Effect of Cool Drinking Water on Production and Shell Quality of Laying Hens in Summer

P. C. Glatz
Pig and Poultry Production Institute, South Australian Research and Development Institute
Roseworthy, South Australia, 5371, Australia

ABSTRACT : Feed intake, egg weight, rate of lay and shell quality characteristics were measured in an Australian tinted egg laying strain from 31-42 weeks of age, housed at 30℃ and provided drinking water at 5, 10, 17 and 30℃. In a second experiment a European brown egg laying strain (59-66 weeks of age) housed at 30℃ were provided drinking water at 5, 10, 15 and 30℃. Brown egg layers given cool drinking water (5, 10 and 15℃) consumed more ($p<0.05$) feed and produced significantly ($p<0.05$) thicker and heavier shells than hens given drinking water at ambient temperature (30℃). However the tinted egg layers given chilled drinking water only consumed more ($p<0.05$) feed and produced thicker ($p<0.05$) and heavier ($p<0.05$) shells when consuming drinking water at 5℃. As the tinted egg layers acclimatised to the environmental temperature there was a decline in the influence of cool drinking water on feed intake and shell quality. For brown egg layers, however, cool drinking water resulted in an improvement ($p<0.05$) in feed intake and shell quality over the entire period birds were provided cool water. These studies suggest that there is potential for using cool drinking water to improve feed intake and shell quality of hens housed under hot conditions. The combination of high ambient temperature and high drinking water temperature, a common occurrence in Australian layer sheds, should be avoided. *(Asian-Aust. J. Anim. Sci. 2001. Vol. 14, No. 6 : 850-854)*

Key Words : Laying Hens, Cool Drinking Water, Shell Quality, Feed Intake

INTRODUCTION

Temperatures in laying houses during summer often exceed 30℃ despite the use of cooling systems. In addition, drinking water temperature for hens can also be 30℃ (Glatz, 1996-see table 1). The detrimental effects of heat stress on growth, rate of lay and egg quality of the hen are well documented (Deaton, 1983). Rate of lay falls during heat wave conditions because the hen reduces feed intake in order to reduce heat production to allow maintenance of homeothermy (Macleod, 1984).

Under hot conditions (30℃) the fowl starts panting and releases its metabolic heat through evaporation. Cool drinking water for hens reduces body temperature and helps to dissipate the metabolic heat (Van Kampen, 1988). Electrophysiological studies suggest that specific receptors for the detection of cold may exist in the tongue, beak and crop (Kitchell, et al., 1959; Gentle and Richardson, 1972; Gentle, 1979; Breward, 1983). Birds select microenvironments where thermoregulatory effects and energy expenditure are minimal (Ogilvie, 1970). Under hot conditions birds spend long periods standing in water (Mittgard, 1980), prefer water cooled roosts (Muiruri et al., 1991) and will wet their head and comb with water to alleviate heat stress (Van Kampen, 1988).

In some trials cool water has stimulated heat-stressed hens to consume more feed (Leeson and Summers, 1975; Janssen, 1985); in other work no benefits for providing cool drinking water have been observed (Damron, 1991; Degen et al., 1992).

The aim of this study was to determine the effect of cool drinking water on feed intake, egg weight, rate of lay and shell quality of a tinted and a brown egg laying strain housed at 30℃.

MATERIALS AND METHODS

Birds, housing and management

The first experiment used an Australian commercial tinted egg laying strain during their peak laying period (31~42 weeks of age) while the second experiment used a European brown egg strain from 59~66 weeks of age. For each experiment a total of 168 birds were housed in single bird cages (30×45×45 cm) in two thermostatically controlled sheds (84 birds/shed) at the poultry unit, Roseworthy Campus, University of Adelaide, 60 km north of Adelaide and 10m km east of Gawler in South Australia. The sheds were set to an air temperature of 30℃ for the duration of the experiments. Each shed comprised three rows of two-tier cages (14 cages/row). Experiments were conducted over consecutive summers and birds had not previously been exposed to high temperatures.

