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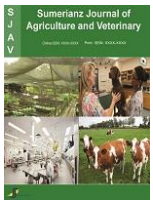

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Temperature – Humidity Index (THI) of Rabbits in a Tropical Environment as Influenced by Dietary Cocoa Pod Husk Meal

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Abstract

The temperature – humidity index (THI) of cross bred rabbits fed differently processed forms of cocoa pod husk meal based – diets was evaluated using sixty animals (24 bucks and 36 does with mean body weight of 606.42±1.30g). Twelve experimental diets were formulated containing raw, fermented and hot – water treated cocoa pod husk meal (CPHM) at 0, 12.5, 25 and 37.5 percent levels each. The rabbits were subjected to nine weeks feeding trial in a completely randomized design during which records of daily ambient temperature and relative humidity were taken using digital thermometer (LCD Digital Thermo - Hygrometer, model MT - 3 with sensor for indoor/outdoor temperatures and relative humidity display at the same time) throughout the study period. The rectal temperature of each rabbit was taken twice at 3 – 4 days interval on a weekly basis with the aid of a clinical thermometer (Ocean med+ England model). The thermometer was inserted into the rectum of the rabbits to a certain depth and reading was taken after 50 – 55 seconds when the mercury level stopped rising. The THI was calculated using appropriate formula. Results showed that the average rectal temperature was between 38.30° *and* 38.63 ℃ while the mean indoor and outdoor temperatures were 29.27 ± 0.04° *and* 28.72 ± 0.18℃ respectively and relative humidity of the rabbitry was 39.30±0.51% with the THI at 26.44; which was less than the critical value of 27.80, implying absence of heat stress. The study concluded that feeding raw, fermented and hot – water treated cocoa pod husk meal based-diets up 37.5 % to rabbits will not imposed additional heat load (heat stress) on the animals in the tropics and therefore establishes the THI of rabbits in a typical tropical environment as 26.44. Farmers are strongly advised to adopt this agro – industrial by –product in diets meant for rabbits in the tropics.

Keywords: Cocao; Housing; Rabbit; Temperature; Tropics.

1. Introduction

Rabbits have been reputed as meat animals and good sources of animal protein in the world. This is due to their peculiarities such as prolificacy, rapid growth rate and ability to subsist on grasses/legumes and agricultural by - products. Rabbit faeces could be used as organic manure. Rabbits could significantly assist in bridging the gap of meat deficit in the world. Animal production systems with ruminants usually require a longer gestation period to yield marketable products at high cost, especially for feed ingredients. Rabbits can subsist on forages under small - scale farming conditions in the tropics. Farm waste materials like cocoa pod husks [1], grasses/legumes and weeds such as *Centrosema pubescens*, *Tridax procumbens* and *Leucaena leucocephala* are common feeding stuffs in rabbit production [2].

Rabbit farming in Nigeria has been reported to be intensively carried out; though some scattered cases of backyard free rearing are found in some communities [3]. Rabbits are frequently housed in wooden or metal cages of varying dimensions. This is evident in urban and densely populated areas with different cage dimensions. In the villages, hutches are made from wooden planks. Rabbitries made of mud with rammed floors and thatch/asbestos roofs are also common. Tropical housing designs often predispose the rabbits to excessive heat stress. Rabbits have a low thermo – neutral zone of about 15^0C. Sterility in bucks commences at 29^0C and rabbits will become extremely stressed above 39^0C [4]. The mean lethal rectal temperature is 42.80^0C [5, 6], while the normal rectal temperature ranges from 38.00^0 – 40.00^0C [7]. In tropical regions, climate poses the main problem for breeders; this is because rabbits are very sensitive to heat. At temperatures above 30^0C, they lose their appetite and their growth rate slows down. At 30^0C, they consume 25 percent less than they would eat when temperature is 23^0C; thereby resulting in slow growth rate of about 20 percent [8]. Therefore, extreme heat resulting from global warming predisposes rabbits to heat stress.

