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Nutritive value of chocolate waste

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Abstract
An experiment was conducted to analyse the chemical composition of chocolate waste for its utility in livestock feeds particularly monogastric species. Chocolate waste samples were collected from different regions of Tamil Nadu, India and were analysed for the proximate and mineral composition. The chocolate waste was also analysed for its gross energy and metabolisable energy. The average dry matter, crude protein, ether extract, crude fibre, total ash and nitrogen free extract were 97.55, 3.11, 10.15, 0.06, 0.68 and 86.00 per cent respectively. The average calcium, phosphorus, iron, manganese, zinc and copper were 0.09 per cent, 0.36 per cent, 74.52 ppm, 19.10 ppm, 0.07 ppm and 0.05 ppm respectively. The gross energy and metabolisable energy in chocolate waste were found to be 4036 kcal/kg and 3571.51 kcal/kg respectively. Hence it could be concluded that chocolate waste is a rich source of energy with good source of nutrients and it can be used in poultry feeds as an alternative to conventional feed ingredient.

Keywords: chocolate waste, proximate composition, metabolizable energy

Introduction
There are many industries in India which manufacture chocolates throughout the year. The chocolate confectionery market volume in India in 2013 was at 103,000 tonnes (Naprta, 2015) [6]. It has been tentatively assessed by chocolate industry that Indian chocolate industry had registered a growth of 15 per cent per annum and is projected to grow to a production level of 3.42 lakh tonnes by the year 2018 resulting in considerable availability of chocolate waste.
Chocolate waste can be obtained from chocolate manufacturing industry. Chocolate waste is the waste that is produced during production of chocolates due to spillage or due to irregular sizes. The chocolate waste that is obtained contains considerable amount of nutrients which can be used as newer feed ingredient in livestock particularly monogastric species.

Materials and Methods
Four samples of chocolate waste of 500 g each were procured from chocolate manufacturing industry from different regions (Cuddalore, Kancheepuram, Thiruvallur and Vellore) of Tamil Nadu, India. The samples were dried in hot air oven and ground for further analysis. The chocolate waste samples were analysed for their proximate and mineral composition. Amino acids, gross energy and metabolisable energy content were also analysed in chocolate waste samples.

Proximate composition of chocolate waste
The proximate composition was determined as per the procedure of AOAC (2000) [1]. The proximate principles of chocolate waste were expressed on percent dry matter basis.

Mineral composition of chocolate waste
Minerals such as calcium, iron and manganese were analysed at Animal Feed Analytical and Quality Assurance Laboratory, Namakkal, Tamil Nadu, India. The copper and zinc in chocolate waste were determined by Atomic Absorption Spectrophotometer (AAS) (Perkin Elmer, AANALYST 400). Phosphorus was estimated calorimetrically as per AOAC (2000) [1]. Major minerals calcium and phosphorus were expressed on per cent dry matter basis and trace minerals such as copper, iron, zinc and manganese were expressed in ppm on dry matter basis.

Amino acid content of chocolate waste

The essential amino acids lysine and methionine in chocolate waste were analysed using ultra high performance liquid chromatography as per the procedure described by Einarsson *et al*. (2001) [3].

Gross energy content of chocolate waste

The gross energy in chocolate waste was determined by using bomb calorimeter following the procedure outlined by Mehra *et al*. (1998) [5].

$$GE = \frac{T \times W - (CV_T + CV_W)}{M}$$

Where

GE - Gross energy (cal/g)

T - Temperature rise in bomb calorimeter

W – Water equivalent in calories/^{0}C (2332 cal/^{0}C)

CV_T - Calorific value of thread (21 cal)

CV_W - Calorific value of fuse wire (9.32cal)

M - Mass of the sample (g)

