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Toxicity and Nutritive Assessment of Castor (*Ricinus cummunis*) Oil and Processed Cake in Rat Diet

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ABSTRACT

The effect of raw and processed Castor Bean Cake (CBC) and varying inclusion levels of Castor Bean Oil (CO) on performance and nutrient digestibility was evaluated in two trials involving albino rats. The first trial assessed the tolerance of albino rats to raw and lye treated CBC while trial II examined the growth response and nutrient digestibility of albino rats to varying levels of CO (0, 2.5, 5.0, 7.5 and 10.0%) in a completely randomized design. Twenty four weaned albino rats of average initial weight of about 28.18 g were used for each trial. In trial I, there was sharp decline ($p<0.5$) in feed intake, weight gain and efficiency of feed conversion as CBC increased. About 2.5 and 5% raw CBC was lethargic to rat but tolerated up to 10% lye treated CBC. Lye treatment reduced the active toxin in castor, lectin (ricin) by 55%. In trial II, feed intake, body weight gained feed conversion efficiency declined with increasing levels of CO in the diets and was significantly ($p<0.05$) depressed at 7.5%. Although, addition of castor oil to rat diet did not have damaging effect on performance and nutrient digestibility in this study, it will be safe not to exceed 7.5% inclusion of castor in diet of albino rat and that the seed should be properly deoiled before being used in animal feed. Lye treatment was potent in deactivating the toxic principle of CBC however, such product should not be applied in rat diet at concentration beyond 100 g kg^{-1} diet.

Key words: Castor, albino rat, performance, digestibility, detoxification

INTRODUCTION

One of the novel legumes is castor oil bean (*Ricinus communis*). It grows in tropical and temperate regions throughout the world, either wild or cultivated (Ken *et al*., 1990). Production of castor is increasing throughout the world, for instance Rajarathinam and Parmar (2011) reported about 5.79% annual increase in production in India, the world largest producer, due to combined effect of increase in area and productivity. Three major products are derived from castor: seeds, oil and meal. A tonne of castor seed yields about 50 kg of oil and 50 kg protein-rich meal. In Western Nigeria, two seed types are common which either grows wild or cultivated as backyard farming system. The large seeded type is cultivated in the southern states where the dehulled seeds are processed for use as flavour enhancing food condiment (Achi, 1992; Enujiugha, 2009). Studies in animal nutrition have shown that castor oil bean meal can be used as protein supplement for ruminants, pigs and poultry (Ken *et al*., 1990; Ani and Okorie, 2005, 2009), however, with some limitations.

The oil from castor seed is one of the few naturally occurring glycerides with high purity, since the fatty acid portion is nearly 90% of ricinoleic (Hui, 1996; Akpan *et al*., 2006). The oil is not only

a naturally-occurring resource; it is also inexpensive and environmentally friendly. Relative to other vegetable oil, it has a good shelf life. Castor oil has long been an article of commerce due to its versatility. The oil is very useful mainly in industries and medicines. The oil is used industrially as coating fabrics and other protective coverings, in the manufacture of high grade lubricant, polish, waxes carbon paper, candle, crayons and biodiesel (Trevino and Trumbo, 2002; Somani *et al*., 2003; Lyons, 2007). Medically, it is used as labour inducing medicine when administered in the required quantity. It has been used for many years as a purgative i.e. a material that induces vomiting (Johnson, 2007; Antwi *et al*., 2009).

The application of the cake in livestock feed was limited due to the presence of three potent antinutritional factors: ricin, ricinine and thermo stable castor allergen (Darby *et al*., 2001; Olsnes, 2004) and possible complicated processing procedures. Reports on detoxification to prepare acceptable product for animal feed are encouraging.

Poor oil extraction which leaves the castor cake with varying levels of oil is another latent challenge facing castor uses in livestock feed. The high viscosity, high boiling point of 313°C (595°F), high molecular weight (298), low melting point (5°C) and very low solidification point (-12C to-8°C) of the oil may be responsible for its low extraction with hydraulic press. The result obtained from past works have shown that the percentage of oil content extracted was around 33.2% out of the range of oil content (40-55%) (Ogunniyi, 2006). No single mechanical method has been successfully used for the total extraction of castor oil leaving the cake with varying level of oil.

