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Chemical characterisation of commonly used dietary oils in broiler production

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Abstract

This study was conducted to characterize different dietary oils commonly used in broiler chicken production. Soybean oil (SYO), Palm-kernel oil (PKO), Sheabutter (SHO), Coconut oil (CO) and Groundnut oil (GNO) were each assayed for their physical and chemical characteristics using standard procedures. The CO had higher (P<0.05) saponification value (14.55mg/KOH) compared to SHO (60.80mg/KOH), which was lowest. ThePKO had significantly higher (P<0.05) acid value (mgKOH/g) (3.65), compared with SHO (0.90). The GNOhad the highest (18.08) for iodine value while PKO (4.71). Peroxide value was highest (P<0.05) in PKO (76.73) and lowest in SYO (4.98). Fatty acid profile was significantly affected by dietary oil sources. The SYBO was higher (P<0.05) in arachidonic acid (2.25) compared with CO (0.07) while Linoleic acid was highest in CO (19.72) compared to GNO (18.05) that had the lowest value. Linolenic acid concentration was higher in GNO (3.14) than SHO (0.16). The CO (8345.06±57.79) had the highest levelof totalcarotene compared withSHO (1550.26 ±12.43) while GNO was highest in α-tocopherol (95.45) content while PKO was lowest (25.59 ± 0.35).The different oils have variedinherent chemical compositions which when deployed as ingredient, may have different impact on performance of broiler chickens

Keywords: Saponification value, Iodine value, Peroxide value, Acid value, Dietary oils

Introduction

The main goalof poultry production is to increase the carcass yield, reduce abdominal fat pad and produce at a minimal cost. Dietary oils are commonly added to broiler diet to supply energy and to improve the acceptability of dusty diets by chickens.Dietaryoils are being used indiscriminately in broiler chicken production without recourse to the effects such oil will have on performance and broiler meat quality. According to Sanz *et al*. (2000), inclusion of sunflower oil in the diets of broiler chickens promoted fatty acid oxidation and depressed fatty acid synthesis thereby lowering abdominal fat percentage of broilers.Eachoil has distinctive characteristics which are dependent on their chemical and physical components that will impact differently when used in the diets for broiler chickens. For decades, researcher has been looking for ways of enhancing the nutritional value of food products; chicken eggs and broiler meat have been attempted. These include genetic, pharmacological, dietary, biotechnological and processing methods. Among the different methods, dietary manipulation has been the most successful and most widely adopted. The term fat is used as a synonym for lipid in the human food as well as in the ingredients for animal nutrition (Baiao and Lara, 2005). The addition of fat to diets, besides supplying energy, reduces the rate of passage of the digesta in the gastrointestinal tract, which allows a better absorption of all nutrients present in the diet (Crespo *et al*., 2002).

Broilers are now produced almost entirely intensively, and in view of the large increases in feed costs, the system almost tended to be uneconomic unless, cheaper feeding options are arrived at. An increasing number of broilers are being grown to heavy weights to meet consumer demands for deboned poultry meat. As birds grow to older ages, the efficiency of utilizing feed declines, making it more important to minimize feed costs. Approximately 70% of the total cost of poultry diets is related to meeting energy needs (Skinner *et al.,* 1992). Thus, choosing the proper level of energy that will optimize growth, carcass quality and feed efficiency makes the difference.

By compensation of energy requirements of chickens with oils instead of carbohydrates, a better performance was attained (Sonaiya, 1988). It was reported that the performance varied according to the amount of the oil (Atteh *et al.,* 1983). Considering diets with similar nutritive value, chickens fed rations containing oil showed better performance than birds fed diets without oil inclusion.Advantages of utilizing oils in poultry diet include decrease of nourishment dust, increase in absorption and digestion of lipoproteins, significant amount of necessary fatty acids and their lower heat compared to carbohydrates and proteins, improved palatability of feed, reduced particle separation, which helps maintain a uniform mixture of each ration. (Leeson and Atteh, 1995). The carbon atoms of the fatty acids are chemically more reduced than carbon atoms found in sugar, therefore oxidation of triglycerides releases more than twice as much energy as carbohydrates. However, high consumption of animal fats containing large amounts of saturated fatty acids such as palmitic acid and stearic acid is associated with high intake of calcium, which causes a type of reaction between fatty acid and calcium and results in the formation of insoluble soap and non-use of nutrients by poultry and eventually will be excreted through faeces (Sibbald and Price, 1977).