Metabolisable energy content of chocolate waste

The metabolisable energy was determined in the chocolate waste that was used for the biological studies. The metabolisable energy content of chocolate waste was determined as per the procedure adopted by Sibbald (1976) [7]. Ten numbers of adult Japanese quails (Two control and eight treatment groups) were used in this study. At the start of the study, the birds were individually weighed and housed in cages. A plastic tray was placed under each cage to collect the excreta. The birds were starved for 24 hours to eliminate the feed taken previously. After 24 hours, the treatment group was force fed with weighed quantity of chocolate waste and the control group was starved to collect the endogenous losses. After 24 hours, excreta from treatment and control group were collected individually. The collected excreta were dried in hot air oven at 80 ^{0}C overnight and were ground and analysed in the bomb calorimeter. The metabolisable energy content in chocolate waste was estimated by the following formula

$$AME\ (kcal/g) = \frac{Gef \times X - Yef}{X}$$

$$TME\ (kcal/g) = \frac{Gef \times X - (Yef - Yec)}{X}$$

Where,

AME - Apparent Metabolisable Energy

TME - True Metabolisable Energy

Gef - Gross energy of feed (kcal/g)

X - Weight of feed (per cent dry matter basis) (g)

Yef - Gross energy voided in excreta by treatment group (kcal/g)

Yec - Gross energy voided in excreta by control group (kcal/g)

Results and Discussion

Proximate composition of chocolate waste

The per cent proximate composition of chocolate waste procured from different regions of Tamil Nadu, India is presented in Table 1. The crude protein values of 3.11 per cent obtained in this study is lower than that of Mc Naughton *et al*. (1997) [4] who reported higher crude protein value of 4.70 per cent. However, the values of ether extract, crude fibre, total ash and nitrogen free extract observed in the present study is in variance with Mc Naughton *et al*. (1997) [4] who reported higher ether extract (18.6 %), crude fibre (1.1 %) and total ash (1.5 %) and lower nitrogen free extract of 71.40 per cent respectively. The study reveals that the crude protein content in chocolate waste is comparable with tapioca flour. The lower crude fibre and higher nitrogen free extract content in chocolate waste indicates that the chocolate waste is a rich source of energy. The lower acid insoluble ash in chocolate waste indicates that the chocolate waste is devoid of contamination by sand or silica.

Mineral composition of chocolate waste

The mineral composition of chocolate waste collected from different regions of Tamil Nadu, India is presented in Table 2. The calcium content obtained in this study is slightly lower than 0.19 per cent reported by Mc Naughton *et al*. (1997) [4]. However, the phosphorus content in the present study is higher than values reported by Mc Naughton *et al*. (1997) [4]. The calcium and phosphorus content in chocolate waste is higher than in maize (0.03 % and 0.29 %) which is the main feed ingredient in poultry feeds. Hence the study indicates that chocolate waste can be used as an alternative to maize without affecting the dietary requirements.

Amino acid content of chocolate waste

The average lysine and methionine content of chocolate waste collected from different regions of Tamil Nadu were 0.002 ± 0.000 and 0.006 ± 0.002 per cent, respectively. The chocolate waste contains only traces of lysine and methionine which indicates that chocolate waste is a very poor source of protein. Hence, the protein content should be taken care of while including chocolate waste in diets of monogastric species.

Gross energy content of chocolate waste

The gross energy content of chocolate waste estimated in this study ranged from 4005.28 ± 3.16 to 4240.67 ± 7.33 kcal/kg. The differences in the gross energy content of chocolate waste may be due to the different processing methods followed in different chocolate manufacturing industries (Adeyemo *et al*., 2013). The gross energy value indicates that chocolate waste is a rich source of energy.

Metabolisable energy content of chocolate waste

The metabolisable energy content of chocolate waste in Japanese quails estimated in this study is tabulated in Table 3. The average metabolisable energy content of chocolate waste in Japanese quails is estimated to be 3571.51 kcal/kg which is lower than the values reported by Mc Naughton *et al*. (1997) [4] who reported ME content of 4848.57 kcal/kg. The metabolisable energy in chocolate waste obtained in this study is similar to ME value of maize. Generally the poultry feed is mainly constituted by the cereal grains which accounts for 50 to 55 per cent of feed, since poultry needs more energy for their growth. Hence, chocolate waste which is a rich source of energy can be used as an alternate energy source in poultry diets replacing the cereal grains.

