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Effects of *Panax ginseng* root meal as feed additive on reproductive performance of Cameroon kabir hens

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ABSTRACT

The Cameroon Kabir chicken has several production traits which makes it desirable by many farmers and hobbyists. This study was aimed at evaluating the potential of P. ginseng as a feed additive in the diet of Cameroon kabir hens reared under intensive conditions. A total of 84 kabir chickens were weighed and assigned to four dietary treatments. The birds in T0 were fed the control diet (0 % PGRM), while those in T1, T2, T3, were fed diets containing 0.5, 0.75 and 1 % PGRM respectively. The results showed that there was a significant difference ($p < 0.05$) in the egg lay, egg mass and hen-day egg production of the birds between the 0.5 % and 0.75 % PGRM groups. The 0.75 % PGRM group recorded the highest mean egg weight, and it was significantly ($p < 0.05$) different from the other PGRM groups, but similar ($p > 0.05$) to the control. There was also a significant difference ($p < 0.05$) in the hatchability percent between the 0.5 % and 0.75 % treatments groups, with the 0.5 % group recording the highest hatchability percent of 65.14 %, and the 0.75 % group recording the least hatchability percent of 12.94 %. Results for the chick hatching weights showed significant differences ($p < 0.05$) between the 0.75 % PGRM group and the control. In conclusion, *P. ginseng* as a feed additive in the diet of Cameroon kabir hens at 0.5 % improved their reproductive performance, and also improved the survivability of their offspring better but not in the number of eggs laid by chicks

1. Introduction

African countries have put in little efforts to conserve the local chicken breeds or lines (Manyelo, Selaledi, Hassan & Mabelebele, 2020). Manyelo et al. (2020) also stated that these chickens are economically, socially, and culturally important to the people of Africa, especially those from marginalised communities. According to Desha, Bhuiyan, Islam and Bhuiyan (2016), local chickens constitute an estimated 80 % of poultry production in Sub-Saharan countries. Nigeria is known to have the highest number of local chickens with an estimated population of 180 million. These local chickens are resistant to diseases although they are also associated with poor productivity, therefore any improvement in the productivity of local chickens will require close attention to nutrition, breeding, and health aspects (Lim et al., 2009; Manyelo et al., 2020). The native chicken in Africa and Cameroon in particular play an important role in household nutrition and poverty alleviation, effectively serving as a living bank and a "trouble fund". The Kabir chicken is a dual-purpose local chicken breed introduced from Israel to foster local chicken productivity for sustained likelihood amongst resource-poor farmers. This chicken is well adapted to heat stress, local feed resources and can harbour many microbes without showing clinical presentations (World Poultry, 2009).

According to Mandey and Sompie (2021), phytoadditives in animal nutrition have attracted a lot of attention for their potential role as alternatives to antibiotic growth promoters. This issue has prompted the search for herbal preparations (medicinal plants) that are safe, cheap, reduce mortality and can still maintain the optimum growth of animals.

Numerous studies have demonstrated the pharmaceutical effects of *P. ginseng* on physical, chemical, and biological stress metabolism (Lim et al., 2009; Spelman et al., 2006; Shim et al., 2010) and systemic immune function. Historically, *P. ginseng* is considered to be one of the most valuable medicinal herbs in East Asian countries such as China, Korea, and Japan (Attele, Wu & Yuan, 1999). The most notable features of ginseng have been suggested to be the modulation of the immune system, cancer, and diabetes (Dey et al., 2003). Studies have shown that broiler chickens fed diets supplemented with 3 % Red Ginseng Marc (RGM) had markedly decreased mortality and serum cholesterol levels, as well as improved meat quality, suggesting that RGM can be utilized in

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practical broiler diets (Kim, Lee & Choi, 2014). Jang et al. (2007) reported that feeding fermented wild ginseng culture by-product can increase egg production and egg quality and it is on the basis of that we set out to ascertain such claims.

At full sexual maturity (6 months of age), kabir males can attain body weights of up to 7.0 kg. The females just like the native chicken are broody and lay up to 200 eggs per cycle. An important characteristic is that they are great for crossbreeding. When crossbred with native chickens, the kabir qualities are retained in the new breed, resulting in a larger-sized chicken, since the kabir has stronger genetic quality (World Poultry, 2009). The farming system of local chicken in Cameroon is more extensive and semi-intensive. This means the kabir chickens are mating freely with the native chickens to produce the Cameroon kabir chickens. Improvement of the reproductive performance is therefore imperative to consolidate gains brought to the local poultry industry by the kabir chicken (World Poultry, 2009).

