Inclusion of an emulsifier to the diets containing different sources of fats on performances of Khaki Campbell ducks

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Summary

An experiment was conducted to study the effects of an emulsifier (glycerol polyethylene glycol ricinoleate: GPGR) and different sources of fat on the performance of Khaki Campbell ducks. Ducks were assigned into five groups with three replicates (10 ducks/ replicate) in each group. Treatments were a control diet (C1: without added oil and emulsifier), control diet added with 2% soybean oil (C2). For the other three groups, maize was replaced with rice bran and added with 2% soybean oil plus emulsifier (T1), 2% palm oil plus emulsifier (T2), and 2% lard plus emulsifier (T3). Feed intakes were not affected (P>0.1) by any dietary treatment. There were also no effects (P>0.1) of dietary treatment on body weight gain and feed efficiency except for T3 group, where body weight gain was lower compared with other treatments, and feed efficiency was lower than C2, T1, and T2. The metabolizability of dry matter tended (P=0.08) to decrease in T1, T2 and T3 groups than in C1 and C2 groups. Apparent metabolizable energy contents were significantly greater (P<0.05) in the C2 group than in the C1 group, but were similar among C1, T1, T2 and T3 groups. The metabolizability of fat and other nutrients were not affected (P>0.10) by dietary treatments. Major carcass traits were unaffected (P>0.10) among the treatments. In conclusion, soybean oil and palm oil with GPGR as emulsifier could be added in the diets containing high amount of rice bran without affecting the performance; whereas lard may adversely affect the performance of ducks.

Key words: Emulsifier, Fats, Growth, Khaki Campbell ducks, Nutrient utilization

Introduction

Duck farming systems in most developing countries, like India, are generally confined to the traditional family-based smallholder farmers. One of the major constraints of this type of system for improving the productivity is the non-availability of sufficient amount of feeds. Thus, it is important to incorporate inexpensive local feed ingredients in the diet of ducks. However, low-priced local feed ingredients such as wheat and rice bran are generally low in energy density. Fats and oils are often included to increase energy density in diets of poultry. Low energy ingredients could be included replacing high-energy ingredients such as corn with the addition of fats. Lipids also supply essential fatty acids, and help in the absorption of fat-soluble vitamins. Most importantly, modification of fatty acid composition in meat and eggs, particularly n-3 polyunsaturated fatty acids (PUFA), i.e. α-linolenic acid and longer chain metabolites eicosapentaenoic acid and docosahexaenoic acid has been of recent interest owing to their beneficial effects on human health (Azad *et al*., 2009; Mandal *et al*., 2014). Fats being insoluble in a water medium of the gastrointestinal tract, need to be emulsified before digestion by lipolytic enzymes (Gu and Li, 2003). The process of this emulsification depends on the nature of fats, which is mainly determined by the chain length, the position of the fatty acids on the triglycerides and the fat saturation (Gu and Li, 2003).

The use of external emulsifiers could solubilize fats, and hence improve the absorption of the fatty acids from the gut. Emulsifiers sometimes enhance the absorption of other nutrients such as protein (Jones *et al*., 1992). Addition of lecithin as an emulsifier has been shown to improve utilization of dietary fats fed to chicks (Roy *et al*., 2010) and pigs (Jones *et al*., 1992). Emulsifiers also improved feed conversion ratio, feed intake and performance of animals depending upon fat sources and age of the animals (Cera *et al*., 1988; Li *et al*., 1990; Roy *et al*., 2010). In a previous experiment, lecithin increased the metabolizability of fats in ducks (Zosangpuii *et al*., 2012). Many emulsifiers have been evaluated for performance and nutrient utilization in chicken and pigs. However, information on the effects of glycerol polyethylene glycol ricinoleate (GPGR) as an emulsifier in diets with different sources of fats on the performances of ducks is not available. We hypothesized that the addition of GPGR emulsifier with fats may replace expensive cereal grains (i.e. maize grains) with inexpensive low-energy density feed ingredients (i.e. rice bran). Therefore, this experiment was undertaken to study the effects of different sources of fats added with GPGR on the performances of Khaki Campbell ducks fed diets replacing maize grains with rice bran.

