NaCl reduced body temperature increased significantly body weight, and improved feed conversion ratio and decreased abdominal fat. Thigh meat was higher with 0.4% KCl supplementation. NaCl and KCl supplementation did not affect feed intake. However, carcass percentage was reduced by 0.2% NaCl and KCl, and 0.4% KCl supplementation. Therefore, in the tropical summer conditions, higher levels of KCl concentration and economic aspect should be further studied.

Key words: feed intake, potassium chloride, sodium chloride, tropical condition, water intake.

6 SUMMARY

It is well known that water intake and maintenance of electrolyte balance play a vital role in the resistance of chicken to high temperature. It was hypothesis that voluntary water intake in response to heat stress may not be sufficient to prevent the reduction of performance in laying hens and broilers, and that stimulation of water intake through supplementation of electrolytes in drinking water may assist the birds to maintain high productivity under heat stress. The present study includes three experiments. Two experiments were carried out with laying hens in controlled ambient temperature conditions to study the effects of sodium chloride (NaCl) and potassium chloride (KCl) supplementation in the drinking water on water intake, feed intake, egg quality, body temperature, body weight and productivity of laying hens under high temperature. The third experiment with broilers was conducted in tropical summer conditions of Viet Nam to find out whether supply NaCl and KCl in drinking water would improve productivity and carcass quality of broilers under tropical summer conditions and which concentration of both minerals should be used. The first experiment was conducted for three weeks (from 26 March to 16 April 2007) at the research station of Hohenheim University, Germany. A total of 48 Hisex hens (76 weeks old) were kept in individual laying cages in climatic chambers and were randomly allocated to three experimental groups of 16 hens each. These groups were given 0; 0.2 and 0.4 % KCl in the drinking water for seven consecutive days of heat stress. Before and after heat stress, birds were given normal drinking water. Water and feed were provided *ad libitum*. The birds were fed a layer diet containing 11.45 MJ/kg Metabolizable Energy, 16.97 % Crude Protein, 3.73% calcium, 0.62% phosphorus, 0.22% sodium and 0.33% chloride. The room temperature was constant at 21±1°C for 7 days, afterwards, it was cycled from 21±1°C to 34±1°C (from 9 to 22 o'clock) for 7 days, and then constant at 21±1°C for 7 days. Humidity was not controlled. 14-hours lighting schedule was maintained during the experiment. Water and feed intake, water: feed ratio, body weight, body temperature, egg production, egg weight, egg shell thickness, egg deformation, egg shell strength, yolk colour and Haugh Unit (HU) were recorded. In the second experiment, effect of NaCl supplementation (0.2 and 0.4%) in drinking water on laying hens was tested under the same temperature program as in the first experiment. A total of 48 Hisex hens (80 weeks old) were used. The third experiment was carried out on the commercial chicken farm from 26 June to 14 August 2007 (49 days). A total of 240 21-day-old broiler chicks (Lohmann meat)

were randomly allocated to 5 treatment groups in a randomized block design. Each treatment consisted of three replicates of 16 chickens each. Both, NaCl and KCl, were supplemented from the beginning of the 4^{th} to 7^{th} weeks of age at 0.2% and 0.4% to drinking town water, and unsupplemented water was used as control. The birds were kept in an open sided poultry house on the rice hull litter. Temperature and humidity of the house were not controlled. Water and feed intake were measured weekly. Body temperature of 15 birds per treatment was measured at 23, 33 and 40 day of age. All birds was individually weighed on day of hatching and afterwards at weekly intervals up to 7 weeks of age. At 49 days of age, one male and one female bird from each replicate (a total of 30 birds) were slaughtered to determine carcass characteristics.

The results showed that in laying hens, heat stress increased water intake, water to feed ratio, body temperature and eggshell defects. Feed intake, egg production and egg weight decreased tendentiously during heat stress. Body weight, eggshell thickness, eggshell strength, egg deformation, yolk color and HU were not significantly affected by heat stress. Supplementation of KCl or NaCl in drinking water increased water intake and water: feed ratio. Only KCl supplementation maintained body weight, egg weight and egg production, and decreased eggshell defects. Feed intake, eggshell deformation, yolk color and HU were not significantly affected by either KCl or NaCl supplementation. The results showed that KCl supplementation through drinking water may be a means to maintain egg production and egg quality which are usually deteriorated when the temperature in the layer house increases while NaCl was less effective under these conditions.