Lighting was held constant at 16 h per day. A mash layer diet was fed *ad libitum*. Ingredients of the diet (g/kg) were: wheat 750; meat meal 120; soyabean meal 60; shell grit 55; premix of vitamins and trace elements 15. Minimum calculated levels of metabolizable energy, crude protein (N×6.25) and calcium were

Corresponding Author: P. C. Glatz. Tel: +61-8-83037786, Fax: +61-8-83037689, E-mail:glatz.phil@saugov.sa.gov.au.
Received October 26, 2000; Accepted January 16, 2001.

11.5 MJ/kg, 17.6% protein and 3.1% calcium.

Driuking water treatments, experimental design and analysis

There were four treatments (drinking water at 5, 10, 17 and 30℃ for experiment 1 and 5, 10, 15 and 30℃ for experiment 2) with each temperature randomly allocated to 6 replicates each comprising 7 individually caged hens. Drinking water was provided to hens via nipple lines in which water was constantly circulated in insulated hosing from water tanks chilled or heated (Hill Refrigeration Equipment, Adelaide, South Australia) to the required temperature. The insulated hosing carrying a specific water temperature were connected to each of the replicates in each shed and continuously circulated through the drinking system. There was an industry view that 17℃ was the usual drinking water temperature provided to layers in Australia. This was taken into consideration when deciding on the drinking water treatments in experiment 1. Subsequent monitoring of water temperature in a layer shed in South Australia showed that drinking water temperature ranged from 16.2~30.0℃ (table 1).

Base SAS software (SAS Institute, 1988) was used to perform an analysis of variance (by GLM procedure) to determine the main effects of drinking water temperature on production parameters over 28d intervals and shell quality characteristics at 32 and 38 weeks in experiment 1 and at 60 and 65 weeks in experiment 2. Duncans Multiple Range test (l.s.d.) was used to separate treatment means at $p<0.05$.

Measurements

For experiment 1, eggs were counted daily from 31-42 weeks of age, feed intake weekly and body weight measured at 30, 34, 38 and 42 weeks of age. On 3 days of each week eggs were weighed. At 32 and 38 weeks of age all eggs produced Monday to Thursday from 09:00 to 11:00 h were weighed to 0.1 g in air. The equator (widest plane perpendicular to the long axis) was marked with a pencil. All pieces of shell (including membrane) were washed in tepid running water. Shell pieces were dried at 70℃ in a still-air oven. The following day, shells were weighed to 0.01 g and shell thickness was measured to nearest 1 μm using a thickness gauge fitted with rounded jaws. Shell % was calculated from the data.
In experiment 2 eggs were counted daily from 59~66 weeks of age, feed intake was measured weekly and shell quality at 60 and 65 weeks of age.

Table 1. Drinking water temperature (℃) recorded in the header tank for a nipple line in a naturally ventilated laying house in South Australia

Month	Water temperature (℃)	Month	Water temperature (℃)
Jan	30.0	Jul	16.2
Feb	28.3	Aug	16.2
Mar	27.4	Sep	17.9
Apr	21.9	Oct	21.5
May	17.4	Nov	21.7
Jun	16.9	Dec	25.6

(Glatz, 1996)

RESULTS AND DISCUSSION

Over 31~34 weeks of age, tinted hens provided 5℃ drinking water consumed more feed (table 2) and produced heavier ($p<0.05$) and thicker ($p<0.05$) shells (table 3) compared with birds consuming water at ambient temperature (30℃). Feed intake of hens provided drinking water at 10 and 15℃ were intermediate to the 5 and 10℃ treatments (table 2). Cool drinking water did not improve rate of lay. Tinted hens responded initially to the high environmental temperature by reducing feed intake and shell quality. Subsequently, by 38 weeks of age the difference between treatments in shell quality could not be detected except for birds provided drinking water at 17℃, which produced thinner shells ($p<0.05$) compared to the 5℃ drinking water treatment (table 3).