The dietary fat could affect mineral metabolism especially that of magnesium, calcium and zinc (Atteh and Lesson 1983; Leeson andAtteh, 1995) this is due to the formation of insoluble soaps between fatty acids and these minerals during digestion, which renders both the fatty acids and these minerals unavailable if the soaps are insoluble. Therefore, this study was aimed at characterizing the compositions of the different dietary oils commonly used in broiler chicken production.

Materials and methods

The profiling of the oils was carried out at the Central Laboratory, Department of Animal Science, University of Ibadan. Five vegetable oils; palm-kernel oil, shea butter, coconut oil, groundnut oil, soybean oil.were obtained from a local market (Bodija market) and analysed for the saponification, peroxide, iodine and acid values (AOAC, 2009).Vitamin E and total carotene as well as the fatty acid profile were also determined (AOAC, 2005)

Statistical analysis

Data were subjected to analysis of variance using SAS (2000) and means were separated using Duncan's Multiple Range option of the same software at $\alpha_{0.05}$.

Results

The chemical characterisation of the oils is shown in Table 1.It was observed that the saponification value (mgKOH) of PKO (104.76) and CO (109.81) were similar but significantly higher ($P<0.05$) than GNO (83.63), SHO (60.80) and SYBO (64.15). Iodine value (g/100g) ranged from 4.71 in PKO to 18.08 in GNO. Acid value (mgKOH/g) of PKO 3.65 was observed to be significantly higher ($p<0.05$) compared with other dietary oils. The lowest acid value (0.90)($p<0.05$) was observed in SHO. However, similar acid value (mgKOH) was

Table 1: Chemical characteristics of the different selected dietary oils

Treatment	Saponification value (mgkoh)	Iodine value (g/100g)	Acid value (mgkoh/g)	Peroxide value (meq/kg)
Palmkernel oil	104.76[a]	4.71[e]	3.65[a]	76.73[a]
Groundnut oil	83.63[c]	18.08[a]	1.60[b]	34.85[b]
Coconut oil	109.81[a]	6.95[d]	1.10[c]	33.52[b]
Sheabutter oil	60.80[e]	13.91[c]	0.90[d]	19.36[c]
Soybean oil	64.15[d]	14.72[b]	1.60[b]	4.98[d]
SEM	5.39	1.34	0.01	3.42

Means with separate superscripts are significantly different (p<0.05) from each other; SEM- Standard Error of Means

obtained from GNO (1.60) and SYBO (1.60). Peroxide value (mgKOH) of oil was significantly dependent ($p<0.05$) on types. Higher ($p<0.05$) peroxide value was in PKO (76.73) compared with GNO (34.85), CO (33.52), SHO (19.36) and SYBO (4.98).

The fatty acid profile of selected dietary oils used in broiler chicken production is shown in Table 2. Arachidonic acid (%) was significantly ($p<0.05$) higher in GNO (2.33) compared to other selected dietary oils. The lowest ($p<0.05$) concentration of arachidonic acid (%) was in SHO (0.08). Behenic acid ranged from 0.03 in PKO to 0.06 in GNO. Concentration of capric acid (%) was significantly higher ($p<0.05$) in SYBO (0.28) compared with other dietary oils. Significantly higher ($p<0.05$) caprylic acid concentration (%) was obtained in CO (2.53) compared with other selected dietary oils. Capric acid concentration in (%) PKO (1.24) was significantly ($p<0.05$) lower compared to other selected dietary oils. Erucic acid concentration (%) ranged from 0.06 in PKO to 0.26 in CO.

