

Iodine Mineral Status of Etawah Crossbred Goat at Different Physiological Stages Fed Elephant Grass and Tofu Byproduct

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Abstract. The objective of the study was to determine the iodine status and to map the thyroxin hormone concentration in etawah crossbred goat (ECG) at different physiological stages and its interrelation to the nutrition and performance. Fifteen female ECG was allotted in three physiological stage groups: female kid, young female goat and lactating goat, fed elephant grass and tofu byproduct. The study was conducted in Tossa Shakti Agro Company (TSA), Central Java, Indonesia. Analysis of variance in completely randomized design was used to determine the effect of physiological stages on soil and feed iodine content, blood serum thyroxin hormone concentration, nutrient and feed dry matter consumption, average daily gain and milk production. Result showed that soil iodine content was adequate to stimulate plant growth (3.109 mg/kg). Consumed feed iodine content was adequate to all physiological stages, female kid, young female and lactating goat (1.003; 0.940 and 0.820 mg/kg, respectively). Thyroxin hormone concentration in blood serum of female kid and young female goat was in normal range (8.23 and 10.05 µg/dl) but the concentration of thyroxin hormone in blood serum of lactating goat was marginal (6.17 µg/dl). Iodine supplementation was required for lactating etawa crossbred goat if tofu byproduct was included in its ration.

Key words : nutrient, iodine, thyroxin hormone, etawah crossbred goat

Abstrak. Penelitian ini bertujuan mengkaji status iodine dan memetakan konsentrasi hormone tiroksin kambing peranakan etawah (PE) pada berbagai status fisiologis dan interelasinya dengan status nutrisi serta performans ternak. Sebanyak 15 ekor kambing PE betina digunakan dalam penelitian yang terbagi atas tiga kelompok status fisiologis, yakni: cembe betina, kambing dara dan kambing laktasi. Sebagai pakan, digunakan rumput gajah dan ampas tahu. Penelitian ini dilakukan di PT. Tossa Shakti Agro (TSA) Kendal, Jawa Tengah. Variabel yang diukur meliputi kandungan iodine tanah dan pakan, kadar hormone tiroksin serum darah, konsumsi bahan kering pakan dan nutrien, pertambahan bobot badan serta produksi susu. Data yang terkumpul diolah secara statistik dengan analisis variansi dalam rancangan acak lengkap guna mengetahui pengaruh status fisiologis terhadap variable-variabel tersebut. Hasil penelitian menunjukkan bahwa kandungan iodine tanah memadai untuk menstimulasi pertumbuhan tanaman (3,109 mg/kg). Kandungan iodine pakan terkonsumsi memadai untuk semua status fisiologis, dalam hal ini cembe betina, kambing dara dan kambing laktasi (masing-masing: 1,003; 0,940 dan 0,820 mg/kg). Konsentrasi hormone tiroksin serum darah cembe betina dan kambing dara dalam kisaran normal (8,23 dan 10,05 ug/dl), tetapi konsentrasi hormone tiroksin serum darah kambing laktasi berada pada batas normal (borderline), yakni 6,17 ug/dl. Suplementasi iodine diperlukan bagi kambing peranakan etawa yang sedang laktasi, jika ampas tahu digunakan sebagai bagian dari ransum.

Kata kunci: nutrien, iodine, hormone, kambing peranakan etawah

Introduction

Iodine is one of micro minerals that play a significant role in metabolism that in turn influence animal productivity. Iodine content in forage or grass is generally limited. Grass roughly contains 200-400 µg/kg DM.

Approximately, 30-50% of iodine in the feedstuff perishes during the storage time. Iodine critical level in goat ration was 300 µg/day (Kearl, 1982). Iodine content is influenced by age and body measurement. Iodine content in the animal is related to

metabolic rate difference (Bourdoux, 1998). Iodine content decreases as the animals age. Usually small animal has more iodine content than the bigger animal. Iodine in animal tissue is known as in-organic and organic iodine (tironin and its metabolites) (Ranjhan, 1980).