The tractable nature and sensitivity of albino rats to diverse diets has prompted its use as model for nutritional studies and serve as the experimental unit for this study. This study was aimed at evaluating the effect of including these products (castor cake and oil) in diet of albino rats. Varying levels of castor oil was therefore introduced in the experimental diets to determine feed intake, body weight change and nutrient digestibility of albino rats. The deoiled residue (castor bean cake) was subjected to parboiling, fermentation, lye treatment or fed raw in the diets of albino rats to assess the effect of processing methods on chemical composition and nutritive value. However, only raw and lye treated CBC were fed to the animals.

MATERIALS AND METHODS

Site of the experiment: The experiment was conducted at the Department of Animal Production and Health, Ladoke Akintola University of Technology (LAUTECH), Ogbomoso, Oyo State, Nigeria in March, 2010.

Castor seed preparation and oil extraction: The large seeded castor seed variety was used and sourced within Ogbomoso. The seeds were sorted to remove some foreign materials and dirt by hand picking. Clean seeds were then dehulled to separate the shell from the nibs (cotyledon) manually on two hard surfaces and using tray to blow away the seed cover. Grinding was performed using mortar and pestle to crush the beans in order to weaken or rupture the cell walls to release castor fat for extraction. The crushed castor kernel was placed in an oven at 70°C to heat up the kernel for easy expression of the oil. The hot crushed castor kernel was placed in muslin cloth and pressed with hydraulic machine. The oil was collected in a clean container and the remains were tagged castor bean cake.

Detoxification of castor bean cake: Different portion of the castor bean cake were made to undergo different treatment such as lye, fermentation and hot water.

Lye treatment: Lye water was prepared by passing water over gray ash in a barrel. The ash was collected from cassava processing plant. The ash is first sieved to remove pieces of charcoal and other impurities. The sieved ash is then placed (without compaction) in a plastic container with holes plugged with sieve cloth at the base of the plastic. Hot water was poured on the ash and a brown liquid dripped at base of the container. This brown liquid represents the lye water used in this study. The pH of the lye water was 9.2. Castor bean cake was placed in a muslin cloth and then soaked in the lye (1 part of the cake to 2 parts of lye weight for weight to completely submerge the cake) for 18 h. It was removed and then sun-dried. Sundried product was then milled to produce lye treated castor bean cake (LCB).

Fermentation: CBC was placed in a muslin cloth and soaked in clean water completely for 3 days under air-tight condition. The water was drained on the 3rd day and the fermented seed sun-dried. It was then milled to produce fermented castor bean cake (FCBC).

Hot water treatment: Another portion of the castor bean cake (in a muslin cloth) was soaked in hot water at 100°C for 20 min and parboil, after which it was drained and dried. This represented parboiled treated castor bean cake (PCBC) The fourth portion serve as the untreated castor bean cake.

Rats and management: Two sets of twenty four weaned albino rats each were used for the experiment and they were sourced from a reputable commercial farm in Ibadan, Oyo State. Small metabolic cages locally fabricated were used to house the rats individually. The environment was disinfected 2-3 days prior to stocking. Feed and water were given *ad libitum* and urine and feaces were collected at the last week of the experiment. The rats were weighed individually and divided into the six groups. Each rat in the group represented a replicate. Each group was checked for any disease, deformity or infection prior to the commencement of the experiment. Animals were weighed and each group was allotted one of the six experimental diets.

Experimental diets: The chemical analysis showed that lye was most potent in deactivating castor toxins and therefore was used and compared with raw in feeding trial. Two types of diets were prepared. One set of diets contained raw and lye treated castor bean cake replacing groundnut cake at 0, 2.5, 5.0 and 10% while the second set of diets contained varying inclusion of castor oil steadily replacing groundnut oil as shown in Table 1 and 2, respectively.

Table 1: Diet formulations for Albino rats fed varying levels of raw and processed CBC

		UCBC			LCBC		
Ingredient (%)	T_1 (control)	T_2 (2.5%)	T_3 (5.0%)	T_4 (10%)	T_5 (2.5%)	T_6 (5.0%)	T_7 (10%)
Corn starch	53	53	53	53	53	53	53
GNC	27	24.5	22	17	24.5	22	17
UCBC	-	2.5	5.0	10	-	-	-
LCBC	-	-	-	-	2.5	5.0	10
*Concentrate	20	20	20	20	20	20	20
Calc. CP (%)	12.15	12	11.85	11.70	12	11.85	11.70

