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Original Article

Growth Performance of New Zealand White Rabbits Administered *Panax ginseng* Extracts

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Abstract

Treatment with *Panax ginseng* has been reported to elicit various biological effects in both animal and human models. Among the reported effects on animal are protein synthesis and growth promoting ability. For a better understanding, the current experiment was conducted to evaluate the effect of oral administration of *P. ginseng* extracts (PGEs) on growth performance parameters of growing New Zealand White (NZW) rabbits. A total of 48 NZW male and female rabbits, with the average age of two months were used for the experiment, conducted in a Randomized Complete Block Design (RCBD). The rabbits were organized into 3 groups of 16 rabbits each (8 males and 8 females), on weight equalization basis and randomly assigned to 3 treatments: T_1, T_2 and T_3, containing PGEs at 0.0, 200.0 and 400.0 mg/ml, respectively. Final body weight and total body weight gain of the male rabbits on T_2 and T_3 were significantly ($p < 0.05$) higher than those of male rabbits on T_1, while feed conversion ratio for the male rabbits recorded a higher ($p < 0.05$) value in T_1 than in T_2 and T_3, which were similar ($p < 0.05$). Trunk length and breast girth of the male rabbits were significantly ($p < 0.05$) higher in T_3 than in T_1 and T_2. Feed intake pattern was similar among the male rabbits, but different between males and females. Significant ($p < 0.05$) differences were not observed in all parameters measured among female rabbits, but all experimental rabbits followed the same pattern of body weight gain. Oral administration of *Panax ginseng* extracts at 200 and 400 mg/ml levels enhanced feed conversion ratio in male NZW rabbits, thereby increasing body weight gain, trunk length and breast girth, while feed intake patterns slightly differed between the male and female growing rabbits.

Keywords: growth pattern; gender effect; morphometrics; plant extract; weight gain

Introduction

Numerous plants that are not conventionally used in livestock production are being explored for their possible benefits, especially in respect of finding non-synthetic materials that can play the roles of synthetic materials and drugs utilized in animal production. This quest is progressively increasing, following the European ban of synthetic drug use in animal production (Lien *et al*., 2013). In Africa, the advocacy is ever gaining momentum and is expected to bring about a definite ban on synthetic drug use in livestock production in the near future. The plants are researched for their use in various aspects of livestock production, which include feed, growth promotion, health, reproduction and regulation of other biological processes in the animal's body.

One of the plants with great potential that is also widely researched is *Panax ginseng*. It is a slow-growing perennial plant with fleshy roots, belonging to the family Araliaceae. *Panax ginseng* grows mainly in North America and Eastern Asia (mostly Korea, North East China, Bhutan and Eastern Siberia), typically in cooler climates (Park *et al*., 2005; Baeg and Seung-Ho, 2013). The plant is short and grows 3-7 compound leaves that drop in the fall and bears a cluster of red or yellow fruits from June to July. The major active components of ginseng are a diverse group of steroidal saponins, labeled 'ginsenosides' (Baeg and Seung-Ho, 2013). Full description of *Panax ginseng* and its chemical components have been documented (WHO, 1999; USDA, NRCS, 2001; Ang-Lee *et al*., 2001; Park *et al*., 2005; Lakshmi *et al*., 2011; Baeg and Seung-Ho, 2013).

The ginsenosides in *Panax ginseng* are digested into pharmacologically active substances by intestinal microorganisms (Lee *et al*., 2004), exerting influence on a

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wide range of biological activities (Lakshmi *et al*., 2011). Dietary wild-ginseng adventitious root meal has been used to increase growth performance, while reducing abdominal fat and serum cholesterol in broiler chickens (Yan *et al*., 2011). Contrary to studies of Ao *et al*. (2011), dietary supplementation with fermented red ginseng extracts did not influence growth performance in broilers and layers, but improved their lymphocyte counts. Pre-treatment of broilers with *P. ginseng* extracts has been reported to ameliorate selenium induced hepatic toxicity, through its antioxidant effect on the liver, leading to its recommendation as a neutraceutical in poultry farms (Shimaa, 2014). In rats, *P. ginseng* was reported to attenuate the adverse effects of flutamide on the testis (Oremosu *et al*., 2013), while it reduced total lipids in diabetic rabbits (Salih, 2012). Beside the beneficial effects of *P. ginseng* in animal models, numerous other benefits of *P. ginseng* have been widely documented (Lakshmi *et al*., 2011) and are being mainly explored in the herbal medicine.