Materials and Methods

Experimental ducks and treatments

Khaki Campbell ducklings were fed a starter diet without any fat supplementation up to 21 days. Then the ducks were offered the experimental grower diets (Tables 1 and 2) with addition of different sources of fats for 53 days. One hundred fifty ducks were assigned into five dietary groups with three replicates (10 birds/ replicate) in each group. Treatments were a control diet without added oil and GPGR emulsifier (C1), C1 diet added with 2% soybean oil (C2), diets prepared having CP and metabolizable energy similar to C1 replacing maize with deoiled rice bran and adding fats, where fats were 2% soybean oil (T1), 2% palm oil (T2) and 2% lard (T3). The GPGR emulsifier (a synthetic emulsifier; Volamel Extra, manufactured by Nukamel Inc., Hoogbuul, Olen, Belgium) was added at 2% (T1, T2 and T3) of the fat sources added to the basal diet. The required quantity of the emulsifier was blended with water and fats before it was mixed with the diets. Feeds in wet mash form were placed in feeders everyday at 8:00 h and 16:30 h. Drinking water was offered *ad libitum* all the time.

Measurements

Body weight of each of the ducks was recorded on day 0 and subsequently one week interval up to 53 days

Table 1: Ingredient and chemical composition (g/kg unless otherwise stated) of diets fed to ducks

Items	Control diet (C1)	Control diet + fat (C2)	Diet containing fat and emulsifier (TE)
Ingredient composition			
Maize grain	580	570	450
Soybean meal	200	200	200
Rice bran	150	140	260
Fish meal	40	40	40
Fat*	0	20	20
Mineral mixture	10	10	10
Di-calcium phosphate	15	15	15
L-lysine	0.6	0.6	0.6
DL-methionine	1.2	1.2	1.2
Common salt	2.0	2.0	2.0
Premix**	0.25	0.25	0.25
Trace minerals***	0.95	0.95	0.95
Chemical composition			
Organic matter	908	905	902
Crude protein	184.7	185.8	187.5
Crude fiber	62.2	62.5	72.3
Nitrogen free extract	629	614	600
Ether extract	31.9	42.4	41.4
Ash	92.4	95.2	98.5

* The T1, T2 and T3 groups were fed with TE diets containing soybean oil, palm oil and lard, respectively. Emulsifier was added at the rate of 2% of added fat. ** Supplied per kg diet: vitamin A 8000 IU, vitamin D_3 1200 IU, vitamin E 24 IU, vitamin K 1.5 IU, thiamin 1 mg, riboflavin 6 mg, niacin 60 mg, pantothenic acid 10 mg, pyridoxine 2.5 mg, cobalamin 20 µg, biotin 0.15 mg, folic acid 100 mg, choline chloride 800 mg, selenium 150 µg. *** For 100 kg feed (in g): Ferrous sulphate 45, zinc sulphate 22.50, manganese sulphate 23.61, copper sulphate 3.60, potassium iodide 0.15, and sodium selenite 0.20

Table 2: Effects of an emulsifier on performance of Khaki Campbell ducks fed different types of fat

Items	Treatments					SEM	P-value
	C1	C2	T1	T2	T3		
Body weight (g)							
Day 0	138.8	141.3	140.8	137.5	140.0	2.57	0.75
Day 14	428.3^{ab}	461.9^{a}	436.1^{ab}	445.0^{a}	397.5^{b}	9.64	0.04
Day 28	858.0^{a}	870.7^{a}	760.6^{bc}	822.5^{ab}	675.0^{c}	21.38	0.01
Day 53	1246^{a}	1277^{a}	1244^{a}	1302^{a}	1159^{b}	25.35	0.03
Intake (g/day)							
Days 0-14	51.7	52.7	51.9	52.0	51.3	8.26	0.90
Days 15-28	88.6	88.5	85.9	86.0	86.4		
Days 29-53	133.8	133.9	130.4	130.2	130.6		
Overall	100.1	100.5	97.9	97.9	98.0	4.47	0.82
Feed to gain ratio (g/g)							
Days 0-14	2.50^{b}	2.30^{b}	2.46^{b}	2.37^{b}	2.79^{a}	0.06	0.02
Days 15-28	2.89^{b}	3.03^{b}	3.79^{a}	3.19^{b}	4.07^{a}	0.11	<0.01
Days 29-53	8.62^{a}	7.94^{ab}	6.64^{bc}	6.79^{bc}	7.34^{c}	0.18	0.04
Overall	4.79^{ab}	4.69^{a}	4.70^{a}	4.46^{a}	5.41^{b}	0.15	0.02

[a, b, c] Means followed by different superscript letters in a row differ significantly (P<0.05)

of experimental period. Measured quantity of feeds was offered to the ducks every day in wet mash form. The residues left were quantified everyday and total feed intake was calculated by estimating the dry matter (DM) content of feeds offered and the residues left.

