Pertanika J. Trop. Agric. Sci. 40 (2): 279 - 284 (2017)

PERTANIKA JOURNALS

TROPICAL AGRICULTURAL SCIENCE

Journal homepage: http://www.pertanika.upm.edu.my/

Enhancing Solubility of Curcumin in Turmeric Oleoresin for Improving Productive Performance of Broiler Chickens

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ABSTRACT

This study examined the effect of enhancing solubility of curcumin, from Turmeric Oleoresin (TO), in boosting the productive performance of broiler chicken. Solid dispersion (SD) technique was used to enhance the solubility of curcumin for use in the broiler chicks' diet. The curcumin solubility (TOPSD) was prepared by mixing TO with carrier (Polyethylene glycol, PEG400) and adsorbent (Banana powder, BP) at the ratio of 1:1:3 by SD technique. High performance liquid chromatography (HPLC) was used to determine solubility of the mixture. The result showed that solubility rate of crude curcumin noticeably increased with carrier and adsorbent ($P<0.05$). This mixture was used to improve productive performance of broiler chickens. Two hundred and forty Arbor Acres chicks were randomly allotted to 10 groups. Each group was replicated 6 times (4 chicks per replication). The effects of sex (120 males and 120 females) and five levels of TOPSD (0, 0.2, 0.4, 0.6 and 0.8 % of diet) were examined in treatments by 5×2 factorial randomly. All chicks were raised for six weeks. Food and water were provided ad libitum. The results showed that increased levels of TOPSD reduced average daily feed intake (ADFI), improved feed conversion ratio (FCR) ($P<0.05$), but without any effect ($P>0.05$) on average daily gain (ADG) when compared with the control group. The sex of the chicks and treatment combination (the level and sex) had no ($P>0.05$) effect on productive performance.

Keywords: Turmeric, oleoresin, curcumin, solubility, broiler

ARTICLE INFO

Article history:
Received: 18 May 2016
Accepted: 19 December 2016

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INTRODUCTION

Curcumin is the principle curcuminoid isolated from the rhizome of turmeric plant (*Curcuma longa*) and various members of the ginger family (*Zingiberaceae*). It is a medicinal plant widely used and cultivated in tropical regions. The active

ISSN: 1511-3701

ingredients found in Turmeric (*Curcuma longa*) are curcumin, demethoxycurcumin, bisdemethoxycurcumin (Wuthi-Udomler et al., 2000) and tetrahydrocurcuminoids (Osawa et al., 1995). Curcumin is known to have antifungal (Wuthi-udomler et al., 2000), immunomodulatory (Antony et al., 1999), antioxidative (Osawa et al., 1995), antimutagenic (Soni et al., 1997), anti-inflammatory (Ammon et al., 1993), and nematocidal (Kiuchi et al., 1993) properties.

Dietary supplementation of curcumin is limited because of its low solubility in alkaline pH and being subject to hydrolysis when exposed to light, which result in poor absorption in animals (Kochhar, 2008). Research shows that curcumin is water insoluble, and has poor over-all solubility, wettability, and bioavailability. The solid dispersion (SD) technique has been used to increase solubility and absorption of poorly soluble drugs by dispersing the drug in a water soluble carrier in a solid state (Lefebvre et al., 1985). The objectives of this research were to: 1) enhance curcumin solubility by mixed Turmeric Oleoresin (TO) with carrier (Polyethylene glycol 400, PEG400) and adsorbent (Banana powder, BP) at the ratio of 1:1:3 (TOPSD) and 2) to determine the appropriate level of TOPSD for supplement in the broiler chicken diets to improve their productive performance.

MATERIALS AND METHODS

Solid dispersion (SD) preparations

Crude curcumin from Turmeric Oleoresin (TO) was mixed with carrier (ethyl acetate, PEG400) and adsorbent (BP) at the ratio of 1:1:3 (TOPSD) using SD technique. Ethyl acetate was removed from all mixed samples in hot air oven at 70°C for 30 minutes and dried in hot air ovens at 40°C for 6-12 hours. The samples were pulverised to 0.05-0.25 mm particle size using mortar and pestle. All samples were analysed for their solubility, quantity, and recovery.

Solubility of curcumin

Ten milligrams of curcumin from TOPSD was transferred into a 10 ml volumetric flask. The samples were dissolved in water. A magnetic stirrer with paddles was rotated at 200 rpm for 5, 15, 30, 60, and 120 min at 37 ± 0.5°C respectively. The supernatants were filtered through a 0.2 µm pore size millipore membrane at the same temperature. An aliquot of 20 µl was injected into high performance liquid chromatography (HPLC). The curcumin quantity and recovery were determined by HPLC using Ultrasphere® C_{18} as an analytical column. Methanol, 2% acetic acid, and acetonitrile at the ratio of 23:36:41(v/v) were used as mobile phase with 420 nm UV detection. All experiments were conducted in triplicates.