Supplementation of KCl or NaCl in drinking water enhanced water intake and water: feed ratio of broilers under tropical summer conditions. 0.4% NaCl supplementation in drinking water reduced body temperature, increased body weight, improved feed conversion ratio (FCR) and decreased abdominal fat while feed intake was not affected by both NaCl and KCl supplementation. Therefore, 0.4% NaCl added in drinking water may be a means to improve productivity of broiler under high temperature. 0.4% KCl supplementation increased thigh meat, and improved FCR. However, carcass percentage was reduced by KCl supplementation. Therefore, in the tropical summer conditions, higher levels of KCl concentration and

economic aspect should be further studied. It was not clear whether the beneficial effects of KCl and NaCl supplementation in drinking water was caused by the cooling effect of the increased water intake and/or the maintenance of electrolytes balance.

7 ZUSAMMENFASSUNG

Es ist allgemein bekannt, dass eine hohe Wasseraufnahme und die Aufrechterhaltung der Elektrolytkonzentration im Organismus eine wichtige Rolle bei der Anpassung an hohe Temperaturen darstellen. Die vorliegende Arbeit geht von der Hypothese aus, dass die normale Wasseraufnahme von Geflügel unter Hitzestress nicht ausreicht, um eine optimale Leistung zu erhalten und dass die Anreicherung des Trinkwassers mit Elektrolyten die Wasseraufnahme stimuliert und somit die Tiere in die Lage versetzt, ihre hohe Leistungen und der Hitzestress bei zu behalten.

Die vorliegende Arbeit umfasst drei Experimente. Zwei Experimente wurden mit Legehennen in Klimakammern durchgeführt, wobei ihr Trinkwasser mit Natrium- und Kaliumchlorid angereichert wurde. Das dritte Experiment wurde mit Masthühnern unter Sommerbedingungen in Vietnam durchgeführt. Auch hier wurden Natrium- und Kaliumchlorid im Trinkwasser supplementiert.

Der erste Versuch wurde mit insgesamt 48 Legehennen (Hisex) an der Versuchseinheit für Nutztierethologie und Kleintierzucht der Universitäts Hohenheim durchgeführt. Die Tiere wurden auf drei Versuchsgruppen zu je 16 Hennen verteilt. Diese erhielten jeweils 0, 0,2 und 0,4% Kaliumchlorid über sieben aufeinander folgende Tage im Trinkwasser verabreicht. Vor und nach dieser Periode war eine Periode mit konstanter Temperatur von jeweils sieben Tagen angeordnet. Während des Hitzestresses wurde die Temperatur zyklisch von 21 auf 34°C (von 9:00 bis 22:00 Uhr) variiert. Die Luftfeuchte wurde nicht kontrolliert. Über die gesamte Versuchszeit erhielten die Tiere ihr Futter und Wasser ad libitum. Das Futter enthielt 11,45 MJ umsetzbare Energie pro Kilogramm, 16,97% Rohprotein, 3,73% Ca, 0,62% P, 0,22% Natrium und 0,33% Chlorid. Das Lichtprogramm war auf 14 Stunden Tageslicht und 8 Stunden Dunkelheit eingestellt. Es wurden ff. Merkmale erfasst: Futter- und Wasseraufnahme, Wasser: Futterverhältnis, Körpergewicht, Körpertemperatur, Eigewicht, Eizahl, Eischalendicke, Eischalendeformation, Bruchfestigkeit, Dotterfarbe und Haugh Units (HU). Im zweiten Versuch wurde die Supplementierung von 0, 0,2 und 0,4% Natriumchlorid im Trinkwasser getestet. Auch hier wurden insgesamt 48 Legehennen eingesetzt. Die Versuchsanlage und -merkmale waren mit Versuch 1 identisch. Die Tiere waren zum Versuchsbeginn 80 Wochen alt.