Metabolism trial

A metabolism trial was conducted after the feeding trial ended. Two ducks from each replicate were transferred to metabolism cages for seven days including a collection period of five days. The amount of feed offered and that of the residue left was measured. The total amount of excreta obtained in a 24 h period was weighed and put in zipped polyethylene sachets. Samples of excreta were pooled replicate wise and frozen at -20°C until analysis.

Carcass traits

The birds were slaughtered on day 54 of experimental period after randomly picking three ducks from each of the replicates of all treatments. The birds were killed after an overnight fast by decapitation, and processed for carcass characteristics as described previously (Zosangpuii *et al*., 2012). The carcass components were stored at -20°C for analyses. For analysis of nutrient contents in meat, the eviscerated frozen carcass cuts were thawed and the muscles were manually separated from bones, minced mechanically and homogenized in a tissue homogenizer (Remi Motors, Mumbai, India).

Blood and intestinal samples

Blood samples were collected directly in test tubes after decapitation from three ducks from each replicate. The serum was separated by centrifuging blood at 2500 rpm for 10 min and harvested into polystyrene tubes and stored at -20°C until analysis.

The duodenum, jejunum and ileum were separated at the time of slaughter, and a small portion of each part was collected in a bottle containing 20% formalin. Thin sections (5 μm) were cut and stained with routine haematoxylin and eosin. After staining, the segments were processed (Iji *et al*., 2001) for light microscopy. All the measurements were made using micro-measurement and image analysis software (Biowizard 4.2, Dewinter Optical Inc., New Delhi, India). The villus length was measured from the tip to the bottom excluding the crypt.

Chemical analysis

The nutrient composition of feeds, excreta and meat was estimated following the AOAC (1995) methods. Serum cholesterol was estimated by using commercial kits (RFCL Ltd., Haridwar, India) in an Automatic Blood Analyzer (Microlab 200, E-Merck India Ltd., India).

Statistical analysis

The data were analyzed in a completely randomized design employing one way analysis of variance using SPSS (1997). Data involving measurement at different time intervals (day) were analyzed by the repeated measure of GLM. All pairwise significant differences ($P<0.05$) between treatment means were separated by Fisher's protected least significant difference using SPSS (1997).

Results

Body weight

The body weight of ducks showed a significant ($P<0.05$) day × diet interaction (Table 2). On day 14 of the experiment, body weights of ducks were similar ($P>0.10$) in all groups except the body weights of T3 ducks, which were significantly lower ($P<0.05$) than that of T2 ducks. On day 28, body weights in T3 groups were lesser ($P<0.05$) compared with body weights in C1, C2 and T2. The body weights of ducks were lower ($P<0.05$) in T3 groups than other groups on day 53.

Feed intake and feed efficiency

Feed intakes by ducks were similar ($P>0.10$) among all the groups and all the periods. The feed to gain ratios showed a significant ($P<0.05$) day x treatment interaction. The feed to gain ratio was greater ($P<0.05$) in T3 group on days 0 to 14, and in T3 and T1 groups on days 15 to 28 compared with other groups. However, these ratios in the T3 group were lower ($P<0.05$) than those in C1 and C2 groups, and were similar ($P>0.10$) in T1 and T2 groups from days 29 to 53. Overall, feed efficiency was lower in T3 than C2, T1 and T2, but were similar ($P>0.10$) between C1 and T3 groups.

Intakes of nutrients and their metabolizability

The intakes of different nutrients during metabolic trial were similar ($P>0.05$) among the treatment except ether extract and nitrogen free extract (Table 3). The ether extract intakes were greater ($P<0.05$) in oil supplemented groups than the group without oil supplementation. The intakes of nitrogen free extract were higher in C1 groups than in T1, T2 and T3 groups. The metabolizability of dry matter showed a tendency ($P=0.08$) to be lower in T1, T2 and T3 groups than in C1 and C2 groups. Apparent metabolizable energy contents were significantly greater ($P<0.05$) in the C2 group than in the C1 group, but were similar among C1, T1, T2 and T3 groups. The metabolizability of other nutrients, i.e. fat, crude protein, nitrogen free extract and energy were not affected ($P>0.10$) by dietary treatments.