*Concentrate: Non-nutritive cellulose: 5.0, Palm oil: 5.0, Bone meal: 2.0, Oyster shell: 0.5, Premix: 0.5, Sucrose: 2.5, Glucose: 2.3, Salt: 2.2, CBC: Castor bean cake, U: Untreated, L: Lye treated

Table 2: Diet composition for albino rats fed diets containing varying levels of castor oil

Parameter	10. 0%GNO	Control	2. 5% CO	5. 0% CO	7. 5% CO	10. 0% CO
Co rn starch	40	40	40	40	40	40
Wheat offal	30	30	30	30	30	30
Soybeans meal	15	15	15	15	15	15
Bone meal	2.5	2.5	2.5	2.5	2.5	2.5
Oyster shell	1.0	1.0	1.0	1.0	1.0	1.0
Premix	0.5	0.5	0.5	0.5	0.5	0.5
Salt	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
Groundnut oil	10	0	7.5	5.0	2.5	0
Castor oil	0	0	2.5	5.0	7.5	10
Calc. analysis						
Crude protein (%)	11.95	12.07	11.95	11.95	11.95	11.95
Energy (kcal kg^{-1})	2650	2570	2655	2660	2667	2675
Fat (%)	12	2.2	12	12	12	12

GNO: Groundnut oil, CO: Castor oil

Data collection: Feed Intake was determined on weekly basis. The leftover was deducted from the initial weighed feed at the beginning of the week using a sensitive weighing balance. This was recorded as weekly feed intake. The differences between the final and initial weight were taken weekly which represented the body weight gain.

Digestibility trial: Feaces were collected for three consecutive days for each rat. The feaces collected on daily basis were weighed, wrapped in a foil paper and oven dried at 70°C. The feacal samples were bulked for each rat, weighed and milled prior to laboratory analysis. The urine was so minute and dried up before the second day of reading.

Chemical analysis: Samples of differently treated castor bean cake were taken milled to 2mm sieve size and stored in a polytene bag for analysis. The duplicate samples of feaces and diets were also taken for proximate analysis according to AOAC (1990). The following antinutritional factors were determined: Lectin, oxalates, phytic acid, tannin. The phytate content was determined by the method of Wheeler and Ferrel (1971) based on the ability of standard ferric chloride to precipitate phytate in dilute HCl extracts of the sample. The tannin content was determined using the method of Makkar and Goodchild (1996). Determination of phytohemagglutinating activity Analysis of the lectin content was conducted by hemagglutination assay in round-bottomed wells of microtitre plates using 1% (v/v) trypsinised cattle blood erythrocytes suspension in saline phosphate buffer, pH 7.0 (Makkar *et al*., 1997). The hemagglutination activity was defined as the minimum amount of the kernel material (in mg per mL of the assay medium) which produced agglutination. The minimum amount was the material per mL of the assay medium in the highest dilution that was positive for agglutination. One Hemagglutinating Unit (HU) was defined as the least amount of material per mL in the last dilution giving positive agglutination (Grant *et al*., 1983).

Statistical analysis: The data were subjected to one-way analysis of variance in a completely randomized design (CRD) of SAS, (1993). Differences among means were separated using Duncan Multiple Range Test option of the same software package.

RESULTS

Effect of processing: The effect of different treatments on castor bean cake on chemical composition is shown in Table 3. Dry matter contents range between 90.41-90.83% with no significant difference across the treatments. Although there were numerical differences in values obtained for crude protein content, ether extract and soluble carbohydrate, no particular trend was observed. Crude fibre was notably lower in fermented castor bean cake with 2.53% compare to other treatments which ranged between 3.45-3.92%. There was downward trend in gross energy composition of treated castor bean (5.48-5.58 kcal g^{-1}) compared to untreated castor bean cake (5.62 kcal g^{-1}). Phosphorous content of lye treated castor bean cake was a bit higher followed by hot water treatment CBC but with lowest calcium. All the treatments employed in this study reduced the level of antinutrients in castor seed cake. Tannin and oxalate appear not to have been significantly affected by the treatments applied whereas over 50% of phytate were removed by all the treatments. Lectin is generally considered to be most toxic factor in castor seed. The lectin (ricin) of castor seeds has been reported to be much less toxic than botulinum toxin but compare to sarin (Lundberg *et al*., 2004). Lectin activity in the defatted meal was very close to that reported by Makkar *et al*. (1997), Aderibigbe *et al*. (1997)) in *Jatropha curcas* seeds. The raw castor meal had higher activity with 2.5 mg of the material to produce positive agglutination per 1 mL of dilution) than the processed/treated samples. Lye treatment was the best as far as reduction of lectin activity was concerned; as it decreased the activity of lectin content in samples tested significantly and reduced the agglutination strength (5.5 mg mL^{-1}) by more than half of the value obtained for the raw meal. Hot water treatment and fermented had 4.3 and 4.5 mg mL^{-1}, respectively representing about 40% reduction in lectin.