Der dritte Versuch wurde mit Masthühnern auf einer kommerziellen Geflügelfarm in Vietnam durchgeführt (26. Juni bis 14.8.2007). Es wurden insgesamt 240 21-Tage alte Masthähnchen (Lohmann Meat) einer randomisierten Blockanlage fünf Behandlungen zugeteilt. Jede Behandlung enthielt drei Wiederholung zu je 16 Tieren. Es wurden Natriumchlorid und Kaliumchlorid in Konzentrationen von 0,2 und 0,4% dem Trinkwasser zugesetzt. Des Weiteren wurde eine Kontrolle ohne Supplementierung gehalten. Die Tiere wurden in einem Offenstall auf Einstreu mit Reisschalen aufgezogen. Temperatur und Luftfeuchte im Stall wurden nicht kontrolliert. Futter- und Wasseraufnahme wurde täglich erfasst. Die Körpertemperatur von 15 Masthähnchen pro Behandlung wurde am 23., 33. und 40. Lebenstag gemessen. Alle Tiere wurden am ersten Tag sowie dann in wöchentlichen Intervallen bis zur Alter von sieben Wochen gewogen. Im Alter von 49 Tagen wurden jeweils ein männliches und ein weibliches Tier jeder Wiederholung (insgesamt 30 Tiere) geschlachtet, um die Schlachtkörperqualitätsmerkmale zu erfassen.

Die Ergebnisse zeigten, dass Legehennen unter Wärmestress ihre Wasseraufnahme erhöhten. Auch das Verhältnis von Wasser: Futter, Körpertemperatur und Eischalendefekte waren erhöht. Futteraufnahme, Legeleistung und Eigewicht waren in der Tendenz reduziert. Das Körpergewicht, Eischalendicke, Bruchfestigkeit, elastische Verformung, Dotterfarbe und HU waren nicht signifikant durch den Hitzestress beeinflusst worden. Die Supplementierung von Natrium und Kaliumchlorid im Trinkwasser führte zu einem Anstieg der Wasseraufnahme und des Wasser: Futterverhältnisses über das Niveau der Kontrollgruppen. Die Legeleistung, Eigewicht, Körpergewicht sowie die Eischalendefekte wurden nur durch die Supplementierung positiv beeinflusst. Futteraufnahme, Eischalendeformation, Dotterfarbe und HU waren durch die Natrium- oder Kaliumchlorid-Supplementierung nicht signifikant beeinflusst. Die Ergebnisse zeigten insgesamt, dass die Kaliumchlorid-Supplementierung über das Trinkwasser eine Maßnahme für die Verbesserung der Legeleistung und verschiedener Eiqualitätskriterien unter hohen Temperaturbedingungen darstellt. Natriumchlorid war in dieser Beziehung weniger effektiv.

Die Supplementierung von Natrium und Kaliumchlorid im Trinkwasser von Masthähnchen verbesserte die Wasseraufnahme und das Wasser: Futter-Verhältnis unter tropischen Sommerbedingungen. 0,4% Natriumchlorid im Trinkwasser von Masthähnchen reduzierte die Körpertemperatur, verbesserte das Körpergewicht und die Futterverwertung und reduzierte den Anteil des Abdominalfetts, während die Futteraufnahme nicht signifikant beeinflusst

wurde. Es kann deshalb geschlossen werden, dass 0,4% Natriumchlorid im Trinkwasser die Produktivität von Masthähnchen unter hohen Temperaturen verbessert. 0,4% Kaliumchlorid dagegen verbesserte den Schenkelfleischanteil und die Futterverwertung. Allerdings war die Ausschlachtung bei Supplementierung mit Kaliumchlorid geringer als in der Kontrollgruppe. In weiterführenden Untersuchungen müsste geklärt werden, ob ein höherer Kaliumchloridgehalt im Trinkwasser zu besseren Ergebnissen führt.

Insgesamt kann festgestellt werden, dass die Anreicherung von Trinkwasser mit Natrium- und Kaliumchlorid eine Maßnahme darstellt, die zu einer wesentlichen Steigerung der Wasseraufnahme beiträgt und deshalb unter tropischen Bedingungen die Leistung von Legehennen und Masthähnchen verbessern kann. Sie ist auch unter einfachen Bedingungen im ländlichen Bereich durchführbar. Es wäre in weiteren Versuchen zu klären, warum bei Legehennen Kaliumchlorid und bei Masthähnchen Natriumchlorid effizienter war. Des Weiteren wäre zu klären, ob die Einflüsse von Kalium- und Natriumchlorid im Trinkwasser in erster Linie durch die Kühlungseffekte aufgrund des höheren Wasserverbrauchs oder durch die Elektrolyte bedingt sind.