The improvement of the reproductive performance of poultry chicken is therefore imperative to consolidate gains brought to the local poultry industry by the kabir chicken. According to Yildirim, Sekeroglu, Eleroglu, Sen and Duman (2013), ginseng is considered as an adaptogenic agent that helps to enhance physical performance, promote vitality, and stimulate metabolic function in most animals. Due to its antimicrobial and antioxidant potential, it has been used to enhance reproductive performance in several animals like pigs, dairy cattle, rabbits, broiler chickens, commercial layers, but little literature is available on its effects on Cameroon local chickens. Also, ginseng is readily available and underutilised in the western highlands of Cameroon. It is considered a weed for some farmers. Furthermore, the rather high productivity of the exotic meat type chicken (broiler), and the egg type chicken (layers), has resulted to overdependence on synthetic drugs for a production whose residues have huge consequences on human health. However, meat and eggs from the local chickens that are managed semi-intensively appear to be organic (natural), highly demanded in the market as compare to the inorganic produced chicken meats. The adaptogenic agent found in ginseng is known to help in the enhancement of physical performance, promote vitality, and stimulate metabolic function as stated by Yildirim et al. (2013). This piece of work is out to reduce high dependency on synthetic products which lead to resistant strains and whose residual effects are detrimental to human health after consumption of the chickens. The main objective of this study is to assess the contribution of *P. ginseng* root meal as a dietary additive on the reproductive performance of the Cameroon kabir chicken.

2. Material and methods

2.1. Study areas

Fresh *P. ginseng* roots of not less than four years were harvested from the Northwest region of Cameroon precisely from Ndop (Ngoketunjia division), with coordinates N 6^0 00′0.00″ to E 10^0 24′ 59.99′′ and was transported to Buea where the experiment took place.

This study was carried out in Molyko-Buea in Fako Division, Southwest Region of Cameroon, precisely at the Faculty of Agriculture and Veterinary Medicine Teaching and Research Farm (FAVM-TRF) University of Buea, which stands at an altitude of 870 m above sea level. The farm lies on coordinates N 4^0 9′0.3888″ to E 9^0 16′ 59.6496′′ (Global Positioning System service). The town of Buea is situated at longitude 4.15°N to latitude 9.24°E with a temperature range of 20 °C to 28 °C and the mean annual relative humidity ranges between 80 % and 95 %. It is found in agro-ecological zone IV (monomodal humid forest) and has a subtropical highland climate because of its location at the foot of Mount Cameroon. Buea has an equatorial climate with 2 major seasons. The rainy season runs from March to October, and the dry season from November to May (Buea Communal Development Plan, 2012). The town tends to be humid, with neighborhoods at a higher elevation enjoying cooler temperatures while lower neighborhoods experience hotter temperatures. Extended periods of rainfall characterise by incessant drizzle which can last for weeks, are common during the rainy season which follows a bimodal pattern with peaks in April and September (Buea Communal and Development, 2012). The topography of Buea is mainly composed of undulating high and low lands with many rocks and gravels. The soils in this area are black and well-drained due to the generally hilly nature of the terrain BCP (2012).

2.2. Ethical and administrative issues related to experimental animals

Kabir chickens were produced and used for this experiment to assess the impacts of *P. ginseng* root meal on the reproductive performance of the chickens. The animals were housed in standard cages at 25 °C on an 18 h light-dark cycle for reproduction. They were supplied with food and water *to* meet their optimum reproductive potential. The experiments were carried out following the National Ethical Committee Guidelines (N°FWA-IRB00001954) and International (European Committee Council Directive of November 24, 1986 (86/69/EEC); Guide for the Care and use of Laboratory Animals, U.S. National Research Council, 1996) for the care and use of laboratory animals. All efforts were made to minimise the suffering and stress of any type to the chickens used.

2.3. Preparation of P. ginseng root before inclusion into the feed as an additive

The roots were washed with clean water to remove dirt. The roots were then chopped with the aid of a knife to reduce the size of the roots, thereby increasing the surface area for drying. Subsequently, the weight of the fresh *P. ginseng* was recorded. The chopped roots were spread in an air circulated oven drier at 40 °C to dry. The ginseng roots were weighed at intervals until the weight became fairly constant after 48 h. The dried ginseng roots were then bagged and carried to the mill. It was ground to powder using a pulverizer machine at the FAVM-TRF feed mill and stored in airtight plastic bags to avoid moisture that could lead to fungal growth. All experimental ingredients (excluding maize) such as; wheat bran, soybean meal, fish meal, premix, bone meal, and oyster shell, were purchased from BELGOCAM, Buea branch. The maize (yellow maize) used for the research was purchased from Bangem, Southwest Region of Cameroon. Fig. 1 shows ginseng root meal powder obtained from the processing.

