Effects of Different Ambient Temperatures on Growth Performances, Digestibility, Carcass Traits and Meat Chemical Components in Fattening Rabbits

ผลของอุณหภูมิสภาพแวดล้อมที่แตกต่างกันต่อการเจริญเติบโต การย่อยได้ ลักษณะซาก และองค์ประกอบทางเคมีของเนื้อกระต่ายขุน

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(Received: 8 November 2018; Accepted: 31 January 2019)

บทคัดย่อ: จุดประสงค์ของการทดลองนี้คือการเปรียบเทียบ ประสิทธิภาพการเจริญเติบโต การย่อยได้ คุณภาพซาก และองค์ประกอบทางเคมีในเนื้อกระต่ายขุนที่ถูกเลี้ยงในโรงเรือนที่มีอุณหภูมิแตกต่างกัน กระต่ายหย่านมสายพันธุ์นิวซีแลนด์ไวท์จำนวน 40 ตัวถูกสุ่มเข้ากลุ่มทดลองเพื่อเพาะเลี้ยงในโรงเรือนที่รักษาอุณหภูมิให้เหมาะสมและคงที่ (OT) ซึ่งไม่เกิดความเครียดจากความร้อน (Temperature Humidity Index: THI=21.5-23.1) และโรงเรือนระบบเปิดที่อุณหภูมิจะแปรเปลี่ยนไปตามสภาพแวดล้อม (AT) ทำให้มีบางช่วงที่เกิดภาวะเครียดจากความร้อนได้ (THI=24.8-36.2) รวมทั้งอุณหภูมิมีการเปลี่ยนแปลงในช่วงกว้าง กลุ่ม AT มีน้ำหนักมีชีวิต อัตราการเจริญเติบโตเฉลี่ยต่อวัน น้ำหนักเข้าฆ่า น้ำหนักซากอุ่น และน้ำหนักซากเย็นต่ำกว่ากลุ่ม OT (P<0.05) ในขณะที่กระต่ายในกลุ่ม AT มีอัตราการย่อยได้ของสารอาหารที่สูงกว่ากลุ่ม OT (P<0.05) นอกจากนี้พบว่าสัดส่วนของน้ำที่เพิ่มขึ้น และสารอาหารที่ลดลงในเนื้อกระต่ายที่เพาะเลี้ยงภายใต้ภาวะเครียดจากความร้อน (P<0.05) จากผลการทดลองนี้การเพาะเลี้ยงกระต่ายภายใต้ความเครียดจากความร้อนส่งผลเสียตามมาในด้านของประสิทธิภาพการผลิต และองค์ประกอบทางเคมีของเนื้อ

คำสำคัญ: อุณหภูมิโดยรอบ การย่อยได้ องค์ประกอบทางเคมีในเนื้อ ประสิทธิภาพ กระต่าย

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Abstract: The study on growth performances, digestibility, carcass traits and meat chemical components of fattening rabbits between different environmental temperatures at housing was the objective of this study. Forty weaned New Zealand white rabbits were randomly separated and reared in an optimal controlled (OT) housing without heat stress environment (Temperature humidity index: THI=21.5-23.1) and an ambient temperature (AT) housing (opened housing) under a severe heat stress and wide temperature fluctuation during the day (THI=24.8-36.2). The AT group was lower in live weight, average daily weight gain, slaughter weight, hot carcass weight and cold carcass weight comparing to OT group (P<0.05), whereas the rabbits in AT group was higher in nutrient digestibility than the OT group (P<0.05). Moreover, higher proportion of water and lower nutrients were observed in the rabbit meat which lived under severe heat stress condition (P<0.05). Based on these results, the rearing rabbits under heat stress provided adverse consequences on productive performances and meat chemical components.

Keywords: Ambient temperature, digestibility, meat chemical components, performance, rabbit

Introduction

The production of meat rabbits is in increasing trend in several countries (FAOSTAT, 2018) including Thailand (Kovitvadhi *et al*., 2016a). Rabbits have a great potential to be an alternative livestock due to a short production cycle, low investment cost, low risk on epidemic disease and functional meat (FAOSTAT, 2018). The demand of rabbit meats in Thailand is still higher than productive efficiency around two times, which is the great opportunities to promote production of this animals (Kovitvadhi *et al*., 2016a). However, high ambient temperature (35-40°C) during summer (March to June) is a main problem of low productive efficiency (Kovitvadhi *et al*., 2016a). Body temperature of rabbits is increased following the increment of ambient temperature (Marai *et al*., 2002). Warm-blood animals need to maintain core temperature to conserve the normal enzyme activities and metabolisms. Therefore, the deterioration on productive performances, nutrient utilization and metabolisms is observed in animals that are produced under heat stress condition or high temperature humidity index (THI) environment (Marai *et al*., 2002). Heat dissipation can reduce and return the body temperature to optimal status. Unfortunately, rabbits are not well tolerance to high temperature environment because rabbits have a low function of sweat gland and dense fur, however a rising of respiratory rate and volume of blood circulation at ear lobe are main heat eradication mechanisms in rabbits (Marai *et al*., 2002). In Thailand, reproductive does are culled because of infertility and low survival rate of kittens during summer and farmers wait for raining season (July to October) to start the new production cycle (Kovitvadhi *et al*., 2016a). Therefore, high ambient temperature is a major factor which affects on productive performances of tropical rabbitry.