8 TÓM TẮT

Nước uống có vai trò rất quan trọng đối với khả năng chống nóng của gia cầm và việc duy trì cân bằng điện giải rất cần thiết để duy trì năng suất trong điều kiện nhiệt độ cao. Nghiên cứu gồm 3 thí nghiệm được thực hiện trong hai điều kiện môi trường khác nhau. Hai thí nghiệm với gà sinh sản được thực hiện trong điều kiện stress nhân tạo nhằm nghiên cứu ảnh hưởng của stress nhiệt và bổ sung muối natri và muối kali vào nước uống đến khả năng tiêu thu nước và thức ăn, cũng như chất lượng trứng, nhiệt độ cơ thể, trọng lượng cơ thể, và năng suất trứng. Thí nghiệm với gà broiler được thực hiện trong điều kiện môi trường mùa hè của Việt Nam nhằm chứng minh liệu việc cung cấp muối natri và muối kali thông qua nước uống có nâng cao năng suất và chất lượng thịt của gà broiler trong mùa nóng và xác định tỷ lệ bổ sung phù hợp.

Thí nghiệm thứ nhất được thực hiện tại trạm nghiên cứu của trường đại học tổng hợp Hoheheim, Đức. Tổng số 48 gà mái giống Hisex 76 tuần tuổi được nuôi trong lồng nuôi cá thể, gà được nuôi trong phòng điều khiển môi trường tự động. Gà thí nghiện được phân bố ngẫu nhiên vào 3 nhóm thí nghiệm, mỗi nhóm gồm 16 gà. Những nhóm thí nghiệm này được cung cấp 0, 0,2% hoặc 0,4% muối kali vào nước uống trong 7 ngày stress nhiệt. Trước và sau stress nhiệt, gà được cung cấp nước uống không bổ sung muối. Thức ăn và nước uống được cung cấp tự do. Thức ăn cho gà đẻ được sử dụng trong thí nghiệm với 11,45 MJ/kg ME, 16.97% CP, 3.73% calcium, 0.62% phosphorus, 0.62% sodium và 0.33% chloride. Thời gian thí nghiệm kéo dài 3 tuần từ 26.3 đến 16.4 năm 2007. Nhiệt độ phòng nuôi được điều khiển là 21±1°C trong 7 ngày, sau đó nhiệt độ được tăng từ 21±1°C lên đến 34±1°C từ 9 đến 22h trong 7 ngày, sau đó nhiệt được hạ xuống 21±1°C trong 7 ngày. Ẩm độ phòng nuôi không được điều khiển. 14h chiếu sáng hàng ngày được duy trì trong suốt quá trình thí nghiệm. Các chỉ tiêu được theo dõi bao gồm: tiêu thụ thức ăn và nước uống, tỷ lệ nước uống và thức ăn tiêu thụ, khối lượng cơ thể, nhiệt độ cơ thể, năng suất trứng, khối lượng trứng, độ dày vỏ trứng, chỉ số biến dạng, khả năng chịu lực của vỏ trứng, mà sắc lòng đỏ, và đợn vị Haugh.

Thí nghiệm thứ hai tập trung nghiên cứu ảnh hưởng của stress nhiệt và việc bổ sung muối natri vào nước uống đến gà mái đẻ. Tổng 48 gà mái giống Hisex 80 tuần tuổi được sử dụng. Bố trí thí nghiệm và các chỉ tiêu nghiên cứu như thí nghiệm thứ nhất.