2.4. Preparation of experimental diets

The experimental diet for the F1 parent chicks was formulated following the guidelines of the National Research Council (NRC, 1994) nutrient requirement of poultry. The formulation was done making sure the resulting mash was isocalorific and isonitrogenous. The calculated chemical composition of the feed was made to be within the range recommended by the NRC for breeders. Four test diets were compounded as shown in Table 1. For each treatment, the ingredients were weighed separately; starting with the macro ingredients using an electronic scale of maximum capacity 30 kg ± 1 g. The micro-ingredients were weighed using the SF-400 electronic kitchen scale. The micro ingredients were first mixed and introduced to the macro ingredients and mixed thoroughly using a mixer. The resulting mash was weighed, bagged, and tagged treatment zero (T0) which served as the control. This procedure was repeated for all the other treatments, with the exception of ginseng which served as the additive (test ingredient) was mixed alongside the micro-ingredients at varying proportions of 500 g, 750 g and 1000 g/100 kg (per 100 kg of feed). The resulting mash was then weighed, bagged and tagged T1, T2, and T3 respectively. The diets contained 16.41 % crude protein with a corresponding metabolisable energy of 2724 kcals/kg.

Fig. 1. Powder *Panax ginseng* from the pulveriser ready for use.

Table 1
Percentage (%) composition of experimental diet at the reproductive stage.

Ingredients	T0 (0 % PGRM)	T1 (0.5 % PGRM)	T2 (0.75 % PGRM)	T3 (0.5 % PGRM)
Maize	51	51	51	51
Wheat bran	15	15	15	15
PGRM	0	0.5	0.75	1
Soybean meal	18	18	18	18
Fish meal	4	4	4	4
Oyster shell	5	5	5	5
Bone meal	2	2	2	2
Premix* (5 %)	5	5	5	5
Total	**100**	**100**	**100**	**100**
Nutrient composition				
Crude protein (%)	16.41	16.41	16.41	16.41
Metabolizable energy (kcal/kg)	2724.37	2724.51	2724.58	2724.66
Calcium (%)	3.944	3.947	3.948	3.949
Lysine (%)	1.13	1.13	1.13	1.13
Methionine (%)	0.47	0.47	0.47	0.47
Cysteine (%)	0.28	0.28	0.28	0.28

* Premix 5 %: crude protein = 40 %; Metabolizable energy = 2078 kcal/kg; Calcium = 8 %; Phosphorus = 2.05 %; Lysine = 3.30 %; Met (Methionine) = 2.40 %; ME = Metabolizable energy.

2.5. Experimental design

The research design adopted for this experiment was a completely randomized design (CRD). The experiment had 4 treatments and each was replicated three times. Each hen and cock was assigned to a dietary treatment at random, so that each experimental unit had the same chance of receiving any one treatment. A total of eighty-four (84) birds were selected for this experiment. Each of the selected birds were weighed. The selected hens had an average weight of 2.0 kg while the cocks had an average weight of 2.4 kg. The control birds (T0) did not receive the test ingredient, while T1, T2 and T3 received graded levels of the test ingredient respectively at 0.5 % (5 g/kg), 0.75 % (7.5 g/kg) and 1 % (10 g/kg). Each replicate had six (6) hens and one cock (1).

2.5.1. Layout of the experimental design

The experimental animals were housed in pens of surface area 4.06 m^2, and the experimental period with ginseng administration was four (4) months/16 weeks (1 month before the start of laying and 3 months during the laying making it 4 months. Also, the chicks after incubation were followed up for the treatments for 3 weeks for post-ginseng effects on survivability and growth. See Fig. 2 for the experimental layout.

The pens in the research units were further partitioned using wood, plywood, and plastic nets. The partitioning was done to give rise to a total of 12 sub-pens of dimension 2.9 m by 1.4 m with uniform dimensions. All pens had the same orientation to make sure that natural lighting, ventilation and other environmental factors were uniform across treatments and replicas. Provision for nighttime lighting was also

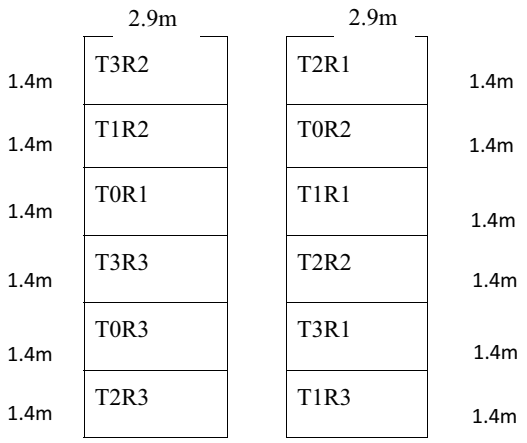

Fig. 2. Layout of the experiment design.

made available by placing a total of eight (8), 10 W' bulbs producing white light through an automatic system.