Growth response of albino rats to dietary inclusion of raw and lye treated castor bean cake: Table 4 shows the performance of albino rat fed varying levels of differently treated castor bean cake. There were significant differences ($p<0.05$) in feed intake, body weight gained and feed

Table 3: Chemical constituents of processed castor cake

Parameter	Untreated CBC	LCBC	FCBC	BCBC
Proximate composition (%)				
Moisture	9.34	9.59	9.56	9.17
Crude protein	38.58	39.43	38.87	39.32
Crude fibre	3.46	2.53	3.92	3.45
Ether extract	11.15	9.79	10.53	10.88
Ash	5.87	6.11	5.92	5.36
NFE	32.60	31.74	32.56	31.54
Gross energy (kcal g^{-1})	5.624	5.493	5.480	5.585
Mineral content (%)				
Ca	0.62	0.54	0.55	0.47
P	0.34	0.45	0.37	0.41
Antinutritive factor (%)				
Lectin HU (mg mL^{-1})	2.50	5.50	4.50	4.30
Tannin	0.25	0.19	0.20	0.15
Phytic acid	0.94	0.62	0.79	0.68
Oxalate	0.46	0.23	0.20	0.15

CBC: Castor bean cake, L: Lye, F: Fermented, Boiled CBC, NFE: Nitrogen free extract, HU: One hemagglutinating unit (HU) is the least amount of material per ml giving positive agglutination

Table 4: Performance of rats fed different levels of raw and lye treated CBC

		Raw CBC (%)			Lye treated CBC (%)			
Parameter	0 (%)	2.5	5.0	10	2.5	5.0	10	SEM
IBW (g)	35.50	32.25	32.15	38.00	34.30	33.40	32.45	2.05
FBW (g)	135.50^{a}	115.50^{ab}	105.17^{b}	88.17^{c}	125.00^{a}	112.00^{b}	99.50^{bc}	10.19
TFI (g)	230.00^{a}	200.30^{ab}	180.30^{b}	156.75^{c}	212.20^{a}	185.75^{b}	165.00^{bc}	15.00
BWG (g)	100.00^{a}	83.25^{b}	73.02^{b}	50.17^{c}	90.70^{a}	78.60^{b}	67.05^{bc}	7.07
FGR	2.30^{c}	2.41^{bc}	2.47^{b}	3.12^{a}	2.34^{c}	2.42^{bc}	2.46^{b}	0.41
Mortality (%)	-	-	2	55	-	-	1	

Means on the same row with different superscript are significantly ($p<0.05$) different. SEM: Standard error mean. WFI: Weekly feed intake IBW: Initial body weight, TFI: Total feed intake, BWG: Body weight gain, FGR: Feed gain ratio

Table 5: Performance of rats fed different levels of castor oil inclusion in diet

Parameter	T_1 (10%GNO)	T_2 (0%)	T_3 (2.5%)	T_4 (5.0%)	T_5 (7.5%)	T_6 (10%)	SEM
IBW (g)	28.18	28.25	28.15	28.45	28.43	27.63	2.12
FBW (g)	105.43^{b}	125.50^{a}	105.17^{b}	98.17^{bc}	97.93^{c}	89.88^{c}	19.19
TFI (g)	158.10^{b}	197.31^{a}	163.38^{b}	146.75^{bc}	136.20^{c}	129.73^{c}	11.94
BWG (g)	77.25^{b}	97.25^{a}	77.02^{b}	69.72^{b}	69.30^{b}	62.25^{b}	5.50
FGR	2.06	2.06	2.14	2.04	1.94	2.12	0.04