Animals and diets

Two hundred and forty Arbor Acres chicks (120 males and 120 females) were randomly allotted to a basal diet (21% crude protein and 8.6% fat) containing TOPSD at 0, 0.2, 0.4, 0.6 and 0.8 % respectively. The chicks were divided into 10 groups with

6 replications (4 chicks per replication) according to 5×2 factorial randomly. All chicks were raised for 6 weeks. Food and water were provided to broiler chickens ad libitum. Body weight and feed intake were recorded weekly between three and six weeks of age. Growth performance was calculated as average daily feed intake (ADFI), average daily gain (ADG) and feed conversion ratio (FCR).

Statistical analysis

Curcumin quantity, curcumin recovery and curcumin solubility from TOPSD samples were compared using PROC TTEST. Data obtained from ADFI, ADG, and FCR were subjected to analysis of variance (SAS, 2001). Treatment means were compared using Duncan's New Multiple Range Test. The values were displayed as least square means (±SE).

RESULTS AND DISCUSSION

Quantity, recovery and solubility of curcumin

The crude TO samples were sticky and black in colour. Adding carrier and adsorbent altered the colour of crude (TO) to light yellow and in powdery form as shown in Figure 1. The crude (TO) contained 16.49% curcumin. Quantity and recovery of curcumin in TOPSD were 2.2% and 67.2% respectively (Table 1). Curcumin from TOPSD showed higher ($P<0.05$) solubility than crude TO (Figure 2). The SD technique increased the solubility and maximised the surface area of curcumin. This might be due to the role of PEG 400 and BP that increased active molecular carriers on the surface of curcumin. Pornanek & Uriyapongson, (2014) conducted experiments to improve recovery and solubility of curcumin from Turmeric Oleoresin (TO) by carrier (Polyethylene glycol 400, PEG 400) and adsorbent (Magnesium oxide, MgO) using SD technique. The ratio of 1:1:3 (TO: PEG400: MgO) suggests the highest

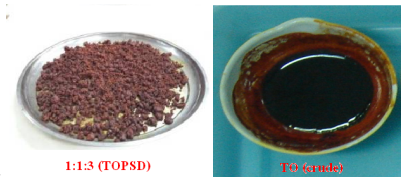

Figure 1. Characteristic of TOPSD and TO

Table 1
Quantity of curcumin and curcumin recovery from TO and TOPSD

TO: PEG400: BP	Curcumin (mg/100mg)	Curcumin recovery (%)
1:0:0 (TO)	16.49±0.01[a]	96.98±4.74[a]
1:1:3 (TOPSD)	2.28±0.01[b]	67.20±4.74[b]

Means in the same column with different lowercase letters differ ($P<0.05$)

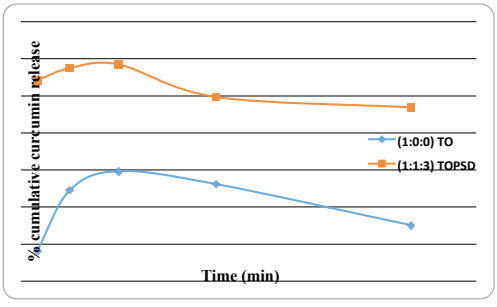

Figure 2. Solubility profile of curcumin from TO and TOPSD in water

recovery rate (81.47%) and the highest solubility in water. Other studies indicated that the solubility of curcumin increased linearly because PEG400 is highly hydrophilic (Modasiya1 & Patel, 2012). Higher solubility of curcumin was also indicated by excellent wettability, which could be observed clearly from the solid dispersion as it rapidly left the surface, and was dispersed in the bulk of dissolution media (Tonnesen, 2002). Moreover, the wetting property of the TOPSD was responsible for enhancing solubility (Leuner & Dressman, 2009; Craig, 2002).