2.6. Feed, egg, hatchery and brooder management

Feed, eggs, hatchery, chicken and pens management were taken into account while carrying out this experiment to ensure quality and optimize performance and the details are stated below.

2.6.1. Management of experimental birds; feed and water

Feeding started at 6am throughout the experimental period. The feed was offered daily and leftover feed was removed from the feeders each morning and weighed before fresh feed was given. Feed and water were restricted while drinkers and feeders were cleaned every morning before administering fresh water and feed to the birds (Water restriction was performed to ensure the litter was dried at all times). Wet litter in breeder management is a thriving factor for microbial growth and subsequent disease outbreaks in the flock. Kabir breeders have a behavioural tendency to spill water when their feed ration is exhausted. It is worth mentioning that water was offered to the birds twice a day, with an exposure time of two hours per session to ensure that they meet their daily water requirement for optimum production)

2.6.2. Egg and hatchery management

The eggs collected were tagged with respect to treatment and replicates and were stored in an insulated box with controlled temperatures and humidity. The eggs were cleaned using a foam wet with 70 % alcohol and the temperature of the environment where the eggs were stored ranged between 16 and 18 °C with humidity from 75 % and 80 %. Prior to incubation, the incubator was cleaned using bleach (NaClO). The incubation temperature and humidity were set at 37.5 °C and 65 % humidity respectively. On the 7th day of incubation, the eggs were candled and the number of infertile and fertile eggs from each treatment was counted and recorded. On the 19th day of incubation, the eggs were transferred to the hatcher with the temperature and humidity regulated to 36.5 °C and 68 % respectively. On the day 23, all eggs were withdrawn from the incubator and embryo mortality was evaluated.

2.6.3. Management of brooder for the day-old chicks

The temperature of the brooder was set at 35 °C and 2 °C was reduced every week until the third week and the temperature were stabilized. The brooder was divided into the various treatment and day-old chicks were brooded into their different compartment. The brooder was well constructed to minimize heat loss and prevent predators like rodents and snakes from entering. Temperature regulation was done with the use of electrical heaters and bulbs and the reduction of temperature was done by reducing the number of heaters and expanding the brooder while taking the readings from the thermohygrometer whose sensor was placed at the different points in the brooder. New chicks from the incubator were supplied feed and water with anti-stress (for three days) in their drinkers. Water and feed were supplied at libitum to the chicks in the brooder and the surface was covered with wood shavings with no overcrowding.

2.7. Data collection from feed trials kabir chickens

Data collection was done daily for egg weight and egg lay. The internal and external egg quality parameters such as yolk weight, albumen weight, Haugh units, albumen height, yolk colour, shell weight, shell thickness, were measured after every two weeks. Based on the specific objectives of the research, the following parameters were evaluated and data collected:

2.7.1. Egg collection, egg lay (EL) and egg weight (EW)

The eggs laid per treatment and per replica were collected from the laying nests, cleaned using a foam and alcohol (95 %), tagged according to their corresponding treatment and the data recorded in designed data sheets. Eggs were collected twice a day (9–11am and 1–4pm) and weighed using an SF-400 electronic scale (5 kg ± 0.1 g). At the end of the day, the sum of the eggs for each of the replicates was recorded in designed data sheets. This was done for every egg picked daily for three months.

2.7.2. Hen-day egg production (HDEP) and egg mass (EMa)

The HDEP and EMa were computed weekly for a period of 11 weeks. The HDEP was computed using the formula;

$$\text{Hen} - \text{day egg production} = \frac{\text{Total number of eggs produced in a week}}{\text{Total number of hen} - \text{days in a week}} \times 100$$