According to Hupp and Rathwell [9], heat stress is the total effect of temperature, humidity, radiation and wind producing conditions higher than the animal's thermo - neutral zone. Rabbits do not possess functional sweat glands, so they lose moisture by perspiration through the skin. The fur on the rabbit's body inhibits the process of cooling by evaporation from the skin. About 80 % of heat loss in rabbits occurs through the evaporation of moisture during the

process of respiration in rabbits. Cooling is also made possible through the mucous membrane in the nasal cavity. The ears also play significant role in cooling the rabbits as the blood moves to the coolest points away from the body core. The rabbit also stretches its body to cool through the processes of radiation and convection. The severe effects of heat stress on rabbits could be summarised as follows: prolonged fatigue, digestive disorders and poor immune status as lymphocytes will be adversely affected. Persistent heat stress can also result in nervous system dysfunction and sometimes death; lower libido as sexual drive is diminished and at the extreme, they can be temporary sterility in rabbit bucks [4]. Lebas, *et al.* [10], reported that high temperatures affect spermatogenesis. Heat stress may also cause long term damage to kidneys [11]. Female rabbits may have abortion of their young; they may also ignore their newly kindled kittens or kindle outside the kindling box on the wire/ floor [12].

In order to mitigate heat stress on rabbits, Robert [12] proffered the following options: Temperature control options like installation of fans, planned breeding through allowing breeders to enjoy vacation/ rest from reproduction at months that have extremely high temperatures and synchronizing breeding of female rabbits to allow them to carry to term and take good care of their young. Reproductive rates can be accelerated by shortening the theoretical interval between two successive litters. Colony rearing that will enable bucks and female rabbits (does) free breeding as soon as the does kindle can also be used. Housing and hutch designs need special modification, where it is difficult to use other alternatives to corrugated iron sheets and where the only option left with the farmer is to put the free standing cages outside; then the provision of grass/raffia or asbestos shade will be of great benefit in reducing the direct effect of sun rays on the rabbits. The value for temperature humidity index (THI) less than 27.80 has been reported to denote absence of heat stress, while any value above 30.00 signifies serious heat stress in rabbits [13]. Furthermore, residual theobromine in cocoa products has been reported to elicit heat stress in rabbits [14-16]. Ojebiyi and Oseni [4] reported that sterility in bucks may commence at 29^0C and that rabbits will become extremely stressed above 35^0C with associated anorexia and reduced growth rate.

In view of the sensitivity of rabbits to heat stress, this study was designed to determine the temperature – humidity index (THI) of rabbits fed cocoa pod husk meal based diets in a typical tropical environment.

2. Materials and Methods

2.1. Study Location

The study was carried out at the Rabbitry Unit of the Teaching and Research Farm, Department of Animal Science, University of Calabar, Calabar, Cross River State, Nigeria. According to the GeoNames geographical database [17]; Calabar is located in the tropics at 4.9517^0 latitude and 8.322^0 longitude (in decimal degrees) with an average elevation/ altitude of 42 metres. Akpan, *et al.* [18], reported that Calabar is located at latitude 3^0N of the equator and longitude 7^0E of the Greenwich meridian, with a land mass of 233.2 sq. miles (604 km^2). The annual rainfall ranges from 3000 – 3500 mm (average of 1,830 mm) and the average daily temperature is 25^0C/77^0F which increases to 30^0C (86^0F) in August. The relative humidity is between 70 and 80 % while the wind speed/direction is 8.10 km/h west and the cloud is broken at 1000 ft. with little cumulonimbus at 2200 ft.