The roles and utilization of *P. ginseng* have not been extensively researched in rabbit production, leading to paucity of data. Rabbit production in developing countries like Nigeria has been regarded as emergent or rudimentary (Onifade *et al*., 1999), therefore researches in rabbit production is a veritable option towards uplifting rabbit production in these countries. The present study was therefore designed to evaluate the growth performance indices, feed intake and weight gain patterns of New Zealand White (NZW) rabbits administered *P. ginseng* extracts.

Materials and Methods

Location and site of the experiment

Thi research work lasted for 4 weeks and was carried out at the Rabbitry unit, Teaching and Research Farm, Federal University of Technology, Owerri, Imo State. Imo State is situated in South Eastern agro-ecological zone of Nigeria and lies between latitude 4° 4' and 6° 3' N and longitude 6° 15' and 8° 15' E. Owerri is about 100 m above sea level with mean annual rainfall of 2,500 mm, temperature range of 26.5-27.5 °C and humidity range of 70-80%. Dry season duration (months with less than 65 mm rainfall) is of three months, which takes place during the months of December, January and February (Ogbuewu *et al*., 2014).

Experimental material

The experimental material for the study is *Panax ginseng* extracts (PGEs). A commercially available capsulated pure *P. ginseng* extract produced by Mason Vitamins was purchased from a reputable pharmacy. The active ingredients are a group of phytochemicals known as ginsonosides (Baeg and Seung-Ho, 2013). Each day, the contents of the *P. ginseng* extracts capsule were dissolved in distilled water at the rates of 0.0, 200 and 400 mg/ml and administered orally to the rabbits according to their treatment group. The preparation was as follows:

Treatment 1 (T_1): No extract was dissolved in the distilled water

Treatment 2 (T_2): 10,000 mg of the extract (solute) was dissolved in 30 ml of distilled water (solvent) in a calibrated tube. The solute + solvent were stirred until all the solute was dissolved. The volume of the solution was then made up to 50 ml.

Treatment 3 (T_3): 20,000 mg of the extract (solute) was dissolved in 30 ml of distilled water (solvent) in a calibrated tube. The solute + solvent were stirred until all the solute was dissolved. The volume of the solution was then made up to 50 ml.

Experimental animals and their management

Forty-eight New Zealand White (NZW) male and female (24 each) growing rabbits (average age of 2 months) were used for the study. On arrival, the rabbits were housed separately in four hutches of twelve cages each and allowed two weeks to acclimatize before administering the treatments. A day after arrival, the rabbits were injected with 0.1 ml vitoxy (an antibiotic containing 20% oxytetracycline) as a prophylactic measure. The rabbits were then divided into two treatment blocks (male and female), each containing three treatment groups. Each experimental block was made up of 8 rabbits per treatment group, assigned on weight equalization basis, replicated 4 times to contain 2 rabbits per replicate. The treatment groups for the male block were MT_1, MT_2 and MT_3, containing 0, 200 and 400 mg/ml PGEs, respectively, while the treatment groups for the female block were FT_1, FT_2 and FT_3, containing 0, 200 and 400 mg/ml PGEs, respectively. The treatments were orally given to rabbits between 7am and 9am for 28 days using a syringe. Feed (Table 1) and water were given freely to the animals, while other standard management practices described by Mailafia *et al*. (2010) were carried out throughout the experiment.

Experimental design

The experiment was carried out in a Randomized Complete Block Design (RCBD) and was made up of three treatments: T_1, T_2 and T_3 containing *Panax ginseng* extracts (PGEs) at 0.0, 200 and 400 mg/ml, respectively. Each treatment was blocked with gender (8 males and 8 females) and contained 16 rabbits with 4 replicates of 4 rabbits (2 males and 2 females) per replicate. The statistical model is:

$Y_{ij} = \mu + T_i + B_j + e_{ij}$

Where: Y_{ij} = Individual observation; μ = Overall mean; T_i = Treatment effect; B_j = Block effect; e_{ij} = Random error, which is assumed to be independently, identically and normally distributed with zero mean and constant variance.