The EMa was calculated using the formula;

$$\text{Egg Mass (EMa)} = \text{ Percent HDEP X 100}$$

2.7.3. External and internal egg quality (EEQ and IEQ)

This data was collected once every two weeks and 10 eggs were collected per replica and sacrificed, and these sacrificed eggs were used to estimate the EEQ and IEQ parameters. The EEQ and IEQ parameters measured were expressed as a percentage of egg weight. They include yolk weight (YW), albumen weight (AW), the Haugh unit (HU) shell weight (SW), and eggshell thickness (ST). The eggs were weighed and cracked specifically at their equator using a clean knife onto a clean dish and left intact. The albumen height was recorded using a calliper (± 0.02 mm) at three regions of the exposed internal egg contents. The yolk was separated from the albumen, weighed using the SF-400 electronic scale (± 0.1 g), and recorded in g (g). The albumen was collected in a hollow dish (Petri dish), weighed using the scale, and recorded in g. The weight of the empty eggshell was then weighed using a scale (± 0.1 g) and recorded in g. The thickness of the four eggshells was measured at three equatorial regions using a calliper, without eggshell membranes (mm). The average of the 3 values gotten from three equatorial regions of each egg served as the value for the ST.

The Haugh units was calculated from the following formula described by Eisen, Bohren, and McKean (1962):

$$HU = 100log(H - -1.7W0.37 + 7.6)$$

where W is egg weight and H is albumen height. Egg yolk colour of the sacrificed eggs was evaluated by the use of a Roche colour fan by placing the yolk contained in a transparent dish over the fan.

2.7.4. Fertility percent (FP) and hatchability percent (HP)

The total number of eggs incubated per treatment were recorded. Candling of the eggs was done on the 7th day of incubation, and infertile eggs were removed, counted and recorded. On the 19th day of the incubation period, the eggs were transferred to hatching baskets labelled according to their treatments and taken to the hatcher. Each basket was partially modified to ensure that chicks do not fall from one treatment to another upon hatching. All hatched chicks were counted and recorded following the treatment they hatched from, and were immediately transferred to the farm. On the 23rd day of incubation, all eggs which didn't hatched were withdrawn from the incubator, cracked open, and the embryo mortality evaluated and recorded. The total number of fertile eggs was a sum of the total number of hatched chicks and the total embryo mortality per treatment. It was calculated using the formula:

$$\text{Fertility percent } (FP) = \frac{\text{number of fertile eggs}}{\text{total incubated eggs}} \times 100$$

After incubating the eggs collected daily from each experimental group, on the 23rd day the total number of chicks hatched per treatment were counted, and the HP was calculated using the formula:

$$\text{Hatchability percent } (\text{HP}) = \frac{\text{number of chicks hatched}}{\text{total fertile eggs}} \times 100$$

Parameters evaluated included; embryo mortality (Emo), chick weight (CW), and chick mortality (CM). These data were collected for a period of 3 weeks to be able to evaluate the survivability of the chicks which were to become the experimental unit without the additive.

2.7.5. Embryo mortality (Emo)

The embryo mortality was determined after the incubation of the eggs (day 23). The eggs which didn't hatch were cracked and observed for the presence of embryos which had developed and died during the incubation process. The number of dead embryos was counted and recorded. Fig. 3 shows the evaluation of the Emo.

2.8. Evaluation of survivability of chicks from the different treatments

A total of 20-day-old chicks were randomly selected from each treatment (T0-T3) to be used for the survivability study in the brooder. A well-constructed, partitioned and labelled brooder was used for this trial. Upon arrival of the chicks at the farm, their hatching weights (HW) were recorded using the SF-400 electronic kitchen scale. Each chick was installed in the brooder compartment corresponding to the treatment from where they were hatched. The chicks were fed and water provided daily for a period of 3 weeks and the chick weight (CW) was recorded on weekly basis using the SF-400 electronic scale. All dead chicks were recorded and removed immediately taking note of their respective treatments.

2.9. Recording weight gain of the experimental chick (CW)

The weight of the chicks was recorded weekly using the SF-400 electronic scale. Weight gain was gotten by calculating the change in weight of the birds.

2.10. Chick mortality (CM)

The chicks were observed daily, and every mortality was removed and recorded against the treatment it originated from

2.11. Statistical analysis

All data collected for each parameter (EL, EW, HDEP, EM, SW, ST, YW, YC, AW, AH, HU, FP, HP, HW, CW, CM, EM). was input in Excel 2016 and later subjected to statistical analysis using Graphpad prism version 9.0 statistical software. Descriptive statistics was done for each of the parameters to obtain the corresponding means and standard error of means. Furthermore, one-way ANOVA and Turkey's multiple comparison tests were used to separate means which were significantly different. Significance was set at $p < 0.05$.

Fig. 3. A fully formed dead embryo from the egg.