Means on the same row with different superscript are significantly ($p<0.05$) different. SEM: Standard error mean. WFI: Weekly feed intake, GNO: Groundnut oil, IBW: Initial body weight, TFI: Total feed intake, CO: Castor oil, BWG: Body weight gain FGR: Feed gain ratio

conversion ratio. Feed intake and body weight gained decreased with increasing levels of CBC. Rats on control gained 100 g followed by rats on lye treated CBC with 90.7g at 2.5% while the least weight gained (50.17 g) was obtained in rats fed raw CBC at 10%. Feed gain ratio of treated CBC at 2.5 and 5% are comparable with control. Mortality occurred at 5% and reached medium lethal dose (L_{50}) at 10% inclusion of untreated castor bean cake. However, rats on lye treated CBC tolerated higher levels between 5 and 10% inclusion with only 2% mortality at higher rate.

Growth response and nutrient digestibility of albino rats to dietary inclusion of castor oil: The response of the rat to the castor oil based diets (Table 5) shows that there were significant ($p<0.05$) differences among weekly feed intake, body weight change, final body weight, total feed intake, body weight gain across the treatments whereas there was no significant($p>0.05$) differences in the feed gain ratio. Weight gained in 0% oil based diet; 97.25 g was higher than comparable values in other treatments which ranged between 62.25-77.25 g. feed intake followed similar trend. The results of digestibility (Table 6) showed that Treatment 6 had the least value ($p<0.05$) in terms of dry matter digestibility while other treatments were comparable ($p>0.05$). The CP digestibility indicated that rats fed non-oil based diets, groundnut oil diet and diet containing castor oil up to 5% had similar ($p>0.05$) CP digestibility. The EE digestibility showed that general inclusion of oil in the experimental diet were comparable ($p>0.05$), but Treatment 2 which was the non-oil based diets had the least value ($p<0.05$).From the CF digestibility, it shows that all treatments except for treatment 6 had comparable values ($p>0.05$) and treatment 6 compared to treatments 3 and 4 had the least value i.e. ($p<0.05$). NFE digestibility for treatments 1, 2 and 3 were comparable ($p>0.05$) and treatments 4, 5 and 6 also had comparable values ($p>0.05$) but had the least values ($p<0.05$) when related to treatments 1, 2 and 3.

Table 6: Nutrient digestibility of rat fed varying levels of castor oil in the diet

Parameters	T_1	T_2	T_3	T_4	T_5	T_6	SEM
DM (%)	70.60^{a}	69.31^{ab}	72.31^{a}	72.51^{a}	70.52^{a}	63.78^{b}	2.40
CP (%)	72.39^{a}	68.40^{ab}	66.64^{ab}	65.87^{ab}	61.35^{b}	59.34^{b}	2.51
EE (%)	93.49^{a}	83.10^{b}	93.20^{a}	92.79^{a}	91.82^{a}	90.20^{a}	3.20
CF (%)	29.58^{ab}	30.02^{ab}	30.61^{a}	32.41^{a}	25.11^{ab}	21.78^{b}	1.55
NFE (%)	77.65^{a}	80.21^{a}	76.18^{a}	70.17^{b}	69.62^{b}	66.72^{b}	2.61

Means on the same row with different superscript are significantly ($p<0.05$) different. SEM: Standard error mean. WFI: Weekly feed intake, DM: Dry matter, CP: Crude protein, EE: Ether extract, CF: Crude fibre, TFI: Total feed intake, NFE: Nitrogen free extract

DISCUSSION

Effect of treatment: The processing techniques affected the chemical profile of castor bean cake. There was a short fall in energy values of treated bean compared to untreated bean. Since all treatments are in a form washed with fluid, there are tendencies that parts of the nutrients were lost to the fluid particularly the soluble carbohydrate as reflected in the nitrogen free extract values of fermented product which also had the least gross energy. The crude protein of the defatted seed was reasonably high compare to many other oilseeds and compared favorably with the conventional sources such as soya bean meal and groundnut cake. The CP was enhanced by dehulling. The crude fibre was low which makes it ideal for poultry. Fermentation also decreased the fibre content of the product and this may influence positively the bioavailability of other nutrients. Decorticated and treated castor seed cake contains high values of phosphorus and calcium than the untreated full-fat seed and this revealed that this nonconventional feedstuffs contain sufficient of these nutrients to meet the nutritional requirements of farm animals. Crude protein of processed meal fell and is in line with findings of Emiola and Ologhobo (2006), who reported that cooking and toasting tended to reduce crude protein content possibly due to leaching and vaporization of some nitrogenous compound during processing. The antinutritional factors were better deactivated by lye treatment which corroborated the findings of Anandan *et al.* (2005) who used processing methods such as soaking in water, steaming, boiling, heating, ammonial, salt and NaOH treatments and reported that NaOH treatment was more potent in detoxifying castor seed meal.