2.2. Collection, Processing and Proximate Analysis of Cocoa Pod Husk Meal (CPHM)

Freshly broken composite cocoa pod husks (derived from improved/hybrid cocoa varieties - CRINc1 – 8, WACRI 11 Hybrids and F3 - Amazon) were obtained from the fermentation units of the Cocoa Research Institute of Nigeria (CRIN) sub - station at Ajassor, Ikom LGA of Cross River State. The pods were collected during the main production season in West Africa (September – March) [19]. The broken pods were washed and sun - dried for two weeks, bulked and milled with hammer mill to produce Cocoa Pod Husk Meal (CPHM) Teguia, *et al.* [20]. The resultant meal was divided into three (3) portions: The raw CPHM (RCPHM), Fermented CPHM (FCPHM) and Hot water - treated CPHM (HCPHM), respectively. CPHM for the fermented treatment was thoroughly mixed with 60 percent water, relative to its weight as ascertained by Bello, *et al.* [21] and bagged using an air tight polythene bag. This was allowed to stand for three (3) days under room temperature, thereafter, it was opened and shade dried for five (5) days to constant weight; before being packed, bagged and stored in a cool dry place until it was used. The final portion of CPHM was treated with hot water that was boiled to 100^0C for 15 minutes [15, 22, 23], which was later drained, shade dried and stored for later use.

2.3. Experimental Diets

Twelve (12) experimental diets (Table 1) were formulated in line with the nutrient needs of rabbits as recommended by Aduku and Olukosi [7]. Each processed form of CPHM was included at 0, 12.5, 25 and 37.5 percent levels for T_1, T_2, T_3, and T_4 (Raw CPHM), T_5, T_6, T_7, T_8 (Fermented CPHM) and T_9, T_{10}, T_{11}, T_{12} (Hot – water treated CPHM), respectively in the experimental diets. Diet without CPHM (0 %) served as control in the experiment. The choice of these levels was based on earlier reports on the use of much lower levels of CPHM for poultry, pigs and rabbits without adverse and significant effects on growth performance characteristics [15, 20, 23]. Feedstuff purchase/choice and procurement of cocoa pod husks as well as methods of processing CPHM and ration formulation gave primary consideration to least cost and maximum biological returns [24]. The proximate composition (Table 2) of the experimental diets was done based on the procedures outlined by A O A C [25].

Table-1. Gross composition of experimental diets

Dietary treatments & levels of RCPHM					Dietary treatments & levels of FCPHM				Dietary treatments & levels of HCPHM			
Ingredients	T_1 (0%)	T_2 (12.5%)	T_3 (25%)	T_4 (37.5%)	T_5 (0%)	T_6 (12.5%)	T_7 (25%)	T_8 (37.5%)	T_9 (0%)	T_{10} (12.5%)	T_{11} (25%)	T_{12} (37.5%)
Yellow Maize	36.00	33.00	30.00	27.00	36.00	33.00	30.00	27.00	36.00	33.00	30.00	27.00
Soybean m.	15.70	16.00	16.00	17.00	15.70	16.00	16.00	17.00	15.70	16.00	16.00	17.00
Fish meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
PKC	4.00	6.00	7.00	8.00	4.00	6.00	7.00	8.00	4.00	6.00	7.00	8.00
Wheat offal	10.00	6.25	5.50	1.00	10.00	6.25	5.50	1.00	10.00	6.25	5.50	1.00
Rice husk	27.00	18.95	9.20	2.20	27.00	18.95	9.20	2.20	27.00	18.95	9.20	2.20
RCPHM	0.00	12.50	25.00	37.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FCPHM	0.00	0.00	0.00	0.00	0.00	12.50	25.00	37.50	0.00	0.00	0.00	0.00
HCPHM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.50	25.00	37.50
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Palm oil	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt (NaCl)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Premix	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis :												
% CP	16.00	16.04	16.32	16.61	16.00	16.04	16.32	16.61	16.00	16.04	16.32	16.61
%CF	10.00	11.65	13.54	15.87	10.00	11.65	13.54	15.87	10.00	11.65	13.54	15.87
*Theob.(g/kg)	0.00	2.83	5.67	8.50	0.00	2.83	5.67	8.50	0.00	2.83	5.67	8.50
ME (Kcal/Kg)	2,500.75	2,505.80	2,524.85	2,536.90	2,500.75	2,505.80	2,524.85	2,536.90	2,500.75	2,505.80	2,524.85	2,536.90