Growth performance measurement

Daily feed intake was measured by weighing the feed given to the animals and leftover, if any. Feeding troughs were placed in such a way that wastage of feed by the animals was prevented. Initial and weekly body weights of the animals were measured and recorded. Daily weight gain, total weight gain, and feed conversion ratio (FCR) of the animals were then calculated. The weights were measured using a digital scale of two g sensitivity.

Linear body measurements

Data on linear body measurements of the rabbits were obtained at the end of the experiment using a flexible measuring tape. The descriptions of the measurements were as follows:

Table 1. Composition of growing rabbit's diet fed administered with PGEs

Ingredients	kg (DM)
Maize	45.00
Soyabean meal	15.00
Palm kernel cake	17.00
Wheat offal	18.50
Fish meal	1.00
Bone ash	2.00
Oyster shell	1.00
Salt	0.25
Vit/Min premix*	0.25
Total	100.00
Calculated analysis: Crude protein (%)	17.33
Metabolizable energy (ME) (Kcal/kg)	2,627.58

*To provide the following per kg of diet; Vit A, 10,000 IU; Vit D, 1,500 IU; Vit E, 3 IU; Vit K, 2 mg; Riboflavin, 3 mg; Vit B_{12}, 0.8 mg; Folic acid, 4 mg; Mn, 8 mg; Zn, 0.5 mg; Iodine, 1.0 mg; Co, 1.2 mg; Cu, 10 mg; Fe, 20 mg.

(i) Head length - from the tip of the nose to the beginning of the cervical vertebra.
(ii) Neck length - from the beginning of the cervical vertebra to the shoulder.
(iii) Trunk length - from the shoulder to the base of the tail (tail drop).
(iv) Breast girth - represents the chest circumference, and was measured just after the fore limbs.
(v) Ear length - from the base of the ear (ear drop) at the junction to the skull to the tip of the ear.
(vi) Tail length - from the base of the tail (tail drop) to the tip of the tail.
(vii) Fore limb length - from the junction of the humerus and scapula (shoulder) to the tip of the phalanges.
(viii) Hind limb length - from the junction of the fermur and acetabulum (hip bone) to the tip of the phalanges.

Feed intake and body weight gain patterns

Feed intake and body weight gain patterns of the rabbits were determined on weekly basis. The weekly feed intake was calculated from the daily feed intake and plotted against weeks on a graph, to obtain the pattern or trend of feed intake for the duration of the experiment. Weekly weight gain of the rabbits was calculated by subtracting successive weekly body weights from the previous body weights, which was used to plot a graph of weight gain against weeks, to obtain the pattern or trend of body weight gain of the rabbits throughout the experimental period.

Data analysis

Data collected were subjected to analysis of variance according to Steel and Torrie (1980), while significantly ($p < 0.05$) different means were separated using Duncan's New Multiple Range Test (DNMRT), as outlined by Obi (1990).

Results

Growth performance

Results of growth performance parameters of the experimental rabbits are presented in Table 2. Significant ($p < 0.05$) differences were recorded among the male rabbits, while none was recorded for the female rabbits. Final body weight and total body weight gain were significantly ($p < 0.05$) higher in rabbits on MT_2 and MT_3 than in rabbits on MT_1 (control). Feed conversion ratio (FCR) value was significantly ($p < 0.05$) higher in MT_1 rabbits than in MT_2 and MT_3 rabbits, which were similar ($p > 0.05$). Initial body weight, daily body weight gain, total feed intake and daily feed intake were similar ($p > 0.05$) among the experimental rabbits.