Carcass traits and meat composition

Hot carcass, carcass yields, breast, legs and heart (as percentage of live weight) did not differ ($P>0.10$) among the treatments (Table 4). However, weights of livers were comparatively higher ($P<0.05$) in the T1 group than C1, C2 and T2. Weights of lungs were greater ($P<0.05$) in the C1 group than in the C2, T1 and T2 groups. Weights of gizzards were higher ($P<0.05$) in T3 than in C2 groups, but were similar ($P>0.10$) for other groups. The weights of giblets (% of BW) were higher ($P<0.05$) compared with other treatments. The meat composition such as moisture, protein and ash (percent on fresh basis) did not differ ($P>0.1$) among treatments. However, fat

Table 3: Effects of an emulsifier on intake and metabolizability of nutrients in ducks fed different types of fats

Items	Treatments					SEM	P-value
	C1	C2	T1	T2	T3		
Intake							
Dry matter (g)	134.3	131.4	130.9	129.6	127.7	1.61	0.27
Ether extract (g)	4.56^{b}	5.57^{a}	5.63^{a}	5.19^{a}	5.02^{a}	0.063	<0.01
Crude protein (g)	24.7	24.5	24.6	24.4	24.1	0.12	0.65
Nitrogen free extract	87.9^{a}	82.0^{ab}	76.7^{b}	80.7^{b}	78.9^{b}	1.47	0.04
Gross energy (kcal)	452.1	472.8	475.6	469.5	479.9	5.78	0.10
AME (kcal)	382.4	416.5	390.5	381.0	396.3	9.65	0.20
Metabolizability							
Dry matter (%)	83.1	86.1	79.1	80.0	79.7	1.35	0.08
Fat (%)	86.9	89.0	90.24	87.8	92.5	1.31	0.14
Crude protein (%)	77.0	74.8	71.3	73.5	72.5	4.73	0.91
Nitrogen free extract (%)	93.6	94.9	91.4	90.6	89.6	1.46	0.20
Energy (%)	84.5	88.1	82.0	81.1	82.5	2.10	0.27
AME (Mcal/kg)	2.843^{b}	3.170^{a}	2.979^{ab}	2.939^{ab}	3.099^{ab}	0.056	0.04
Villi length (µm)							
Duodenum	818	667	685	779	862	87.5	0.44
Jejunum	687	684	601	603	714	67.2	0.67
Ilium	561	550	621	618	576	40.1	0.65
Cholesterol (mg/dl)	154	164	182	164	155	5.74	0.35

[a, b] Means followed by different superscript letters in a row differ significantly (P<0.05). AME: Apparent metabolizable energy, and SEM: Standard error of mean

Table 4: Effects of an emulsifier on carcass traits and meat composition of ducks fed different types of fats

Items	Treatments					SEM	P-value
	C1	C2	T1	T2	T3		
Carcass traits (% of BW)							
Hot carcass	57.73	58.67	60.76	60.36	61.37	2.29	0.64
Breast	15.63	14.78	13.51	16.03	14.65	0.728	0.53
Legs	9.37	9.29	10.02	9.35	10.94	0.417	0.25
Liver	1.90^{b}	1.94^{b}	2.43^{a}	1.71^{b}	2.17^{ab}	0.057	<0.01
Lungs	0.81^{a}	0.61^{b}	0.58^{b}	0.63^{b}	0.67^{ab}	0.038	0.02
Gizzard	3.28^{ab}	2.92^{b}	3.18^{ab}	3.10^{ab}	3.88^{a}	0.164	0.04
Heart	0.72	0.72	0.78	0.80	0.79	0.027	0.35
Giblets	6.25^{b}	6.11^{b}	7.19^{a}	6.34^{b}	7.52^{a}	0.166	<0.01
Carcass yield	46.63	47.51	48.75	47.45	48.16	2.45	0.47
Meat composition (% of fresh basis)							
Moisture	71.9	70.3	73.3	71.3	71.01	0.847	0.22
Protein	18.3	17.9	19.1	19.1	19.2	0.455	0.25
Fat	2.16^{a}	3.00^{c}	2.45^{ab}	3.05^{c}	2.62^{b}	0.088	0.03
Ash	1.51	1.67	1.63	1.48	1.51	0.069	0.34

[a, b] Means followed by different superscript letters in a row differ significantly (P<0.05)

percent in meat was higher in C2 and T2 than in C1, T1 and T3.

Intestinal morphology

The villi length of duodenum, jejunum and ilium was not impacted (P>0.10) by various dietary treatments. The concentrations of cholesterol in serum were also similar (P>0.10) in different treatments.