For the second experiment, however, brown egg layers provided 5, 10 and 15℃ drinking water consumed more ($p<0.05$) feed (table 4), produced heavier ($p<0.05$) eggs and thicker ($p<0.05$) shells (table 5) compared to birds consuming water at ambient temperature (30℃) over the entire experimental period. There were no significant changes in egg production observed although the numerical reduction in laying rate is apparent for both tinted and brown egg layers (tables 2 and 4).

In the first experiment the tinted layer acclimatised to the high shed temperatures within four weeks and there was a decline in the effectiveness of chilled water to stimulate an increase in feed intake, which contrasted to the response of hens in the second experiment. There is some danger in comparing the results of the 2 experiments because of the age difference in the birds. The results could merely reflect an age difference in the response of birds to high shed temperatures. Nevertheless it is considered that the European strain did find it more difficult to acclimatise to high temperature compared to the Australian strain and continued to derive a thermoregulatory benefit from drinking the cool water. Anecdotal reports from within Australia support these observations although the benefits of cool drinking water for brown egg layer and tinted would need to be examined during the peak egg and late laying period respectively to validate the opinion.

There have been variable reports in the literature

Table 2. Effect of drinking water temperature (℃) on production parameters of tinted egg layers over 3 periods from 31-42 weeks of age

Drinking water temp (℃)	Feed intake (g/hen/day)	Rate of lay (%)	Egg weight (g)	Body weigt (g)
		Period 1 (31-34 weeks)		(34 weeks)
5	114[a]	87	55.6	1959
10	112[ab]	86	55.0	1928
17	111[ab]	89	55.0	1924
30	107[b]	90	54.8	1900
l.s.d. (p=0.05)	5	ns	ns	ns
		Period 2 (35-38 weeks)		(38 weeks)
5	107[a]	83	57.3	1963
10	103[ab]	82	56.6	1919
17	103[ab]	81	55.9	1932
30	101[b]	84	55.7	1900
l.s.d. (p=0.05)	5	ns	ns	ns
		Period 3 (39-42 weeks)		(42 weeks)
5	106	86	58.3	1997
10	104	87	58.0	1962
17	106	88	57.6	1966
30	102	86	57.1	1926
l.s.d. (p=0.05)	ns	ns	ns	ns

[ab] Means within columns within period followed by different letters are significantly different ($p<0.05$).
ns=not significant in analysis of variance.
l.s.d.=least significant difference.

Table 3. Effect of drinking water temperature (℃) on shell characteristics of tinted egg layers at 32 and 38 weeks of age

Drinking water temp (℃)	Egg weight (g)		Shell weight (g)		Shell percentage (%)		Shell thickness (μm)	
	32 weeks	38 weeks	32 weeks	38 weeks	32 weeks	38 weeks	32 weeks	38 weeks
5	56.0	57.3	5.3[a]	5.3	9.5[a]	9.2	367[a]	362[a]
10	55.9	56.1	5.2[ab]	5.1	9.3[ab]	9.1	361[a]	357[ab]
17	55.3	56.0	5.1[b]	5.0	9.2[ab]	8.9	357[ab]	347[b]
30	55.1	56.3	4.9[b]	5.1	9.1[b]	8.9	350[b]	352[ab]
l.s.d. (p=0.05)	ns	ns	0.2	ns	0.3	ns	10	11

[ab] Means within columns followed by different letters are significantly different ($p<0.05$).
ns=not significant in analysis of variance.
l.s.d.=least significant difference.

on the benefits of cool drinking water for hens housed at hot temperatures. Rate of lay is not affected by environmental temperatures up to 30℃ (Van Kampen, 1984) accounting for the lack of an effect of cool drinking water on rate of lay of hens in both trials despite the numerical trends. There are a number of other possible reasons for the conflicting reports in the literature on the benefits of cool water for layers in summer. Significant findings can be masked if not analysed over shorter periods and lack of replication of treatments in experiments makes it difficult to detect differences. Damron (1991) for example analysed all data from the experiment over an 8-week period. In addition drinking water was cooled only to 10℃ and birds were subjected to heat stress for only 57% of the time. Similarly Degen et al. (1992) provided water cooled only to 18.5℃ and for only 2.5 h per day and could not detect any growth benefits to broiler breeders. It is surmised that providing cooler water in the above experiments may have resulted in significant benefits for hens.