Gross Composition of Bio -Super Premix per Kg:
Vitamin A -1,5000,000IU; Vitamin D3 - 300,000IU; Vitamin E - 400mg; Vitamin K3 - 100mg;
Vitamin B2 - 400mg; Vitamin B12 - 2,000mg; Nicotinamide - 2,000mg; Calcium D - Panto-
thenate - 800mg; Choline Chloride - 40,000mg; Ferrous sulphate - 2,000mg; Manganese sulphate - 5,000mg; Copper sulphate - 80mg; Zinc oxide - 3,000mg; Cobalt sulphate - 10mg; Potassium iodide - 120mg;
DL-Methionine - 10,000mg and Antioxidant - 18,000mg.
The premix was manufactured by Bio - Pharmachemie Company, HCM City, Vietnam.
CF - Crude Fibre
CP - Crude Protein
*Theob.: Theobromine content - calculated based on standard method proposed by Odunsi and Longe (1998).
ME - Metabolizable Energy

Table-2. Proximate composition (determined analysis) of experimental diets

		RCPHM DIETS				FCPHM DIETS				HCPHM DIETS			
Parameter	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	
(%)	0%	12.5%	25%	37.5%	0%	12.5%	25%	37.5%	0%	12.5%	25%	37.5%	S.E.M
Dry matter	88.28^{c}	89.03^{b}	92.64^{a}	87.10^{f}	88.28^{c}	88.70^{b}	88.75^{b}	88.32^{b}	88.28^{c}	87.32^{c}	87.99^{d}	88.61^{b}	0.050
Crude protein	18.30^{b}	17.86^{d}	18.08^{c}	14.04^{f}	18.30^{b}	17.80^{d}	15.89^{e}	17.45^{c}	18.30^{b}	14.16^{f}	15.56^{e}	18.73^{a}	0.009
Crude fibre	14.13^{f}	18.55^{cd}	20.03^{e}	23.53^{b}	14.13^{f}	14.67^{f}	13.38^{f}	26.37^{a}	14.13^{f}	22.66^{c}	21.46^{d}	23.08^{b}	0.007
EE	10.53^{e}	12.17^{b}	11.57^{c}	10.63^{e}	10.53	11.36^{c}	14.81^{a}	10.98^{d}	10.53^{e}	9.91^{f}	11.13^{c}	10.95^{d}	0.009
Ash	10.21^{e}	10.94^{a}	8.36^{d}	9.31^{d}	10.21^{e}	7.60^{f}	8.48^{d}	10.82^{b}	10.21^{e}	10.45^{c}	10.38^{d}	10.38^{d}	0.006
NFE	46.83^{b}	40.48^{d}	41.96^{c}	42.49^{c}	46.83^{b}	48.57^{a}	47.44^{b}	34.38^{e}	46.83^{b}	42.82^{c}	41.47^{d}	36.86^{e}	0.009

a, b, c…f: means on the same row with different superscripts are significantly different ($P < 0.05$)
All Mean values are obtained from Triplicate samples per treatment/diet
RCPHM: Raw Cocoa Pod Husk Meal
FCPHM: Fermented Cocoa Pod Husk Meal
HCPHM: Hot -water treated Cocoa Pod Husk Meal
EE: Ether extract
NFE: Nitrogen free extract
S.E.M: Standard Error of Mean

2.4. Experimental Rabbits and Management

Sixty (60) weaned mixed breed rabbits between 5 and 6 weeks old of both sexes (24 bucks and 36 does), (average initial body weight of 606.42±1.30g/rabbit) were used in this study. The rabbits were purchased from a reputable rabbitry (Domino farms, Use - Offot) in Uyo, Akwa Ibom State, Nigeria. They were managed based on standard experimental procedures. On arrival at the rabbitry facility, the animals were provided with anti – stress vitalyte (Anidone – vita dox) at 0.50g per 75 litres of chlorine - free water. Concrete drinking troughs and fabricated feeding troughs were provided in each cage. The rabbits adjusted for two weeks before the actual commencement of the feeding trial and within this period; they were placed on commercial pelleted grower mash. The animals were further screened against ecto and endo parasites via subcutaneous injection of Ivermectin (Kepromec) at the recommended level (0.20 ml per rabbit) [7]. Thereafter, the animals were subjected to nine (9) weeks (63 days) feeding trial during which internal and external temperatures of the building as well as rectal temperature of the rabbits were determined accordingly.