Response of albino rats to castor bean cake based diets: The tolerance of rats to castor toxin occurred below 5% inclusion of untreated CBC while higher level between 5 and 10% were tolerated for lye treated CBC. There appear to be positive correlation between lectin content in detoxified CBC and performance of rat. Lye treatment was able to achieve about 55% reduction of lectin (ricin) and this was translated in higher feed consumption and better weight gain such that 5% lye CBC compared favourably with 2.5% untreated CBC. This finding is in agreement with the work of Bamgbose *et al.* (1996), who reported that increasing the level of Cotton seed cake in the finisher diets resulted in significant depression in the performances of broilers in terms of daily feed intake daily weight gain and final live weights. Enami and Safafar (2010) in a 6-week feeding trial of winstar rat with graded level of canola also reported that adding canola meal did not change daily weight gained but reduced feed intake. Partial substitution of Soybean Meal (SBM) by Canola Meal (CM) caused an increase in feed conversion ratio. It was observed that the rats on 10% untreated CBC went off feed and probably died out of starvation. The animals appear to have sensed the irritating factors in the diets. The high oil content that characterized castor bean cake prompted another study to assess the effect of residual oil on cake quality, performance and nutrient digestibility of albino rats.

Performance and nutrient Digestibility of rats fed varying level of castor oil based diet: Feed intake decreased with increasing levels of castor oil inclusion in the experimental diets. Rats on non-oil based diets had the highest feed intake compared to those on oil based diets. It appears that oil inclusion in diets of albino rats did not favour feed consumption. Although, the use of 5-10% groundnut oil has been reported by Ojokoh *et al.* (2002), Aletor (1993) and Aning *et al.* (1998), the result of this study has called for cautious use of oil in rats diets (not beyond 7.5%) to prevent depression in feed intake. Similarly, body weight gain declined numerically, with increasing level of castor oil. It means that castor oil depressed growth performance of albino rats. Since chemical composition of the diets were similar except for varying levels of castor oil, depressed body weight gain with increased level of castor oil indicated that the oil contain certain growth depressing factors. In terms of feed to gain ratio, better conversion ratio seemed to occur in rats with 7.5% level of castor oil inclusion. From the result of digestibility, it is clear that high inclusion of castor oil slightly depressed digestibility of the experimental diets. This may be due to its purgative effect (Johnson, 2007; Antwi *et al.*, 2009) or the oil may contain certain factors that obstruct digestion of the nutrient.

Literature has indicated that the oil itself contains a number of fatty acids similar to those in cooking oils, such as oleic acid, linoleic acid, stearic acid and palmitic acid. However, among vegetable oils, castor oil is distinguished by its high content, about 90% of ricinoleic acid (Hui, 1996; Akpan *et al.*, 2006). No other vegetable oil contains so high a proportion of fatty hydroxyacids. Castor oils unsaturated bond, high molecular weight (298), low melting point (5°C) and very low solidification point (-12 to-18°C) make it industrially useful, most of all for the highest and most stable viscosity of any vegetable oil (Bonjean, 1991).

CONCLUSION

For effective utilization of kernel meal from castor seed, it is imperative to remove the fibrous seed coat and deoil properly to arrive at a more suitable product for animal use. Apparently, about 39% crude protein was realized from dehulled cake which is high and compared closely with the more conventional protein sources such as groundnut cake. Untreated castor bean cake is lethargic at 5 mg g^{-1} diet for Albino rats. The use of lye in treating castor bean cake reduced the lectins component (by 55%) in this study. Treated castor bean cake should therefore be fed in low concentration in the diet (below 10%) to mitigate the adverse effects of residual antinutritional factors in monogastric animals.

Groundnut oil is more digestible than castor oil. However, castor toxin not accrued from the oil, except for the purgative effect which produced slight depression in the performance of albino rat particularly at 7.5%. Hence, it will be safe not to exceed 7.5% inclusion of castor oil in diet of albino rat. The purgative effect may also serve to impede the absorption of other nutrients.

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