Table 2. Growth performance of growing rabbits administered *Panax ginseng* extracts

Parameters	MT_1	MT_2	MT_3	FT_1	FT_2	FT_3	SEM
Initial body weight (g)	731.50	764.00	726.25	730.25	736.25	728.38	12.75
Final body weight (g)	$1,224.63^{b}$	$1,358.50^{a}$	$1,332.50^{a}$	$1,232.88^{b}$	$1,254.63^{b}$	$1,262.00^{b}$	16.40
Total body weight gain (g)	493.13^{b}	594.50^{a}	606.25^{a}	502.63^{b}	518.38^{b}	533.62^{b}	14.13
Daily body weight gain (g)	17.61	21.23	21.65	17.95	18.51	19.06	2.70
Total feed intake (g)	2,031.13	2,046.34	2045.26	2,034.30	1,988.97	2,030.25	19.68
Daily feed intake (g)	72.54	73.08	73.05	72.65	71.03	72.51	4.68
FCR (g feed/g gain)	4.12^{a}	3.44^{b}	3.37^{b}	4.05^{a}	3.84^{ab}	3.80^{ab}	0.20
Mortality (Counts)	0	0	0	1	0	0	-

^{ab}: Means within a row with different superscripts are significantly ($p < 0.05$) different. MT = Male treatment; FT = Female treatment; SEM = Standard error of means; FCR = Feed conversion ratio.

Linear body measurements

Linear body measurements of the rabbits are presented in Table 3. Head, neck, ear, tail, fore limb and hind limb lengths were similar ($p > 0.05$) among the experimental rabbits. The breast girth was significantly ($p < 0.05$) higher in MT_3 rabbits than in MT_1, MT_2, FT_1, FT_2 and FT_3 rabbits which were similar ($p > 0.05$), while trunk length was similar ($p > 0.05$) between MT_3 and FT_3 rabbits, but trunk length of MT_3 rabbits was significantly ($p < 0.05$) higher than that of MT_1, MT_2, FT_1 and FT_2 rabbits.

Feed intake and body weight gain patterns

The experimental rabbits followed similar pattern of feed intake and body weight gain. However, in the male rabbits, feed intake continuously increased from the first week to the fourth week, while the female rabbits recorded a progressive increase from the first week, which peaked at the third week and declined in the fourth week (Fig. 1). However, body weight gain pattern of all the experimental rabbits (Fig. 2) was highest in the first week, dropped in the second, increased in the third week and then greatly dropped or remain almost the same in the fourth week.

Discussion

Growth performance

Growth performance evaluation of growing male and female rabbits administered *Panax ginseng* extracts (PGEs) shows that PGEs significantly ($p < 0.05$) increased total body weight gain in the growing male rabbits receiving 200 and 400 mg/ml. Considering the initial body weights, which were similar ($p > 0.05$) among the treatments, the significantly ($p < 0.05$) higher final body weights recorded in the growing male rabbits treated with PGEs at 200 and 400 mg/ml were probably caused by increased body weight gain, mediated by PGEs. Furthermore, the significant ($p < 0.05$) increase in total body weight gain of PGEs treated male rabbits is obviously a cumulative effect of the daily body weight gain, which was similar ($p > 0.05$) among the rabbits. The growth promoting effect of PGEs recorded in this experiment is not surprising, considering the reports of many studies on the ability of *P. ginseng* to enhance various growth processes in the animal's body; which include protein synthesis and cellular growth (Khalil *et al*., 2008; Kim *et al*., 2010; Shimaa, 2014).

Table 3. Linear body measurements of growing rabbits administered *Panax ginseng* extracts

Parameters (cm)	MT_1	MT_2	MT_3	FT_1	FT_2	FT_3	SEM
Head length	9.68	9.56	9.88	9.85	9.40	9.51	0.83
Neck length	4.50	4.63	4.85	4.06	4.24	4.73	0.54
Trunk length	27.14^{b}	27.33^{b}	29.24^{a}	27.19^{b}	27.31^{b}	28.29^{ab}	0.65
Breast girth	20.63^{b}	20.44^{b}	22.71^{a}	21.25^{b}	21.01^{b}	21.55^{b}	0.37
Ear length	9.88	9.95	9.93	10.03	10.10	10.24	0.91
Tail length	6.50	6.75	6.73	6.25	5.94	6.11	0.69
Fore limb length	14.86	15.03	15.86	14.46	14.69	15.30	1.09
Hind limb length	24.31	24.81	25.45	24.59	24.85	25.05	1.38

[ab]: Means within a row with different superscripts are significantly ($P<0.05$) different. MT = Male treatment; FT = Female treatment; SEM = Standard error of means.