Another factor, which could influence the variation in response of birds to cool drinking water, is drinking behavior. Some birds in the current trial were observed drinking directly from the nipples; others drank from both the nipple and the V trough beneath the nipple, while some birds drank only the spilled water in the V trough. Under these circumstances birds drinking only from the nipple would be obtaining cooler water compared to others drinking water from the V trough because water would warm after coming in contact with the water trough. Consideration also needs to be given to the influence of beak trimming on the drinking behavior (Glatz, 2000). Birds severely trimmed may find it difficult to drink both hot and cold water due to pain responses in the beak from presence of neuromas. The method of delivering cool water to birds may have also influenced the differences observed in responses of hens to provision of cool drinking water reported in the literature. Water that is continuously circulated from water chillers would be more effective at delivering the correct water temperature to birds than open systems where water might be expected to increase in temperature to equilibrate with environmental temperatures. Thus factors such as age of bird, strain, beak trimming quality, previous exposure of birds to high temperature and the drinking water system all could interact to influence the benefits of providing cool water to birds during summer.

Table 4. Effect of drinking water temperature (℃) on production parameters for brown egg layers over 2 periods from 59-66 weeks of age

Drinking water temp (℃)	Feed intake (g/hen/day)	Egg weight (g)	Rate of lay (%)
	Period 1 (59-62 weeks)		
5	113^{a}	69.4^{a}	72
10	108^{ab}	67.8^{b}	71
15	103^{b}	66.6^{b}	75
30	96^{c}	64.6^{c}	68
l.s.d. (p=0.05)	6	1.9	ns
	Period 2 (63-66 weeks)		
5	109^{a}	69.4^{a}	74
10	109^{a}	68.1^{a}	76
15	102^{b}	65.8^{b}	76
30	95^{c}	64.0^{c}	69
l.s.d. (p=0.05)	5	1.6	ns

[a,b,c] Means within a column within a comparison with different superscripts are significantly different ($p<0.05$).
ns=not significant in analysis of variance.
l.s.d.=least significant difference.

Table 5. Effect of drinking water temperature (℃) on shell characteristics of brown egg layers at 60 and 65 weeks of age

Drinking water temp (℃)	Egg weight (g)	Shell weight (g)	Shell thickness (μm)
	Age (60 weeks)		
5	70.4^{a}	6.3^{a}	376^{a}
10	67.2^{ab}	6.0^{ab}	369^{ab}
15	66.7^{b}	5.7^{bc}	358^{c}
30	65.6^{c}	5.6^{c}	354^{c}
l.s.d. (p=0.05)	2.1	0.3	10
	Age (65 weeks)		
5	69.2^{a}	6.3^{a}	370^{a}
10	67.7^{a}	5.9^{b}	366^{a}
15	66.8^{b}	5.8^{bc}	360^{a}
30	64.9^{c}	5.5^{c}	345^{b}
l.s.d. (p=0.05)	2.1	0.3	12

[a,b,c] Means within a column within a comparison with different superscripts are significantly different ($p<0.05$).
ns=not significant in analysis of variance.
l.s.d.=least significant difference.

Overall, however these present studies have demonstrated that when birds are exposed to environmental temperatures of 30℃ and provided hot drinking water (a common occurrence under Australian summer housing conditions) hens may not perform to their true potential. If hens were exposed to even hotter environmental temperatures it is likely that cool drinking water would have had a greater value in maintaining production parameters of hens, improving bird comfort and reducing mortality. It was not possible in this study to examine the underlying mechanisms, which contributed to the increase in feed intake, egg weight and shell quality of hens consuming chilled water. It is considered that warm water reduces water consumption and feed intake, which has implications for shell quality. The measurement of water turnover, drinking and feeding behaviour and body temperature of hens is required if further studies with chilled drinking water are undertaken. Furthermore there is a need to examine the role of thermal receptors in the physiological response of hens provided cool drinking water.