Most of experimental design was performed following the real management program which was continuous production along the year using seasons (summer *vs* winter) as main factors to study the effects from different environmental conditions (Chiericato *et al*., 1993; Dalle Zotte and Paci, 2014; Ghosh *et al*., 2008; Marai *et al*., 1999, 2001). As we known, there is clear that poor productive

performances in growing rabbits are found during summer (Marai *et al*., 2002). In contrast, if we can support housing that can rear rabbits under thermoneutral zone, the productivity should be improved (Hermes *et al*., 1999; Pla *et al*., 1994; Zeferino *et al*., 2011, 2013). The energy cost to decrease and control the housing temperature should be considered. The meat rabbits in Thailand have not been imported from other countries for more than ten years (Kovitvadhi *et al*., 2016a). Animals which can survive and provide good productive performances in tropical climate were selected by farmers. The resistance to high and fluctuation of temperature (genetic effects) may be developed in these meat rabbits in Thailand which providing benefits for farmers (Zeferino *et al*., 2011). Therefore, this study aims to investigate the differences on growth performance, digestibility, carcass traits and meat chemical components between optimal controlled and ambient condition (real production condition) of fattening rabbits.

Materials and Methods

Animals, housing, diets and experimental design

Forty weaned New Zealand white rabbits (40-days-old) were randomly selected with equal sex from rabbitry and distributed into optimal controlled (OT) and ambient temperature (AT) groups. The OT group lived in control temperature room (24 ± 1°C) at the Animal Experimental Unit, Faculty of Veterinary Medicine, Kasetsart University, Bangkok, Thailand (13.844479N, 100.577498E); whereas rabbits in AT group were reared at ambient temperature from March to June 2017 during summer season at rabbitry, Kanchanaburi province, Thailand (14.04007N, 99.545354E). The temperature humidity index (THI) was calculated everyday which reported in Fig.1 following this equation: THI = dry bulb temperature in Celsius - [{0.31 - (0.31 × Relative humidity index)} × {dry bulb temperature in Celsius - 14.4}]. Absent and severe heat stress were considered, if THI is lower than 27.8 and higher than 28.9, respectively (Marai *et al*., 2001). The same individual cage, equipments, management system, diets and feeding were performed for both groups. The experiment was conducted from 40 to 93 days of age. A commercial pelleted diet (Lee Feed Mill, Publ. Co., Ltd., Phetchaburi, Thailand) which was appropriate for nutrient requirement and clean water were provided *ad libitum*. This study was carried out following the guidelines and achieved the allowance from Institutional Animal Care and Use Committee of Kasetsart University, Bangkok, Thailand (ACKU60-VET-015).

Growth performance and digestibility

The rabbit's live weight and feed intake were monitored every two weeks from 45 to 87 days old for calculating average daily feed intake (ADFI), average daily weight gain (ADG) and feed conversion ratio (FCR). Mortality and morbidity were controlled daily by the same observer. For digestibility study during experimental period, the feed intake was recorded and calculated, whereas diets were analyzed in duplicate for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF) and ash by ignition to 550°C for organic matter (OM) calculation, according to the Association of Official Analytical Chemists (AOAC, 2000). According to Kovitvadhi *et al*.'s (2016b) procedure, faeces were collected daily at 48 days old for four days period, weighted and stored at -20°C for chemical analysis in duplicate for DM, ash, EE and CP (AOAC, 2000). The calculation of apparent digestibility on DM and nutrients was conducted

following to the European standardized method (Perez *et al*., 1995).

Carcass traits and meat chemical components

At 93 days old, twenty rabbits per group were stunned by concussion and slaughtered without fasting. The carcasses were prepared following Kovitvadhi *et al*. (2016b) and the results were expressed as a percentage of slaughter weight (SW). The chilled carcass weight (CCW) after 24 h of chilling at 4°C was recorded, whereas thoracic organs, liver and kidneys were calculated as percentages of CCW. *Longissimus dorsi* (LD) and *Gastrocnemius* muscles (GC) were excised and lyophilized for chemical component analysis on DM, ash, EE and CP (AOAC, 2000) expressing as fresh matter.