3. Results

3.1. Effects of graded levels of P. ginseng root meal on the quantity of egg produced

The quantity of egg production by kabir hens supplemented with graded levels of *P. ginseng* root meal is found in Table 2 with all statistical significance established at $P < 0.05$. The mean egg lay of the control [T0 (0 % PGRM)], was statistically similar to all the test diets. However, T2 (0.75 % PGRM) significantly had a lower egg lay compared to T1 (0.5 % PGRM). For mean egg weight, T2 recorded the highest egg weight (57.28 g) but it was not statistically significant to the other treatments. The egg weight for T2 was higher and significantly different to treatment 1 and 3. The mean HDEP followed a similar trend like egg lay. However, T2 (0.75 % PGRM) significantly had a lower HDEP compared to T1 (0.5 % PGRM). The trend in mean egg mass was similar to that of the HDEP. T2 recorded the least egg mass 2.46 kg, which was significantly lower compared to the egg mass for T1 which recorded an egg mass of 3.79 kg.

3.2. Weekly egg laying and egg weight patterns of hen fed with PGRM supplement

The egg lay pattern for the various treatment groups is shown in Fig. 4. The birds in T1 seems to maintain a fairly high level of egg production throughout the 11 weeks' period, while the birds in T2 had a lower level of production. After a general peak in production by week 3, there was a general slump in week 4 and 5 for all the treatment groups. However, by week 6, T1 recovered and started rising again, while the other treatments continued to fall. See details in Fig. 4. The egg weight pattern of hens supplemented with PGRM is indicated in Fig. 5. It was observed that there was a general rise in egg weight over the 11 weeks' period for all the treatment groups. Details can be seen in Figs. 4& 5.

3.3. The effects of graded levels of P. ginseng root meal on egg quality

There was no significant difference amongst dietary treatments for all the external and internal egg quality parameters such as; shell weight, shell thickness, yolk weight, albumen weight, albumen height and Haugh units. Details in Table 3.

Results for the yolk colour index of eggs evaluated for the different dietary treatments are represented on Fig. 6. From the graph, there exists a significant difference ($p < 0.05$) between the yolk colour index of T2 and that of T1. The treatment T2 (0.75 % PGRM) recorded the highest mean yolk colour index (8.25), while T1 recorded the least mean yolk colour index (6.58).

3.4. Fertility and hatchability rate

There was no significant difference ($p < 0.05$) in the fertility percent amongst the various treatments as shown in Table 4. However, the rate of hatchability of T1 differed significantly ($p < 0.05$) with T2 and T3. The control (T0) however recorded statistically similar ($p > 0.05$) results to T1 for hatchability.

3.5. Growth and survivability of chicks from kabir hens fed with PGRM as supplement

There was no significant difference in the embryo mortality and the chick weight amongst dietary treatments. A significant difference was observed in the chick mortality results, where 0 mortality was recorded from T2. The results observed for T2 (0.75 % PGRM), was significantly different from the results of all the other treatment groups. However, hatching weight was significantly lower in treatment 1 (T1) compared to the other treatments and the control. See details in Table 5.

Table 2
Egg production parameters of Kabir hens fed graded levels of *P. ginseng* root meal additive.

Parameter	T0 (0 %)	T1 (0.5 %)	T2 (0.75 %)	T3 (1 %)	p-value
Egg lay	24 ± 2.65 ^{ab}	30 ± 2.26 ^{a}	18 ± 1.96 ^{b}	24 ± 4.07 ^{ab}	0.04
Egg weight (g)	55.69 ± 0.37 ^{a}	52.88 ± 0.39 ^{b}	57.28 ± 0.50 ^{a}	53.67 ± 0.38 ^{b}	<0.0001
HDEP (%)	57.14 ± 6.31^{ab}	71.21 ± 4.99 ^{a}	42.85 ± 4.68 ^{b}	56.49 ± 9.15 ^{ab}	0.0033
Egg mass (kg)	3.19 ± 0.35 ^{ab}	3.79 ± 0.26 ^{a}	2.46 ± 0.25 ^{b}	3.04 ± 0.45 ^{ab}	0.0144

Values shown are mean ± SEM (standard error of mean). $^{a–b}$ Mean values within rows with different letters are significantly different ($P < 0.05$). g stands for grams. HDEP (hen day egg production).