From a practical point of view egg farmers should monitor drinking water temperature in their sheds in addition to ambient temperature and consider providing cooled water to hens, particularly during heat waves. In particular, hot weather early in the summer season might have a significant impact on bird performance and shell quality. Relatively inexpensive ways to assist in keeping drinking water cool are to regularly flush drinking water lines, keep incoming water lines out of direct sunlight, insulate water lines, use ice in header tanks and ensure water storage tanks are well shaded. A more expensive option is the installation of an external water-cooling unit.

ACKNOWLEDGMENTS

The funding support for the project by the Rural Industries Research and Development Corporation is acknowledged.

REFERENCES

Breward, J. 1983. Cutaneous nociceptors in the chicken beak.

J. Physiol. 346:56.

Degen, A. A., M. Kam and A. Rosenstrauch. 1992. Effect of restricted cooled drinking water on the performance of broiler breeder hens in a hot, dry climate. Br. Poult. Sci. 33:917-924.

Damron, B. L. 1991. Cooling of drinking water for laying hens. Poult. Sci. 70:2368-70.

Deaton, J. W. 1983. Alleviation of heat stress for avian egg production - A Review. World's Poult. Sci. J. 39: 210-217.

Gentle, M. J. 1979. Effects of water temperature on short-term water intake and medullary neuronal responses in the hen. Br. Poult. Sci. 20:533-39.

Gentle, M. J. and A. Richardson. 1972. Changes in the electroencephalogram of the chicken produced by stimulation of the crop. Br. Poult. Sci. 13:163-70.

Glatz, P. C. 1996. Ideal drinking water temperature for layers. A final report to the Rural Industries Research and Development Corporation, Canberra, Australia, Project Number DAS24E, p. 24.

Glatz, P. C. 2000. Beak trimming methods- Review. Asian-Aus. J. Anim. Sci. 13(11): 1619-1637.

Janssen, W. M. M. A. 1985. Effects of water temperature and feed density on the performance of laying hens kept under thermal stress. Zootec. Internat. Oct. pp. 28-39.

Kitchell, R. L., L. Strom and Y. Zotterman. 1959. Electrophysiological studies of thermal and taste reception in chickens and pigeons. Acta Physiol. Scand. 46:133-151.

Leeson, S. and J. D. Summers. 1975. Cool water during heat stress results in more eggs. Poult. Digest. pp. 369-370.

Macleod, M. G. 1984. Factors influencing the agreement between thermal physiology measurements and field performance in poultry. Archiv. Exp. Vet. Med. 38(3): 399-410.

Mittgard, U. 1980. Heat loss from the feet of mallards (*Anas platyrhynchos*) and arteriovenous heat exchange in the rete tibiotarsa. Ibis. 122:354-359.

Muiruri, H. K., P. C. Harrison, and H. W. Gonyou. 1991. The use of water-cooled roosts by hens for thermoregulation. Appl. Anim. Behav. Sci. 28:333-339.

Ogilvie, D. M., 1970. Temperature selection in day-old chickens (*Gallus domesticus*) and young Japanese quail (*C. Coturnix japonicus*). Can. J. Zool. 48:1295-1298.

Statistical Analyses Systems Institute Inc. 1988. SAS Procedures Guide, Release 6.03 edn. SAS Institute Inc., Cary, North Carolina.

Van Kampen, M. 1984. Physiological responses of poultry to ambient temperature. Archiv. Exp. Vet. Med. 38(3):384-391.

Van Kampen, M. 1988. Effects of drinking water temperature and leg cooling on heat stress of laying hens (*Gallus domesticus*). J. Therm. Biol. 13(1):43-47.