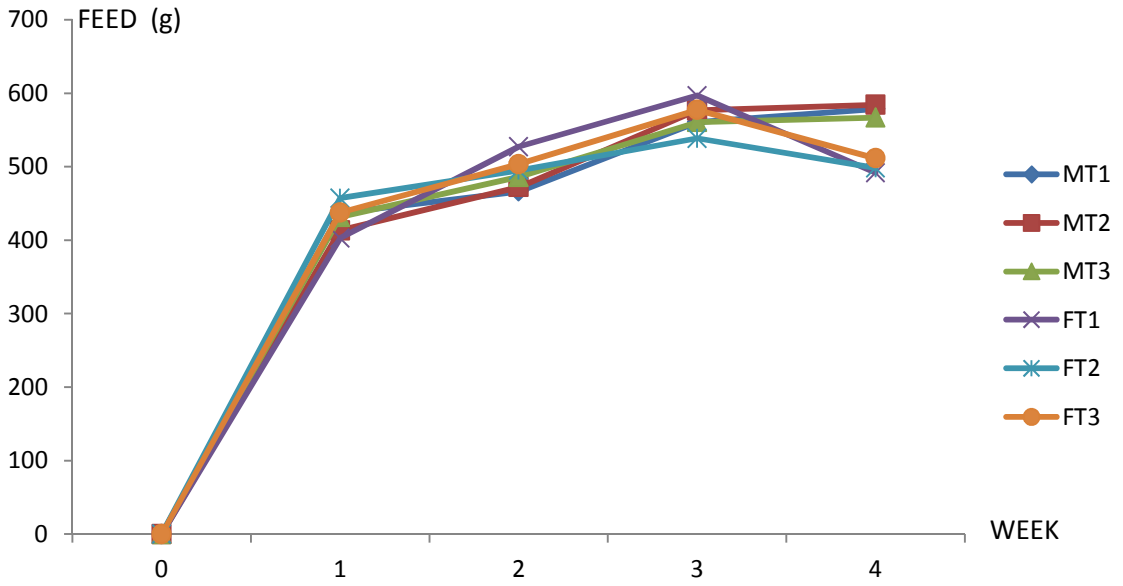

Fig. 1. Feed intake patterns of the experimental rabbits

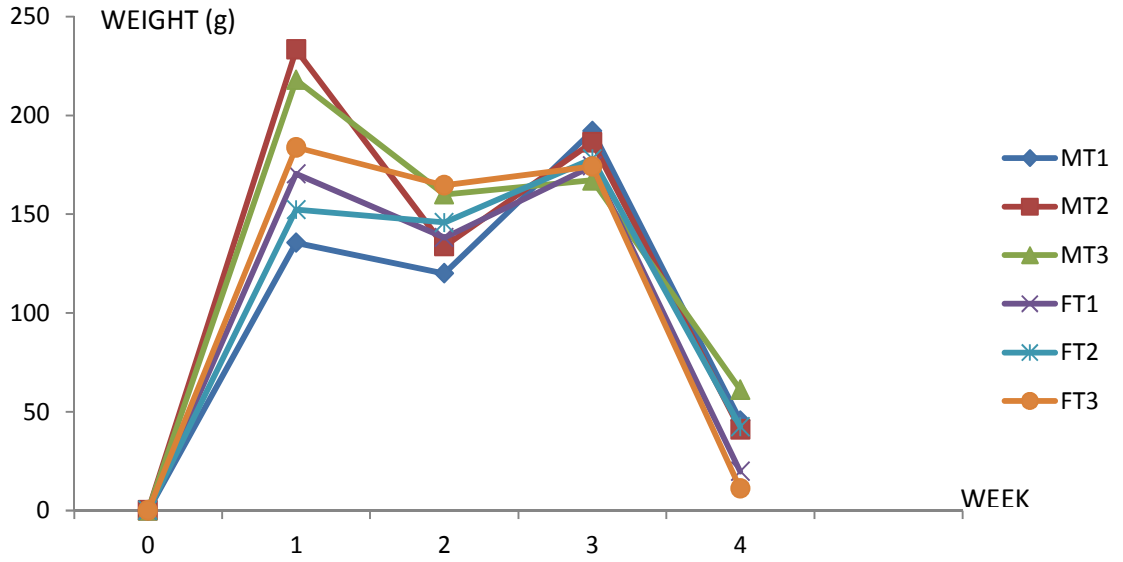

Fig. 2. Body weight gain patterns of the experimental rabbits

Feed intake did not increased, but feed conversion ratio calculations revealed better values for PGEs treated male rabbits on 200 and 400 mg/ml, suggesting that appetite centre (Ahima and Antwi, 2008; Esonu, 2015) of the animals were not affected by the extracts, but nutrient metabolism, utilization and other growth promoting physiological/biochemical processes, like blood circulation, amino acid/protein synthesis and glycogen storage that may have been enhanced (Sotaniemi *et al*., 1995; Edens *et al*., 2001; Yang *et al*., 2003). There is a possible gender difference/effect in the way the animals responded to the extracts, since the evaluated growth performance parameters of the female rabbits were not significantly influenced by the administration of PGEs. Moreover, the androgenic property of *P. ginseng* has been reported (Salvati *et al*., 1996).

Linear body measurements

The linear body measurements of the growing male and female rabbits were only significantly ($p < 0.05$), whereas they increased at the trunk and breast girth of the male rabbits receiving *P. ginseng* extracts (PGEs) at 400 mg/ml. Trunk length and breast girth constitute the measurement of the major parts of an animal's body, greater than other body parts put together in most animals (Lawrence and Fowler, 2002). This probably explains why significant ($p < 0.05$) increases were only observed in them among all linear body measurement parameters evaluated.

Feed intake and body weight gain patterns

The amount of feed consumed and the amount of weight gained by the animals are major parameters determining the growth performance of the animals and can basically be regarded as the input and output parameters respectively. Feed intake and body weight gain patterns of the rabbits show trends of how the absolute values of total feed intake and total body weight gain (Table 2) were reached, within the experimental period. This partly answers the physiological question of "how?" (Frandson *et al*., 2009), that is, how the rabbits fed and gained weight. Within the period of the current experiment, the evaluated feed intake pattern of the male rabbits increased from week one to week four, which is in agreement