Discussion

Supplementation of soybean oil and palm oil with emulsifier did not affect the body weights of ducks. However, body weights of ducks were lower for the lard and emulsifier added group than other groups. The reason is not clear. It has been reported that supplementation of lard to diets fed from days 0 to 14 negatively affected digestibilities of DM and CP; however, digestibilities of DM, GE and CP were improved during the later phase in pigs (Xing *et al*., 2004). Soares and Lopez-Bote (2002) also demonstrated that digestibility of lard was significantly lower than the digestibility of soybean oil during the first two-week period, whereas digestibility of lard was comparable to that of soybean oil in the subsequent period. It appears that lard was not well-utilized in the diets of ducks particularly at the initial days of adaptation. There are contrasting reports on the effects of fats and emulsifiers on the performance of non-ruminants. Jones *et al*. (1992) reported that different fat sources did not improve growth performance for the first 7 to 14 d post-weaning diet in piglets. However, Xing *et al*. (2004) reported a linear improvement of body weight gain due to supplementation of lard with lysolecithin in pig from days 15 to 35. Roy *et al*. (2010) recently observed that GPGR emulsifier improved the performances of broiler chickens using palm oil. Feed intakes by ducks were not influenced by emulsifier as also reported by Roy *et al*. (2010) in broiler chickens and Jones *et al*. (1992) and Overland *et al*. (1994) in pigs.

There was a tendency (P=0.08) for the C1 and C2 diets to have greater DM digestibility compared with T1, T2 and T3 diets, which might be attributed to the inclusion of deoiled rice bran replacing maize grain. The emulsifier did not influence the digestibilities of fats from different sources fed to ducks in this experiment.

The addition of soybean lecithin in adult roosters (Blanch *et al*., 1996) and phospholipids (0.3% Lysoforte) in pigs (Dierick and Decuypere, 2004) also did not improve the utilization of animal fat. Jones *et al*. (1992) studied the interaction between fat source and type of emulsifier. Tallow was more digestible when lecithin as an emulsifier was added compared with lyso-lecithin. There was a decrease in digestibility of lard when lecithin was the emulsifier *versus* when lysolecithin was the emulsifier. In this experiment, the emulsifiers had no effect ($P>0.10$) on the metabolizability of any fats in ducks, which might be due to low levels of fat in the diets. Soy-lecithin as an external emulsifier also did not improve the apparent digestibility of rendered fat in cereal-soybean meal-based diets (Overland *et al*., 1994) and of lard and soybean oil (Soares and Lopez-Bote, 2002) fed to growing pigs. Although the metabolizability of energy was not affected by dietary treatments, apparent metabolizable energy (AME) content improved in the C2 diet compared with the C1 diet due to addition of soybean oil in the C2 diet. However, the AME contents were similar among C1, T1, T2 and T3 diets, which suggested that maize grains could be replaced with 20% deoiled rice bran and addition of 2% fats in ducks without altering AME contents.

The morphology of intestinal epithelium is associated with intestinal function and is influenced by diets (Jiang *et al*., 2012). Inclusion of GPGR did not affect the serum cholesterol. The addition of GPGR, however, decreased serum total cholesterol in the study of Roy *et al*. (2010). Relatively low level of fat in the diet of ducks compared with the study of Roy *et al*. (2010) probably did not show any response on the cholesterol levels. In our previous study, lecithin decreased the serum cholesterol levels in ducks added with 3% of different fat sources.

Addition of different sources of fats may affect the intestinal absorptive surface area and functionality. Cera *et al*. (1988) reported that pigs fed corn-oil-supplemented diets (6% corn oil) had shorter villi than pigs fed diets without added corn oil. Similarly, Li *et al*. (1990) showed that pigs fed a combination of 50% soybean oil and 50% coconut oil had long and round villi, whereas pigs fed diets containing soybean oil or coconut oil alone had shorter villi. In this study, added fats or fats with emulsifier did not affect intestinal villi height. It seems that low levels of fat may not affect the intestinal morphology in ducks. The studies of Cera *et al*. (1988) and Li *et al*. (1990) included fats at higher levels (5 to 10%), but fats were included at 2% level in this study.

Soybean oil with emulsifier increased the relative liver weights, which could be due to increased lipid metabolism in the liver as a result of soybean oil supplementation along with emulsifier. The fat percentage in meat was in general greater due to addition of fats which could involve accretion of fats in meat. Huang *et al*. (2008) noted that addition of soy-lecithin in broiler increased fat percentage in thigh meat.

In conclusion, this study suggests that lard may adversely affect the growth performance of duck, whereas soybean oil and palm oil with the inclusion of GPGR as an emulsifier could be used to increase energy density replacing low energy ingredients in the diets without affecting the performance of ducks.

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