Thí nghiệm thứ 3 được thực hiện trên trang trại từ 26.6 đến 14.8 năm 2007. Tổng số 240 gà broiler giống Lohman 21 ngày tuổi được phân bổ ngẫu nhiên vào 5 lô thí nghiệm. Mỗi lô thí nghiệm được chia làm 3 lô lặp lại, mỗi lô gồm 16 gà. Muối natri và kali được bổ sung vào

nước uống với tỷ lệ là 0.2 và 0.4%, lô không bổ sung muối được coi là lô đối chứng. Muối natri và kali được bổ sung từ 4 đến 7 tuần tuổi. Gà được tiêm những loại vaccine phòng những bệnh quan trọng phổ biến tại địa phương. Gà thí nghiệm được nuôi trên nền đệm lót bằng vỏ trấu trong kiểu chuồng nuôi thông thoáng tự nhiên. Nhiệt độ và ẩm độ chuồng nuôi không được điều khiển. Lượng nước uống và thực ăn tiêu thụ trong tuần được xác định. Nhiệt độ cơ thể được đo trên 15 gà tại ngày tuổi thứ 23, 33 và 40 cho mỗi lô thí nghiệm. Khối lượng cơ thể của tất cả gà thí nghiệm được xác định tại thời điểm 1 ngày tuổi và hàng tuần. Một trống và một mái trong một lô lặp lại (tổng là 30 con) được chọn để mổ khảo sát tại thời điểm 49 ngày tuổi.

Kết quả cho thấy, stress nhiệt làm tăng lượng nước tiêu thụ và tỷ lệ nước uống và thức ăn tiêu thụ, tăng nhiệt độ cơ thể, tăng tỷ lệ trứng hỏng. Thức ăn tiêu thụ, năng suất trứng và khối lượng trứng có xu hướng giảm trong quá trình stress nhiệt. Trong điều kiện stress nhiệt, bổ sung muối natri và muối kali làm tăng lượng nước uống tiêu thụ và tăng tỷ lệ nước uống và thực ăn tiêu thụ. Trọng lượng cơ thể, khối lượng trứng, và năng suất trứng của gà uống nước bổ sung muối kali được duy trì , đồng thời giảm số lượng trứng hỏng trong thời gian tiếp xúc với nhiệt độ cao. Tiêu thụ thức ăn, chỉ số hình dạng trứng và màu sắc lòng đỏ không bị ảnh hưởng bởi việc bổ sung muối natri hay muối kali. Những kết quả trên chỉ ra rằng, bổ sung muối kali vào nước uống có thể là một phương pháp để duy trì năng suất, chất lượng trứng trong điều kiện nhiệt độ chuồng nuôi tăng cao, trong khi đó bổ sung muối natri trong nước không mang lại kết quả mong đợi trong điều kiện tương tự.

Trong điều kiện mùa hè ở vùng nhiệt đới, bổ sung muối natri hay muối kali vào nước uống làm tăng lượng nước uống tiệu thụ và tăng tỷ lệ nước uống và thức ăn tiêu thụ. 0.4% muối natri bổ sung vào nước uống đã làm giảm nhiệt độ cơ thể, tăng khối lượng cơ thể, và nâng cao hiệu quả sử dụng thức ăn, giảm tỷ lệ mỡ bụng, do đó, bổ sung 0.4% muối natri có thể là một phương thức để nâng cao năng suất gà broiler trong điều kiện nóng ẩm ở vùng nhiệt đới. Bổ sung muối natri hay muối kali không ảnh hưởng đến khả năng tiêu thụ thức ăn. Bổ sung 0.4% muối kali làm tăng tỷ lệ thịt ngực. Tuy nhiên, bổ sung 0.2% muối natri hay muối kali, và 0.4% muối kali lại làm giảm tỷ lệ thịt xẻ. Chính vì vậy, trong điều kiện mùa hè ở vùng nhiệt đới, cần nghiên cứu ảnh hưởng của bổ sung muối kali ở tỷ lệ cao hơn, cũng như cần nghiên cứu khía cạnh hiệu quả kinh tế.

ACKNOWLEDGMENTS

I greatly appreciate Prof. W. Bessei for his kindness, invaluable advices, constant guidance and valuable suggestions in preparing and conducting the research and in writing my thesis.

I would like to thank Prof. Dr. M. Grashorn for great help whenever asked.

The experiments with laying hens presented in this thesis were carried out at the Department of Poultry Science (470), Hohenheim University, Germany and were financed by this Department. An experiment with broiler was conducted in Viet Nam and was financed by Centre for Agriculture in the Tropics and Subtropics of Hohenheim University. I thank for these financial supports.