with reported feed intake pattern for rabbits of same age (Gidenne *et al*., 2010). Furthermore, feed intake pattern of the female rabbits increased from week one to week three and declined in week four. Growth pattern (body weight gain pattern) of the animals did not follow the standard growth curve as described by Lawrence and Fowler (2002). Unlike normal growth pattern, which gradually increases to a peak, stays for some time and then declines, the growth pattern mediated by oral administration of *P. ginseng* extracts (PGEs) in this study, showed an initial growth surge, which was prominent in the treated male rabbits, before it declined to follow the normal growth pattern. It could mean that the administration of PGEs which encourages protein synthesis and cellular growth (Khalil *et al*., 2008; Kim *et al*., 2010; Shimaa, 2014) were capable of inducing enormous acute weight gain through sudden increase in growth processes of the animal's body. However, this effect by PGEs may have been attenuated by homeostasis (Frandson *et al*., 2009), which resulted in regulating body weight gain of the rabbits to a tolerable, but enhanced level, which then followed the normal trajectory of growth.

Conclusions

The present study demonstrated that *Panax ginseng* extracts (PGEs) promotes body weight gain and increases trunk length and breast girth size in growing New Zealand White (NZW) male rabbits. Although the effect was not recorded in the growing NZW female rabbits, the body weight gain pattern or growth pattern of both growing male and female NZW rabbits were affected, slightly deviating from the normal growth pattern. There is also a slight deviation from reported feed intake pattern for the female rabbits administered PGEs. Furthermore, the result of the hereby experiment shows that total body weight gain of the New Zealand White male rabbits, which became significant

($p < 0.05$) at 200 mg/ml was more responsive to PGEs than trunk and breast girth, which became significant ($p < 0.05$) at 400 mg/ml. Therefore, the study revealed that *Panax ginseng* extracts can be used at 200-400 mg/ml oral administration to enhance growth performance in growing NZW rabbit bucks.

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Conflict of Interest

The authors declare that there are no conflicts of interest related to this article.

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