Iodine in animal body is particularly the component of thyroid hormone and its importance is reflected in metabolic role of thyroxin hormone or 3',5',3,5 tetraiodotironin (T4) dan 3',3,5 triiodotironin (T3) (Todini, 2007). Thyroxin hormone (T4) is the main secreted product (77%) of thyroid gland (Todini, 2007). Thus, thyroxin hormone concentration in the blood is one of important indicator of animal iodine status (Iveta et al., 2011). Thyroxin hormone (T4) is thyroid hormone which is important to transport and negative feedback regulation whereas T3 is active form of thyroid hormone in target cell (Altiner, 2006). Small amounts of T3 were synthesized in the thyroid gland, most of which derived from T4 deiodination in several tissues, particularly liver and kidney (Todini, 2007). Thyroxin hormone has role on thermoregulation, energy and protein metabolism, and animal metabolic response on nutritional and environment changes (Huszenicza, 2002). Thyroxine significance in metabolism is also reflected in its influences on growth, reproduction, mammary gland development and milk production regulation (Novoselec, 2009).

Iodine is not included in essential mineral for plant but 0.5-1 mg/kg iodine in the soil can stimulate forage growth (Weng et al., 2008; Landini et al., 2011). Iodine up to 10 mg/kg in the soil can be toxic for plant (Umaly and Poel, 1970). Amachi et al. (2005) stated that the sea is the main source of iodine. Iodine can be transferred from the sea water to atmosphere through iodine molecular volatilization (I₂) or organic iodine form such as CH₃I, CH₂I₂ and C₂H₅I produced by sea organisms. Iodine is then transferred to soil through wet and dry

deposition. The phenomenon causes low iodine content in forage at hilly area, iodine deficiency in animals besides owing to erosion and leaching.

According to Kears (1982), young ruminant, early pregnant and non lactating ruminant need feed with 0.25 mg/kg iodine, while lactating ruminant needs 0.5 mg/kg iodine. Iodine toxic level in feed was 50-100 mg/kg (Iveta et al., 2002). Small ruminants are less sensitive to iodine intoxication than the big ones (Paulikova et al., 2002). Meschy (2000) stated goat needs more iodine content in feed than other ruminants; furthermore 0.3 mg/kg iodine is insufficient to prevent goiter in kid. According to NRC (2007) iodine content in feed should be 0.5 mg/kg DM for growing goat and non lactating goat, and 0.8 mg/kg DM for lactating goat. Feedstuff containing goitrogenic compound ie, cyanide and isoflavon could inhibit iodine utilization by thyroid gland implied on low thyroxin hormone and decreased animal's performance/productivity (Todini, 2007).

Iodine status in animal is reflected by thyroid hormone concentration in blood serum, related to physiological stage. Normal concentration of the hormone is 6.10-8.30 µg/dl (Todini, 2007). According to Iveta et al. (2011), thyroid hormone concentration was influenced by metabolic load. Todini (2007) stated that high metabolic load also stimulated deiodination of T4 to a more active T3, thereby decreasing T4 concentration. Metabolic load which influenced the supply rate and utilization of that thyroid hormone varied according to animal physiological stage (Nudda et al., 2009). Metabolic load of female kid is higher than that of young female goat, as of lactating goat is higher than that of goat with two previous physiological stages (Meschy, 2000; Novoselec et al., 2009).

Central Java province has the highest goat population in Indonesia (21.34%) compared to

other provinces. Central Java also has local breed goat namely Etawah crossbred goat (ECG) or Kaligesing goat in Purworejo regency. The ECG is the cross mating between kacang goat and etawah goat (EG). The ECG has developed well since 1925 and genetically served as dual purpose goat. Kaligesing ECG race is local breed natural from Indonesia. Obst and Napitupulu (1984) stated that productivity of ECG in Indonesia was low (0.45-2.2 kg/day), compared the its optimal milk production capacity (2-3 kg/day). The ECG production centre is usually in upland area.

The research was conducted to study the iodine status and to map the thyroxin hormone based on physiological stages of ECG which fed the elephant grass and tofu byproduct. The information obtained would be used to determine the supplementation of iodine in the ration, formulation the mineral supplement with iodine enrichment, and proper supplementation time.

Materials and Methods

Fifteen female ECG were used in the study. Ration consisted of elephant grass and tofu byproduct meal. Elephant grass was harvested from the grass planted in the surrounding company (TSA) area. Tofu by product was bought from outside company. The distance of that area to the coastline was about 10 km with hilly and wavy topography.

Fifteen female ECG were allotted in 3 groups of female kid, young female goat and second-mid stage lactating goat with average body weight of 13.12, 19.62 and 40.72 kg,

respectively. Each group had 5 heads as replication.