Table 1: The per cent proximate composition of chocolate waste on (dry matter basis) collected from different regions of Tamil Nadu, India (Mean ± SE)

Proximate composition	Different regions of Tamil Nadu, India				Mean ± SE
	Vellore	Thiruvallur	Kancheepuram	Cuddalore	
DM	98.43 ± 0.19	95.96 ±0.64	98.06 ±0.06	97.74 ±0.23	97.55 ±0.55
CP	4.44 ±0.44	5.21 ±0.15	0.60 ±0.12	2.19 ±0.12	3.11 ±1.05
EE	32.63 ± 0.72	6.67 ±0.28	0.45 ±0.10	0.84 ±0.13	10.15 ±7.63
CF	0.00 ±0.00	0.06 ±0.01	0.19 ±0.01	0.00 ±0.00	0.06 ±0.04
TA	0.94 ±0.04	0.82 ±0.07	0.53 ±0.04	0.44 ±0.14	0.68 ±0.12
AIA	0.12 ±0.08	0.35 ±0.26	0.45 ±0.02	0.00 ±0.00	0.23 ±0.10
NFE	61.99 ± 0.87	87.24 ±0.08	98.23 ±0.15	96.53 ±0.09	86.00 ±8.36

Each value is a mean of four observations

Table 2. The mineral composition of chocolate waste collected from different regions of Tamil Nadu, India (Mean ± SE)

Minerals	Different regions of Tamil Nadu, India				Mean ± SE
	Vellore	Thiruvallur	Kancheepuram	Cuddalore	
Calcium, (%)	0.07 ±0.02	0.07 ±0.03	0.10 ±0.01	0.10 ±0.02	0.09 ± 0.01
Phosphorus, (%)	0.35 ±0.03	0.89 ±0.04	0.02 ±0.01	0.20 ±0.03	0.36 ± 0.19
Iron, (ppm)	54.34 ± 0.12	177.77 ±0.22	25.53 ±0.32	40.42 ± 0.16	74.52 ± 34.91
Manganese, (ppm)	0.00 ±0.00	50.67 ±0.46	25.73 ±0.67	0.00 ±0.00	19.10 ± 12.15
Zinc, (ppm)	0.15 ±0.05	0.05 ±0.02	0.02 ±0.01	0.07 ±0.03	0.07 ± 0.03
Copper, (ppm)	0.05 ±0.02	0.03 ±0.01	0.01 ±0.00	0.11 ±0.03	0.05 ± 0.02

Each value is a mean of four observations

Table 3. Metabolisable energy values of chocolate waste in Japanese quails

Quantity of feed consumed / bird, g (DM basis)	GE (kcal/g)	AME		TME	
	In excreta of Japanese quails fed chocolate waste	kcal/g	kcal/kg	kcal/g	kcal/kg
24.32	12.962	3.503	3503.00	3.523	3523.33
24.18	13.058	3.495	3495.96	3.516	3516.40
24.22	11.076	3.578	3578.65	3.599	3599.07
24.14	11.611	3.555	3555.00	3.575	3575.48
24.27	10.418	3.606	3606.71	3.627	3627.09
24.26	13.000	3.500	3500.11	3.520	3520.50
24.12	10.307	3.608	3608.64	3.629	3629.14
24.38	11.597	3.560	3560.30	3.580	3580.59
Mean ± SE	11.75 ± 0.40	3.55 ± 0.02	3551.05 ± 16.48	3.57 ± 0.02	3571.51 ± 16.49

Mean of eight observations

*Gross energy in chocolate waste = 4.036 (kcal/g)

*Gross energy in excreta of Japanese quails fed no chocolate waste = 0.478 (kcal/g)

Conclusion

It could be concluded that the chocolate waste obtained from chocolate manufacturing industry during production of chocolates is a good source of nutrients with high energy value and poor source of protein. Hence it can be used as feed ingredient in livestock feeds as an alternative to energy rich cereal grains.

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