2.5. Housing and Equipment

The experimental animals were accommodated individually in double tier wooden hutches (with wire mesh floor) measuring 65 × 65 × 65 cm (L × H× W) and raised 25 cm from the ground and placed in a standard rabbitry with corrugated roof and half walls to allow for cross ventilation.

2.6. Experimental Design

Animals were randomly distributed to the test diets using a simple Completely Randomized Design (CRD) with three processed forms of CPHM. They were twelve (12) dietary treatments with five (5) rabbits (2 bucks and 3 does) per treatment. The rabbits were assigned to the various treatments after equalizing for body weight and sex.

2.7. Temperature – Humidity Index (THI) Determination

Records of daily ambient temperature and relative humidity were taken using digital thermometer (LCD Digital Thermo - Hygrometer, model MT - 3 with sensor for indoor/outdoor temperatures and relative humidity display at the same time) throughout the study period. The digital thermo - hygrometer had the following specifications – Indoor temperature range: $-30^0 \sim +50^0$C ($-22^0 \sim 122^0$F), outdoor temperature range: $-50^0 \sim +70^0$C ($-58^0 \sim 158^0$F) and indoor Relative humidity range: 20 ~ 99 percent. The rectal temperature of each rabbit was taken twice at 3 – 4 days interval on a weekly basis with the aid of a clinical thermometer (Ocean med$^+$ England model). The thermometer was inserted into the rectum of the rabbit to a certain depth and reading was taken after 50 – 55 seconds when the mercury level stopped rising. The THI was calculated from the formula proposed by Marai, *et al.* [13] as follows:

$THI = db^0C – [(0.31 - .31 (RH/100) (db^0C – 14.4)]$

Key:

RH: Relative Humidity in percent

db: Average daily ambient temperature (dry bulb) of the rabbitry in degree Celsius

3. Results and Discussion

3.1. Rectal Temperature of Rabbits, Ambient Temperature of Rabbitry and THI

Table 3 shows results for the mean rectal temperature of rabbits fed diets containing differently processed forms of cocoa pod husk meal (CPHM); while Table 4 summarises the average daily ambient temperature and relative humidity of the rabbitry used in this study. The average rectal temperature recorded in this study ranges from 38.30 – 38.48^0C across dietary treatments. The average indoor, outdoor temperature and relative humidity values were 29.27 ± 0.04^0C, 28.72 ± 0.18^0C and 39.30±0.51 percent, respectively. Accordingly, the temperature – humidity index (THI) obtained in this study was 26.44.

The mean weekly rectal temperature recorded for rabbits fed raw, fermented and hot – water treated cocoa pod husk meal ranges from $38.30^0 – 38.63^0$C. The range is within the normal rectal temperature range ($38^0 – 40^0$C) for healthy rabbits [7, 8], implying that rabbits in this study did not suffer from hyperthermia; even though Adeyina, *et al.* [15] reported that rectal temperature in rabbits increased tremendously with higher levels of hot – water treated cocoa bean shell. Research findings by Adeyina, *et al.* [16] revealed that rabbits treated with synthetic theobromine had higher rectal temperature compared with rabbits administered with theobromine from cocoa bean shell extract. The normal rectal temperature in this study was due to the fact that theobromine was administered through processed and treated cocoa pod husk meal and not in the synthetic form. This difference could be attributed to the relative potency of theobromine as influenced by source [16]. The increase in rectal temperature of rabbits in the earlier study suggests the influence of theobromine on the hypothalamus centre of the brain in response to the negative feedback of the toxic effect of theobromine in rabbits. However, Ojebiyi and Oseni [4] reported that sterility in bucks may commence at 29^0C and that rabbits will become extremely stressed above 35^0C with associated anorexia and reduced growth rate. This confirms the report of Mohammed, *et al.* [26] that theobromine in cocoa by – products like cocoa bean shell and cocoa pod husk led to poor growth in rats. The average rectal temperature in rabbits is 42.80^0C [6]. The average daily temperature, relative humidity and the temperature – humidity index (THI) of the rabbitry (Table 4) shows a mean indoor temperature of 29.27 ± 0.04^0C, outdoor temperature of 28.72 ± 0.18^0C, relative humidity of 39.30±0.51 percent and THI at 26.44. The value for THI less than 27.80 has been reported to denote absence of heat stress, while any value above 30.00 signifies serious heat stress [13]. Based on the THI value, it could be stated that rabbits in this study did not suffer from heat stress as the disposition of the animals appeared normal throughout the duration of the study period.