Different dietary oils contained significantly different ($p<0.05$) lauric acid concentration (%). The GNO had higher ($p<0.05$) concentration of lauric acid (%) (5.23) compared to other selected dietary oils. There was no significant ($p>0.05$) difference observed in the linoleic acid concentration of PKO (18.21) and GNO (18.05), The SYBO had the highest ($p<0.05$) linoleic acid concentration. The linolenic acid concentration (%) ranged from 0.16 in SHO to 3.14 in GNO. The CO and SHO had similar lignoceric acid concentrations (%) and were higher ($p<0.05$) compared to other selected dietary oils.The lowest ($p<0.05$) margaric acid concentrations (%) was in SHO (0.19), while GNO had the highest ($p<0.05$) margaric acid (1.06) concentration (%). Myristic acid concentration (%)ranged from 0.67 in PKO to 3.79 in CO.The oleic acid concentration in GNO 42.15 was significantly higher ($p<0.05$) than in other selected oils. The PKO (38.65) and SYBO (37.67) contained similar ($p>0.05$) oleic acid concentration (%). The CO (26.95) and SHO (26.93) had similar but significantly lower oleic acid (%) compared with other dietary oils. Palmitic acid concentration (%) was significantly affected ($p<0.05$) by varying dietary oil types. It was observed that GNO (8.83) had the highest ($p<0.05$) palmitic acid concentration (%) compared to other dietary oil sources. The lowest ($p<0.05$) palmitic acid concentration (%) was observed in SHO (3.54). Palmitoleic acid concentration (%) ranged from 0.40 in GNO to 0.41 in CO. The concentration of stearic acid (%) varies significantly in different dietary oils. Higher ($p<0.05$) concentration of stearic acid (%) was

Table 2: Fatty acid profile of selected dietary oils used in broiler chicken production

Fatty Acids (%)	A	B	C	D	E	SEM
Arachidonic	2.10^{c}	2.33^{a}	0.07^{d}	0.08^{e}	2.25^{b}	0.28
Behenic	0.03^{e}	0.06^{a}	0.04^{d}	0.05^{b}	0.04^{c}	0.04
Capric	0.03^{b}	0.16^{e}	0.16^{c}	0.15^{d}	0.28^{a}	0.02
Caprylic	1.38^{c}	1.20^{e}	2.53^{a}	2.50^{b}	1.36^{d}	0.15
Capric	1.24^{e}	1.07^{d}	3.74^{a}	3.71^{b}	1.26^{c}	0.33
Erucic	0.06^{e}	0.08^{c}	0.26^{a}	0.24^{b}	0.04^{d}	0.02
Lauric	3.92^{b}	5.23^{a}	1.28^{d}	1.26^{e}	2.02^{c}	0.42
Linoleic	18.21^{e}	18.05^{e}	19.72^{b}	19.65^{c}	43.27^{a}	3.09
Linolenic	2.81^{c}	3.14^{a}	0.19^{d}	0.16^{e}	2.83^{b}	0.36
Lignoceric	0.05^{c}	0.04^{b}	0.11^{a}	0.10^{a}	0.06^{c}	0.01
Margaric	0.99^{c}	1.06^{a}	0.20^{c}	0.19^{e}	1.02^{b}	0.11
Myristic	0.67^{d}	0.76^{b}	3.79^{a}	3.77^{a}	0.70^{c}	0.40
Oleic	38.65^{b}	42.15^{a}	26.95^{d}	26.93^{d}	37.67^{b}	1.69
Palmitic	5.77^{c}	8.83^{a}	3.57^{d}	3.54^{e}	8.83^{b}	0.52
Palmitoleic	0.66^{d}	0.40^{e}	0.41^{a}	0.38^{b}	0.08^{a}	x0.04
Stearic	3.13^{d}	4.07^{a}	3.54^{b}	3.51^{c}	2.89^{e}	0.11

Means with separate superscripts are significantly different from each other.
A-palm-kernel oil, B-groundnut oil, C-coconut oil, D-sheabutter oil, E-soybean oil

Table 3: Vitamin profile of the oil (mg/kg)

Sample	Vitamin A	Vitamin E
Palmkernel oil	2.05 ± 0.01	48.80 ± 0.01
Soybean oil	2.19 ± 0.02	53.29 ± 0.02
Groundnut oil	1.86 ± 0.02	38.39 ± 0.21
Sheabutter	1.73 ± 0.01	38.25 ± 0.01
Coconut oil	1.97 ± 0.01	47.57 ± 0.01

observed in GNO (4.07) compared with PKO (3.13), CO (3.54), SHO (3.51) and SYBO (2.89).

The vitamin profile of the different selected dietary oils is shown inTable 3. Total carotene concentration (µg/mL) in PKO (2.05) and SYBO (2.19) were significantly higher ($p<0.05$) compared with other dietary oils. The lowest ($p<0.05$) total carotene concentration (µg/mL) was observed in SHO (1.73). The α-tocopherol (µg/mL) concentration varied significantly ($p<0.05$) in different selected dietary oils. Significantly higher ($p<0.05$) α-tocopherol concentration (µg/mL) was obtained in SYBO (53.29) compared with other dietary oils.