Statistical analysis

All of the statistical analyses were performed by R-statistic with package Rcmdr in Rstudio (R Development Core Team, 2008). Statistical analyses for significant differences of each parameter between the groups were performed according to Student *t*-test, whereas Welch's *t*-test was applied in case of unequal variances. The significance was established at $P<0.05$.

Results and Discussion

The severe heat stress (higher than 28.9; Marai *et al*., 2001) and broad THI fluctuation between the day (THI=24.8-36.2) were observed in AT group, whereas the OT group was absence of heat stress and narrow THI difference between the day (THI=21.5-23.1; Figure 1). The group of animals which suffer from heat stress was lower in live weight after two weeks, ADG and ADFI comparing to animals who lived in optimal condition ($P<0.05$; Table 1). However, there was no statistically significant difference on FCR between the groups ($P=0.66$, Table 1). The DM in experimental diets was 90.7% as fed basis, whereas OM, ash, EE, CP, CF and nitrogen-free extract were 94.3, 5.69, 2.42, 16.1, 13.4 and 62.4%DM, respectively.

The negative consequences on live weigh, ADFI and ADG were observed during summer period comparing to winter period (Chiericato *et al*., 1993; Dalle Zotte and Paci, 2014; Ghosh *et al*., 2008; Marai *et al*., 1999, 2001) and also in heat stress

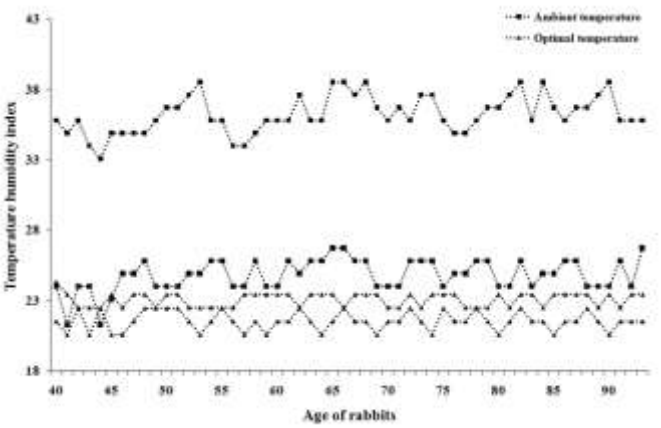

Figure 1. Temperature humidity index during experiment (the upper and lower lines of each temperature represent highest and lowest temperature humidity index of each day)

Table 1. Effects of different environmental conditions (optimal *vs* ambient temperatures) on growth performance, apparent digestibility, carcass traits and meat chemical components of fattening rabbits (n=20/group)

Items	Groups			
	Optimal (OT)	Ambient (AT)	SEM[1]	*P*-value[2]
Growth performance				
Live weight (g)				
at 45 days	928	922	14.3	0.84
at 59 days	1481	1330	44.1	0.08
at 73 days	1911	1621	50.4	0.004*
at 87 days	2237	1875	61.7	0.001*
Average daily weight gain (g/day)	28.8	22.7	1.17	0.01
Average daily feed intake (g/day)	118	87.6	5.02	0.001*
Feed conversion ratio	3.97	3.88	0.09	0.66
Apparent digestibility (%)				
Dry matter	56.4	68.2	1.96	0.001
Organic matter	63.5	75.8	2.17	0.001
Ether extract	79.9	89.2	1.83	0.01
Crude protein	63.3	76.4	2.02	0.001
Carcass traits				
Slaughter weight (SW) at 93 days (g)	2348	1963	74.0	0.01
Hot carcass weight (HCW) (g)	1481	1173	50.9	0.001
Skin, paws and feet (%SW)	17.3	23.8	0.85	0.001
Full gastrointestinal tract (%SW)	17.2	16.0	0.52	0.26*
Cold carcass weight (CCW) (g)	1296	1032	45.6	0.001*
Dressing percentage (%)	55.0	52.9	0.68	0.13
Liver (%CCW)	5.58	5.69	0.21	0.81
Kidney (%CCW)	1.11	1.08	0.02	0.59
Thoracic organs (%CCW)	1.49	1.53	0.06	0.80*
Chemical composition of Longissimus dorsi muscle				
Moisture (%Fresh matter)	72.2	75.2	0.39	0.001
Protein (%Fresh matter)	24.7	21.8	0.41	0.001
Ether extract (%Fresh matter)	0.61	0.33	0.06	0.03
Ash (%Fresh matter)	1.36	1.13	0.02	0.001
Chemical composition of Gastrocnemius muscle				
Moisture (%Fresh matter)	69.7	77.4	0.93	0.001*
Protein (%Fresh matter)	26.0	19.6	0.77	0.001*
Ether extract (%Fresh matter)	1.84	0.93	0.20	0.02
Ash (%Fresh matter)	1.48	1.07	0.04	0.001*