Venobject tube was used to collect blood sample from vena jugularis in goat. The research was done in one month. Soil sample was composite of 5 subsamples from 5 points from 3 different places in the grass production area of TSA. The soil sample was collected from 20 cm deep. The grass samples were obtained from the same locations with the soil samples obtained, and then were composited.

Iodine content in the soil, thyroxin hormone (T4) content in blood serum, feed dry matter intake, nutrient and iodine content in feed, average daily gain, growth rate and milk production were observed. Iodine content in the soil was extracted by Watts and Mitchell method (2009), then measured using high performance liquid chromatography (HPLC). Iodine status in the grass was determined by colorimetric (Bourdoux, 1998). Thyroxin hormone (T4) in blood serum was determined by commercial ELISA kit and micro-titrimetric plates. Nutrient composition (Table 1) was determined use proximate analysis according to Weende method (Harris, 1970). The feed intake was determined by subtract the feed given and the feed unconsumed. Average daily gain was measured by weighing the initial weight and final weight during the experiment. Milk productions were the average of milk production in early, middle and the end during the study. The obtained data were analyzed by Analysis of Variance and were processed by Costat statistic programme.

Table 1. Nutritional composition of the experimental diets (DM basis)

Ingredients	CP (g/kg)	CF (g/kg)	NFE (g/kg)	EE (g/kg)	Ash	TDN
Elephant grass	95.2	311.3	418.2	22.7	152.6	554.3
Tofu by product	210.8	242.5	417.4	97.1	32.2	718.5

CP : Crude protein ; CF : crude fiber ; NFE: nitrogen free extract ; EE : ether extract ; TDN : total digestible nutrient

Results and Discussion

Iodine status of animal is resultant of several factors which interact each other and reflected among other in blood serum thyroxin hormone concentration. The factors are iodine content in the soil, iodine content in the feed, nutrient consumption and physiological stage of animal

As shown in Table 2, soil iodine content was 3.09 mg/kg. Iodine was not classified as essential mineral for plant, but 0.5-1 mg/kg iodine in the soil could stimulate the plant growth (Weng et al., 2008; Landini et al., 2011).

Table 2. Soil iodine concentration and iodine concentration in feed (DM basis)

Ingredient	Iodine content (mg/kg)
Soil	3.09
Elephant grass	1.503
Tofu byproduct	0.068

Soil iodine content is toxic for plant if the content reaches 10 mg/kg (Umaly and Poel, 1970). The soil iodine content in the study area was fit, even the topography of research area was hilly which is sensitive to erosion and leaching. The TSA Company was located near the coastal area. Amachi et al., (2005) stated that major iodine sources in the soil come from the sea. Further they stated that iodine could be transferred from sea water to atmosphere through iodine molecular volatilization (I_2) or organic iodine form as CH_3I , CH_2I_2 , or C_2H_5I which is produced by sea organisms, then the iodine was transferred to the soil through wet and dry deposition.

Elephant grass is the main feed in this investigation, so the grass is the main sources of iodine consumed by the goat. The iodine content in elephant grass was 1.503 mg/kg dry matter basis (Table 2). Kears (1982) stated that young ruminant, early pregnant and non lactation need feed with the iodine content was 0.25 mg/kg, while for lactating ruminant need iodine content was 0.5 mg/kg. The iodine is

toxic when the content was 50-100 mg/kg. The small ruminant is less sensitive to toxicity than that of big ruminant (Paulikova et al., 2002). Meschy (2000) stated that iodine content required in goat feed was higher than that of other ruminant species. 0.3 mg/kg iodine was inadequate to prevent the goiter in goat kids. Feed iodine content recommended by NRC (2007) was 0.5 mg/kg for goat in growth phase and 0.8 mg/kg for goat in lactation phase. Iodine content in grass was adequate to support the goat requirement at all physiological stages (Kearl, 1982; Meschy, 2000; NRC., 2007).

Elephant grass and tofu byproduct were given to goat in this investigation. Iodine content in tofu by product analysis showed the result as 0.068 mg/kg, whereas in elephant grass was 1.503 mg/kg. The iodine content in elephant grass and tofu byproduct was shown in Table 2. Calculation based on iodine content in elephant grass and tofu byproduct (Table 2.) and dry matter consumption of both feeds ingredients (Table 3) showed that daily iodine consumption were 0.37; 0.41 and 0.77 mg/day in female kid, young female goat and lactating goat respectively, with proportion were : 1.001; 0.942 and 0.818 mg/kg of consumed dry matter. Thyroxin hormone concentration in blood serum reflected the iodine status of animal. Iodine concentration in blood serum related with the iodine supply, main nutrient, performance and physiological stage of animal (Haenlein and Anke, 2011). Iodine concentration in blood serum on female kid, young female goat and lactating goat was shown in Table 4.