Discussion

The chemical characterization of the oils is shown in Table 1. It was observed that the saponification value of PKO (104.76) and CO (109.81) were significantly higher compared to GNO (83.63), SHO (60.80) and SYBO (64.15). These values were lesser than4.947 reported for racemosaseed (Amoo and Moza, 1999), but compared favourably with0.9202 reported for cotton seed: coconut oil and sunflower seed (Pearson, 1976). Higher Iodine value (µg/mL)in PKO could be due tohigher degree of unsaturation compared with GNO which places it as a non-drying oilused as a lubricant in industries which is similar to 83 in castor oil as reported (Asuquo *et al.*, 2012). Acid value (µg/mL) is indirect measures of free fatty acid contents present in the oil, an index of freshness.Higher values give an indication that the oil is susceptible to rancidity. The higher value obtained forPKOin this study could mean that it contains more of free fatty acids compared to other dietary oils. TheSHO had the least acid value (µg/mL) which indicated that it contained less of free fatty acid which corroborates earlier report (Oyenuga, 1968). Peroxide value (µg/mL) of oil was significantly affected by different oiltypes. Higher peroxide value (µg/mL) was obtained in PKO which was within the range reported for some locally processed Nigerian oils (Aletor *et al.*, 1990), but differed significantly from GNO (34.85), CO (33.52), SHO (19.36) and SYBO (4.98). The peroxide valuesof GNO, CO, SHO, and SYBO were very low which indicates of low oxidation. Therefore, such oils were acceptable due to the absence of odour and its richness in flavor (Pearson, 1981)

The three essential fatty acid in the oils differed significantly (Table 2). Arachidonic acid (%) was highest in GNO compared to other selected dietary oils. Oyenuga (1968) reported arachidonic acid (%) as one of the three essential fatty acids needed as building blocks of protein. The values obtained are low when compared withthose reported for other crude oils. Different oil sources significantly affected lauric acid concentration (%). It was observed that GNO had higher concentration of lauric acid (%) compared to other selected dietary oils. Oyenuga (1968) reported that the fatty acids myristic and oleic (%) with low fatty acid content shows that the oil would not easily go rancid under a good storage condition. Both fatty acid profile and acid value are very important in determining the use of oil for edibility purposes and should not exceed 0.4% (Esuoso and Odedokun, 1997)

Linoleic acid concentration of PKO and GNO were similar but lower compared to other selected oils. The SYBO had the highest linoleic acid concentration. The CO and SHO had similar lignoceric acid concentrations (%) and were higher compared to other selected dietary oils.

The lowest margaric acid concentration was observed in SHO, while GNO had the highest margaric acid concentration. Myristic acid concentration (%) ranged from 0.67 (PKO) to 3.79 (CO). The oleic acid concentration in GNO was significantly higher compared to other selected oils. The PKO and SYBO were similar in oleic acid concentration. The CO and SHO were similar and significantly lower in oleic acid compared to other selected dietary oils. Palmitic acid concentration (%) was significantly affected by dietary oil types. From the current study, GNO had the highestpalmitic acid concentration (%) compared to other dietary oil types. The lowest palmitic acid concentration (%) was observed in SHO.

Palmitoleic acid concentration (%) ranged from 0.40 (GNO) to 0.41(CO). Saturated fatty acids with fewer than 12 carbon atoms being called short and medium chain fatty acids (MCFAs) have been found only in CO in the amount not exceeding 7.6% of total methylesther of fatty acids (FAMEs). Expectedly SFAs were established as extraordinary predominal FA in the highest amounts of 92.1% of total FAMEs in CO and they are represented especially by lauric (C12:0) and myristic (C14:0) acids in the amount of 47.7% and 19.9%, respectively. The concentration of stearic acid vary significantly in different selected dietary oils. Higher concentration of stearic acid was observed in GNO compared to other selected dietary oils.

The vitamin profile of the different selected dietary oils (Table 3) was affected by different oil types. Total carotene concentration (µg/mL) in PKO (2.05) and SYBO (2.19) were significantly higher compared to other selected dietary oils. The lowest total carotene concentration was observed in SHO (1.73). α-tocopherol concentration (µg/mL) varied significantly in different selected dietary oils. Higher α-tocopherol concentration (µg/mL) was observed in SYBO (53.29) compared with other dietary oils.

Conclusion

Selected dietary oils had varying physical and chemical properties which were expected to have varying impact when used in broiler chicken's diets.

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