[1]Standard error of mean

condition comparing to optimal environmental temperature (Hermes *et al*., 1999; Pla *et al*., 1994; Zeferino *et al*., 2011, 2013). Moreover, the temperature fluctuation is another factor influencing these observed paramters (Pla *et al*., 1994). These results in this study are the same as other studies because rabbits cannot control a normal core temperature and heat prostration sets when the THI is higher than 30. Most of energy is allocated for heat dissipation pathway by increasing ventilation and blood flow to ear lobe to eradicate heat and return to normal core temperature. Therefore, there is less energy for growth which consequences on poor productive performances (Habeeb *et al*., 1993). In addition, the function of appetite center in hypothalamus is inhibited by the impulse from peripheral thermal receptor. Therefore, this pathway influences on the reduction of feed intake when the rabbits are under the high temperature environment (Marai *et al*., 2002) that was observed in this study and others (Chiericato *et al*., 1993; Marai *et al*., 2001; Zeferino *et al*., 2011). Moreover, rabbits in summer production period increased significantly water consumption, leading to reduce feed intake (Marai *et al*., 2001). Most of research articles and in this study were not observed the different on FCR (Marai *et al*., 1999, 2001; Zeferino *et al*., 2011) because the correlation in the same direction was presented between feed intake and weight gain.

The apparent digestibility on DM, OM, EE and CP was lower in OT group than in AT group (P<0.01, Table 1). Rabbits reared at 32°C were better on DM and CP digestibility than at 20°C (Hermes *et al*., 1999) which is in agreement with results of the current study. The longer gut transit time due to the lower feed intake at high temperature condition should be the cause of higher efficiency on nutrient digestibility. The lower CF digestibility of rabbits under optimal temperature group can be an evidence to confirm the higher gut flow rate than the high temperature group (Hermes *et al*., 1999). On the other hand, Marai *et al*. (2001) found the lower apparent digestibility on DM and CP of rabbits during summer production period comparing to winter. No differences of feed intake between summer and winter seasons in the study of Marai *et al*. (2001) may be the cause of this contrast results, whereas our studies and Hermes *et al*. (1999) observed the lower feed intake in rabbits under heat stress condition. Fortunately, there was no any morbidity or mortality of rabbit in any group during study. Therefore, rabbits can resist and survive in this AT condition in Thailand but the poor productive performances are presented.

SW, Hot carcass weight (HCW) and CCW of OT group were heavier than AT group (P<0.01, Table 1). The higher proportion of skin, paws and feet from SW was found comparing to AT group (P<0.001), however there were no statistical differences between groups on other carcass trait parameters (P>0.05, Table 1). The lower of HCW and CCW in rabbits rearing under heat stress are consequences from lower SW and poor productive performances (Chiericato *et al*., 1993; Dalle Zotte and Paci, 2014; Ghosh *et al*., 2008; Marai *et al*., 1999, 2001; Pla *et al*., 1994; Zeferino *et al*., 2013). Lower moisture and higher nutrients (protein, EE and ash) of LD and GC muscles were observed in OT group (P<0.05, Table 1). The meat from rabbits which rearing under 30°C is brighter than 18°C; this may be due to the higher proportion of water in the meat (Zeferino *et al*., 2013). The greater proportion of nutrients and lower proportion of moisture in meat of OT group may be the cause of the higher nutrient components comparing to the meat from AT group (Rotta *et al*., 2009). On the other hand, Hermes *et al*.

(1999) were not found any statistical difference between the diverse on housing temperatures at 20, 26 and 32°C on meat chemical components. However, the lower trend of EE in meat was presented respecting to the increasing of temperature (Hermes *et al*., 1999). Low energy intake and amount of fat storage in bodies of rabbits under hot ambient temperature were observed, resulting lower fat storage in their meat (Chiericato *et al*., 1993; Marai *et al*., 1999; Zeferino *et al*., 2013).

Conclusion

The rabbits rearing under severe heat stress condition (AT group) were lower in live weight, ADG, ADFI, SW, HCW and CCW, whereas higher in apparent digestibility on DM, OM, EE and CP were observed comparing to rabbits lived in the housing with controlled optimal temperature (OT group). Therefore, production of rabbits under hot climate did not deteriorate only the productive performances but also meat chemical components.

Acknowledgements

This research study received financial support from the Faculty of Veterinary Medicine, Kasetsart University, Bangkok, Thailand. The authors would like to humbly thank to the farmers who in Kanchanaburi province which allow us to perform the experiment in their farms.

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