Thyroxin hormone concentration on blood serum was highest ($P < 0.05$) in young female goat, the concentration was 10.05 $\mu\text{g/dl}$. The concentrations of the hormone in female kid and lactating goat were 8.23 and 6.17 $\mu\text{g/dl}$, respectively. The thyroxin hormone concentration on blood serum was located in

Table 3. Feed intake, crude protein, TDN and iodine intake (mean ± SE), dry matter basis

Consumption	Physiological stage		
	Female kid	Young female goat	Lactating goat
Feed intake			
Daily average (g/day)	368 ^c ± 4.0	437 ^b ± 12.2	943 ^a ± 18.4
Percentage from body weight (%)	2.83 ^a ± 0.087	2.24 ^b ± 0.127	2.23 ^b ± 0.053
Elephant grass proportion (%)	65.18 ^a ± 0.837	61.16 ^b ± 0.525	52.32 ^c ± 0.268
Tofu byproduct proportion (%)	34.82 ^c ± 0.837	38.84 ^b ± 0.525	47.68 ^a ± 0.601
Dry matter waste (g/day)	40 ^a ± 2.4	22 ^b ± 2.6	34 ^a ± 2.9
CP intake			
Daily average (g/day)	49.86 ^c ± 0.618	61.17 ^b ± 1.759	141.74 ^a ± 2.641
Percentage from dry matter (%)	13.53 ^c ± 0.098	14.01 ^b ± 0.062	15.03 ^a ± 0.031
TDN intake			
Daily average (g/day)	225 ^c ± 2.4	270 ^b ± 7.5	596 ^a ± 11.5
Percentage from dry matter (%)	61.14 ^c ± 0.138	61.80 ^b ± 0.087	63.26 ^a ± 0.045
Iodine intake			
Daily average (mg/day)	0.37 ^c ± 0.006	0.41 ^b ± 0.027	0.77 ^a ± 0.017
Proportion from dry matter (mg/kg)	1.001 ^a ± 0.0124	0.942 ^b ± 0.0072	0.818 ^c ± 0.0039

Values bearing different superscripts within row are significantly different (P<0.05)

Table 4. Thyroxin hormone concentration (T4) in blood serum and goat performance(mean ± SE)

Item	Female kid	Young female goat	Lactating goat
Thyroxin hormone concentration (T4) (µg/dL)	8.23 ^b ± 0.20	10.05 ^a ± 0.07	6.17 ^c ± 0.18
Average daily gain (g/day)	55 ^a ± 0.67	61 ^a ± 1.03	26 ^b ± 2.11
Growth rate (%)	0.37 ^a ± 0.026	0.28 ^b ± 0.003	0.06 ^c ± 0.003
Milk production (mL)	-	-	850 ± 17.39

Values bearing different superscripts within row are significantly different (P<0.05)

normal number, as 6.10 – 8.30 µg/dl. The result was supported by adequate consumed feed iodine level (Table 3) according to NRC (2007). The thyroxin hormone concentration was highest in the young female goat because the use and supply rate in the tissue of young female goat was lower than goat in other physiological stages (female kid and lactating goat), at was the case for supported the maintenance and the lower growth rate (P<0.05) than female kid namely 0.28 vs 0.37% (Table 4). The supply rate of thyroxin hormone to female kid tissue was higher than that of young female goat, because its metabolic load was greater than young female goat (Iveta et al., 2011). The high metabolic load could stimulate deiodination of T4 to be T3 which more active so could reduce the T4 concentration (Todini, 2007; Todini et al., 2007; Abdollahi et al., 2013).

The high metabolic load to milk production and the iodine excretion with milk, cause the thyroxin hormone concentration in lactating goat blood serum was lower than other physiological stages goat, thus the hormone concentration in borderline, namely 6.17 µg/dl. Goat excrete the iodine in the milk is higher than other ruminant species (Flachowsky et al., 2014). Nudda et al. (2009) stated that iodine excreted through dairy cattle milk was 2% but in goat could reach 94% from iodine consumed daily. Thyroid hormone concentration was found in lactation goat might be caused by goitrogenic compound in tofu byproduct which could reduce the iodine utilization to thyroxin hormone synthesis. Feed consumption data (Table 3) showed that proportion of tofu byproduct consumption was highest in lactation goat compared to those in kid and young goat (47.68vs 38.84 and 34.82%).