4. Discussion

The use of PGRM as an additive in the current study improved the egg production potentials (EL, EW, HDEP, EM) of the kabir hens. It is important to emphasize ginsenosides are the primary component of ginseng, and positively affect reproductive organs and other tissues. The results obtained may be attributed to the improvement in health status of birds fed supplemented diets, and can also be attributed to the stimulating effect of ginsenosides on oocyte meiotic maturation proliferation through the cumulus cells (Kang, Park & Kim, 2016). Furthermore, Tan, Ge, Mi, Jin and Zhang (2010) indicated in his study that administration of ginsenoside significantly increased the number of granular cells, which is a major component of the ovarian follicle in laying hens, leading to a more cuboidal shape of the granular cells in hens on the ginsenoside-supplemented diet. This could a major contributing factor for the increase in laying performance of the kabir hens fed PGRM in this study. These results are similar to that of Jang et al. (2007) who reported that fermented wild ginseng culture by-product increased egg production for hens consuming both 2.5 and 5.0 % wild ginseng for 6 weeks when compared to the controls. This could be attributed to the potential of ginsenosides to improve physiological function of animals, thereby exerting a positive effect on production.

With the exception of yolk colour, all other egg quality parameters (FP, SW, ST, YW, AW, AH, HU) were not significantly different from the control. This might be due to the differences in the components or concentration of the feed components which has been well documented by Colin, George and Ensminger (2004). The yolk pigment (xanthophylls), depends on fat-soluble pigments in the diet of the hen as reported by Lokaewmanee, Yamauchi, Komori and Saito (2011). The paler yolk at 0.5 % inclusion may suggest that xanthophylls in the egg yolk interacted with ginsenosides of PGRM fed to the hens. Pale yolks can result from any factor that inhibits liver function, subsequent lipid metabolism and deposition of pigment in the yolk (Lee, Bae, Park, Ahn & Cho, 2015). These results were similar to that Yildirim et al., 2013 who observed that with the exception of yolk colour, Korean ginseng (*P. ginseng C.A. Meyer*) root extract added to the feed of brown laying hens at levels of 0, 50, 100, and 150 mg/kg from 20 to 32 weeks of age did not affect egg production and egg quality traits. Their study further indicated that higher levels of ginseng root (100 and 150 mg/kg of feed) caused yolk colour values to be lower than the yolks of eggs from control hens, indicative of a less intense yellowish–orange colour. The inconsistency observed might be due to the use of different ginseng sources, different methods of preparation of the ginseng products, and strains used in the experiments.

Using PGRM as additive in the diet of kabir hens did not significantly ($P > 0.05$) improve their fertility percent. These results may be indicative that 0.5 % PGRM addition in the diet of kabir hens rather played an inhibitory role on egg fertility and further studies are recommended to investigate such role. In terms of hatchability, there was however an improvement in hens that were fed PGRM. These results differ slightly

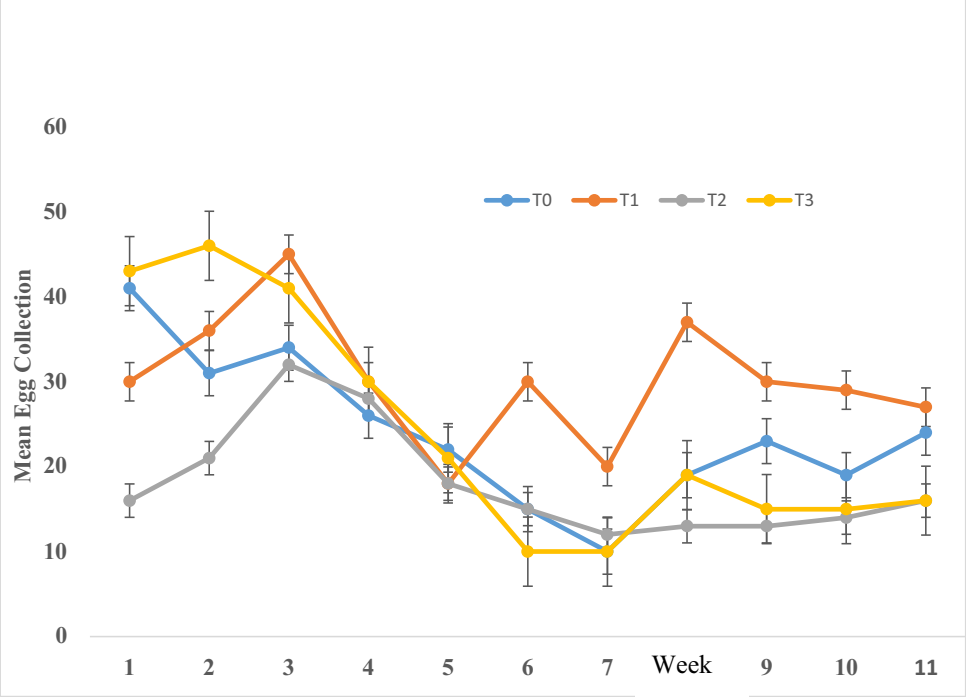

Fig. 4. Weekly egg laying pattern of hens fed *P. ginseng* root meal supplement.