Influence of TOPSD on growth performance of broilers

Effects of dietary supplementation of TOPSD on growth performance of broilers are shown in Table 2. The ADG of all trials were not significantly different (P>0.05). Supplementation of TOPSD at 0.6% and 0.8% in the diet resulted in lower ADFI than the TOPSD-fed broiler at 0%, 0.2% and 0.4% (P<0.05). The FCR of the broiler fed with 0.2, 0.4, 0.6 and 0.8% TOPSD were significantly lower (P<0.05) than that broiler fed with TOPSD at 0% of diet. Sex of the chicks and the treatment combination between the level and sex had no (P>0.05) effect on growth of broiler chickens. Enhancing solubility of curcumin in turmeric oleoresin (TOPSD) showed lower FCR. An improved FCR in TOPSD-fed group at level of 0.2%, 0.4%, 0.6% and 0.8% may be due to optimum antioxidant activity of curcumin to stimulate protein synthesis via the enzymatic systems in

Table 2
Effects of TOPSD levels on productive performance of broiler chickens

Items	TOPSD (%)												SEM	P-value		
	0		0.2		0.4		0.6		0.8							
	M	F	M	F	M	F	M	F	M	F				Trt	sex	trt*sex
Initial weight (g/h)	43.33	44.13	44.13	43.16	43.33	43.80	43.16	43.80	43.50	43.80	0.17			0.99	0.49	0.56
Final weight (g/h)	1485.00	1505.00	1592.08	1575.00	1560.00	1579.58	1497.00	1514.58	1486.25	1532.70	11.76			0.05	0.46	0.94
Weight gain (g/h)	1460.86	1460.87	1547.95	1531.83	1516.66	1535.78	1454.33	1457.75	1442.75	1488.90	11.75			0.06	0.46	0.95
ADFI (g/h/d)	63.48^{a}	63.81^{a}	63.13^{a}	63.10^{a}	62.14^{ab}	62.20^{ab}	61.59^{b}	61.48^{b}	61.35^{b}	61.57^{b}	0.18			0.01	0.51	0.86
ADG (g/h/d)	34.32	34.78	36.85	36.47	36.11	36.56	34.62	35.01	34.35	35.45	0.27			0.05	0.47	0.95
FCR	1.85^{a}	1.83^{a}	1.71b	1.73^{b}	1.72^{b}	1.70^{b}	1.78^{b}	1.75^{b}	1.77^{b}	1.74^{b}	0.01			0.01	0.46	0.92

ADFI means average daily feed intake, ADG means average daily gain, and FCR means feed conversion ratio, (g/h) = gram per head, (g/h/d) = gram per head per days, ^{a,b,c} means within a low with different superscript letters are significantly different at P<0.05. 0 = diet with no TOPSD, 0.2 = diet with 0.2 % TOPSD /kg diet, 0.4 = diet with 0.4% TOPSD /kg diet, 0.6 = diet with 0.6% TOPSD /kg diet, 0.8 = diet with 0.8% TOPSD /kg diet, M= male, F=female

the chicken. This is consistent with the findings of Osawa et al., 1995. Similar findings about alteration in performance parameters of broiler fed turmeric powder were reported by other researchers (Wuthi-Udomler et al., 2000; Samarasinghe et al., 2003; Durrani et al., 2006). Turmeric powder improves the liver function of broiler by decreasing the activity of alanine aminotransferase and alkaline phosphatase (Emadi & Kermanshahi, 2007a). It also enhances the antioxidant status of heat stressed broilers by improving the activity of glutathione peroxidase and superoxide dismutase and decreasing the concentration of malondialdehyde (MDA) (Zienali et al., 2011).

Adding 0.5% turmeric to the diet of the broiler chicks improved their FCR (2.08) compared with the control group (2.47) (Al-Sultan, SI. 2003). The broiler chicks that were fed dietary turmeric powder (TP) showed weight gain, energy efficiency ratio, yield of production, and lower FCR than those which were on basal diet ($P<0.05$) (Suvanated et al., 2003). Therefore, it is possible that the enhanced growth of broiler chicken is directly attributed to the role of turmeric in their feed which improved their digestive system (Platel & Srinivasan, 2000) and increased villus length and weight in the duodenum, jejunum and ceca of broiler chickens at 42 days of age (Rajput et al., 2012).

CONCLUSION

The aqueous solubility of curcumin was improved by adding TO into PEG400 and BP at 1:1:3 ratio. The treated curcumin had a higher solubility rate than crude curcumin from TO. Supplementation of the TOPSD in broiler chickens lowered FCR and reduced ADFI, while ADG of all trials was not significantly different compared with the control group.

ACKNOWLEDGEMENTS

This study was supported by Rajamangala University of Technology Isan Sakon Nakhon Campus, Sakon Nakhon Thailand 47160. We thank Sakon Nakhon Rajabhat University International Conference 2015 (SNRU-IC 2015) for providing relevant inputs to this paper.

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