Ni'mah (2009) stated that Tofu by product contains isoflavon consisted of genistein and daidzein, as 65.93 and 63.68 mg/100 g, respectively. Isoflavon is the compound which can reduce the thyroxin hormone synthesis through inhibit the thyroid peroxidase activity one enzyme could catalyzed the thyrosin residual iodination in thyroid gland (Dillingham et al., 2007; Somjen et al., 2012). Kearl (1982) stated that iodine supply needed to be doubled than normal requirement in ration with goitrogenic compound. Iodine status on lactation ECG was expected has impact on low milk production. As shown in Table 4, average daily milk production was 850 ml, while the potency of milk production between 2-3 kg/day (Obst and Napitupulu, 1984).

The low milk production might be caused by the low feed consumption even the nutrient composition was adequate for goat, as CP 15.03% and TDN 63.26% (Table 3). According to Ranjhan (1982), the requirements of dairy goat with 40 kg body weight in second mid lactation period with ADG 20 g/day were 10 %CP and 55 %TDN respectively. The low performance of goat was caused by inadequate of feed dry matter consumption, so that the consumed nutrient not adequate. The consumption of feed dry matter was only 2.23% from body weight but the dry matter consumption according to Ranjhan (1980) should be 4% from the body weight. The requirement of CP and TDN for dairy goat with 40 kg body weight were 145.6 g and 880 g, but in this study, the consumption of CP was only 141.74 g and the TDN consumption was only 596g/head/day (Table 3.). The body weight of lactating goat tends to increase, as 26 g/day (Table 4). That phenomenon might be due to delaying of lipid and carbohydrate catabolism along with the level of thyroxin (T4) hormone at the borderline, so that the increasing of fat deposition in adipose tissue was occurred (Biondi, 2010). According to Swanson and Miller

(1973), decreasing of milk production caused by hypothyroidism resulted in increasing of energy supply to body weight gain. Thrift et al. (1999) reported that lactating Brahman cattle with inductive hypothyroidism for 84 days showed the decreasing of milk production and higher increasing of body weight gain than control group, namely 54.6 vs. 15.7kg ($P < 0.01$)

Average daily gain (ADG) of female kid and young female goat were 55 and 61 g respectively (Table 4). The ECG was the large breed type, which according to Ranjhan (1980) its average daily gain could reach 86 for female kid with 14 kg body weight, and 100 g/day for young female goat with 20 kg body weight. The adequate consumed feed iodine and blood serum thyroxin (T4) hormone concentration showed that the low performance (ADG) of that female kid and young female goat was caused by inadequate consumed nutrient as result of inadequate feed dry matter intake. The dry matter intake of female kid and young female goat was 368 and 437, respectively (Table 3). The dry matter intake just 2.83% and 2.24% from its body weight, that amount was lower than the requirement as 4.1% and 4.0% (Ranjhan, 1980). The inadequate feed intake is also reflected by the average daily dry matter wasted of female kid, young female goat and lactating goat, namely 40; 22 and 34 g/day respectively (Table 3). Harris (1970) stated that voluntary intake was reached when the average daily dry matter wasted was 100-200 g/head/day. Inadequate dry matter intake caused low nutrient consumption, inadequate to produce optimal average daily gain. The CP and TDN consumption on female kid were 49.86 and 225 g/head/day respectively, while the CP and TDN consumption of young female goat were 61.17 and 270 g/day respectively (Table 3). On the other hand, CP and TDN requirement for female kid were 109.8 and 384 g/day, while the CP and TDN requirement for young female goat were 101.6 and 520 g/day.

Conclusion

There was the influence of physiological stages on iodine status of goat. The thyroxin (T4) hormone concentration in blood serum of young goat was greater than those of female kid and lactating goat. The lowest blood serum thyroxin hormone (T4) concentration was found in lactating goat. Feeding tofu byproduct as one of ration component where iodine level in ration were in normal range, resulted in normal blood serum thyroxin hormone concentration in female kid and young female goat, whereas in lactating goat was borderline. Iodine supplementation was required for lactating etawa crossbred goat, if tofu byproduct was included in its ration.

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