Table-3. Mean weekly rectal temperature (degree Celsius) of rabbits fed cocoa pod husk meal- based

		RCPHM				FCPHM				HCPHM			
Week	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	S.E. M
	0%	12.5%	25%	37.5%	0%	12.5%	25%	37.5%	0%	12.5%	25%	37.5%	
1	38.35	38.48	38.28	38.10	39.13	38.95	38.78	38.90	38.56	38.78	38.88	38.50	0.09
2	38.70	38.24	38.20	38.53	38.40	38.30	38.38	38.80	38.30	38.54	38.65	38.70	0.06
3	37.95	38.55	38.14	38.35	38.40	39.15	39.08	38.60	38.82	38.66	38.28	38.83	0.11
4	38.67	38.63	38.74	38.38	38.55	38.63	38.15	38.50	37.98	38.15	38.08	38.33	0.07
5	38.47	38.78	38.76	38.70	38.53	38.73	38.53	38.87	38.48	38.58	38.93	38.57	0.04
6	38.10	38.13	38.54	38.40	38.53	38.07	38.43	38.90	38.22	38.18	38.33	38.30	0.07
7	38.20	38.48	38.24	38.68	38.05	38.33	38.00	38.63	38.40	38.25	38.13	38.27	0.06
8	38.20	38.75	38.16	37.95	38.30	38.10	38.00	38.27	38.18	38.08	37.89	37.87	0.07
9	38.10	38.25	38.12	38.03	38.15	38.10	38.35	38.17	38.04	38.00	38.17	38.00	0.03
Total	344.74	346.29	345.18	345.12	346.04	346.36	345.70	347.64	344.98	345.22	345.34	345.37	0.23
Mean	38.30	38.48	38.35	38.35	38.45	38.48	38.41	38.63	38.33	38.36	38.37	38.37	0.03

RCPHM: Raw Cocoa Pod Husk Meal
FCPHM: Fermented Cocoa Pod Husk Meal
HCPHM: Hot -water treated Cocoa Pod Husk Meal
S.E.M.: Standard Error of mean

Table-4. Average daily ambient temperature (degree Celsius) and Relative humidity (%) of the rabbitry that housed the rabbits fed CPHM Diets

Week	Indoor temperature	Outdoor temperature	Relative humidity
1	29.96	29.52	39.00
2	28.52	27.93	49.00
3	29.40	28.97	46.71
4	29.80	29.56	41.86
5	28.68	28.74	31.71
6	29.21	28.59	36.77
7	29.40	28.50	35.12
8	29.30	28.40	37.00
9	29.20	28.30	36.50
Total	263.47	258.51	353.67
Mean ± S.E. M	29.27±0.04	28.72±0.18	39.30±0.51

THI = 26.44
THI = db0C -[{0.31 - 0.31 (RH/100)} (db0C - 14.4)] (Marai et al. 2002)
Where: THI -Temperature -Humidity Index
db0C - Ambient temperature of the rabbitry
R.H.- Relative humidity
THI < 27.80, signifies absence of heat stress
THI > 30.00, signifies heat stress

4. Conclusion

Within the experimental conditions of this study, it is concluded that cocoa pod husk meal based – diets did not impose excess heat load that could have culminated to heat stress on the rabbits in the tropical environment. The temperature – humidity index was 26.44, which was less than 27.80; hence the rabbits did not suffer from heat stress.

Recommendation

The study recommends that farmers can feed up to 37.5 % cocoa pod husk meal based – diets to rabbits without fear of heat stress on the rabbits.

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