I am very grateful to Vietnamese government and the German Academic Exchange Service (DAAD) for financial support during the study time in Germany.

During my study, research as well as excusion, there was a need for the cooperation and enthusiasm that I received from my colleagues, and friends. I would like to thank all of them for their help and support.

A special word of thanks goes to my parents, siblings, especially my wife-Bich Nguyet and my daughter-Thuy Duong for their moral support and patience. Therefore, I dedicate this dissertation to them.

Curriculum Vitae

1. Personal Data	
Family name	**NGUYEN VAN**
Fisrt name	**DAI**
Date of birth	09. February 1975
Nationality	Vietnamese
Family status	Married
Sex	Male
Office in Viet Nam	Northern Mountainous Livestock Research and Development Center-National Institute of Animal Husbandry
Permanent address	To DP 3, Luong Chau, Song Cong, Thai Nguyen, Viet Nam
Contact	vandai75@uni-hohenheim.de. Tel: 0711 459 23102
2. Education	
1992-1997	*-Thai Nguyen University, Thai Nguyen, Viet Nam* +Bachelor of Agricultural Science . +Grade: very good
1998-2001	*-Thai Nguyen University, Thai Nguyen, Viet Nam* +Master of Agricultural Science +Thesis: *Phenotypic characteristics and performance of hybrid broilers between local and imported breed (male Mia x female Kabir) kept in intensive and semi-intensive system in Thai Nguyen province.* +Grade: very good
2004-2008	*-Hohenheim University, Stuttgart, Germany* + As Ph.D. student. Topic: "Effect of sodium and potassium chloride supplementation in drinking water on chicken performance under high ambient temperature"
3. Working Experience	
1998-1999	*-Thai Nguyen University, Thai Nguyen, Viet Nam* +Teaching Assistant
2000-to date	*- Northern Mountainous Livestock Research and Development Center-NIAH, Viet Nam* +Researcher: poultry and transferring technology

4. Publications

Dai, N. V., W. Bessei and N. H. Quang, 2008. *The effects of sodium and potassium chloride supplementation in drinking water on performance of broilers under tropical summer conditions*. Arch. Geflkde. (In press).

Hanh D. D., T.V. Can and **Dai,** N. V., 2008. *The results of study on improvement body size and productivity of Vietnamese horse for mountainous area*. International conference of Interdependencies between upland and lowland agriculture and resource management, Uni Hohenheim, Stuttgart, Germany.

Dai, N. V., W. Bessei and Z. Nasir, 2008. *Effect of potassium chloride supplementation in drinking water on water and feed intake and egg quality of laying hens under cyclic heat stress*. Arch. Geflkde. (In press).

Dai, N. V., W. Bessei and Z. Nasir, 2008. *Effect of sodium chloride supplementation in drinking water on water and feed intake and egg quality of laying hens under cyclic heat stress*. Arch. Geflkde. (In press).

Dai, N. V., W. Bessei and N. H. Quang, 2008. *Sodium chloride supplementation in drinking water and performance of broilers under tropical summer conditions*.The 13th Animal Science congress of the Asian-Australasian Association of Animal Production Societies. Hanoi, Viet Nam, 22-26 September, 2008 (accepted).

Dai, N. V. and W. Bessei, 2007. *Potassium chloride supplementation in drinking water of laying hens as a means to maintain high productivity under high ambient temperature*. Tropentag, University of Kassel-Witzenhausen, Germany.

Dai, N. V., D. D. Hanh and T. V. Can, 2003. *The result of building scavenging chicken farms in Song Cong town, Thai Nguyen provine.* Animal Husbandry Journal. Animal Husbandry Association of Viet Nam, 13.

Dai, N. V., T. T. Van, T. Long, D. D. Hanh, 2001. *Phenotypic characteristics and performance of hybrid broilers between local and imported breed (male Mia x female Kabir) kept in intensive and semi-intensive system in Thai Nguyen province*. Animal Husbandry Journal. Animal Husbandry Association of Viet Nam, 7.

Date August 13, 2008 Signature: Nguyen Van Dai