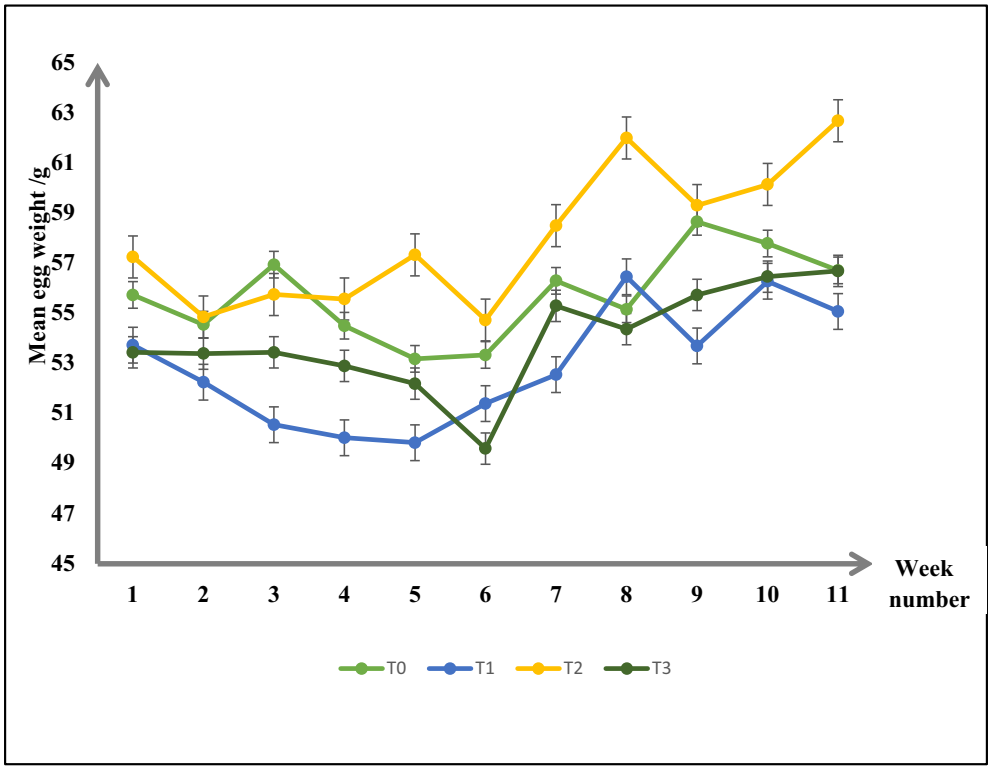

Fig. 5. Weekly mean egg weight/g pattern of hens fed *P. ginseng* root meal supplement.

with that of Azazi, Darwish, El-Hameid, Habib and Razik (2011) who reported that both the fertility and hatchability of eggs resulting from Sinai laying hens supplemented with diets containing 150 mg/kg and 300 mg/kg ginseng showed a significant increase. The results also deviated slightly to those of Raphael, Christian and Juliano (2015), who reported that substituting soybean with *Moringa oleifera* meal in the diets of kabir hens had no significant impact on both the fertility and hatchability of the laying hens. Egg production, as well as fertility and hatchability are lowly heritable in chicken (0.06 to 0.13, Sapp, Rekaya, Misztal & Wing, 2004), and are affected by several factors such as strain of chicken, nutrition, mortality, health management practices, age at point of lay, and persistency of lay (Kim, 2013). The results observed

Table 3
Effects of PGRM on the external and internal egg quality of kabir hens.

Parameter	T0 (0 %)	T1 (0.5 %)	T2 (0.75 %)	T3 (1 %)	*p*-value
Shell weight (g)	6.92 ± 0.25	6.75 ± 0.13	6.83 ± 0.29	6.91 ± 0.193	0.0598
Shell thickness (mm)	0.48 ± 0.021	0.46 ± 0.022	0.45 ± 0.016	0.45 ± 0.01	0.7547
Yolk weight (g)	15.33 ± 0.59	14.00 ± 0.34	15.08 ± 0.35	14.92 ± 0.43	0.1793
Albumen weight (g)	31.33 ± 1.41	29.58 ± 0.94	30.67 ± 0.89	28.83 ± 2.61	0.7050
Albumen height (mm)	5.60 ± 0.60	5.38 ± 0.56	5.72 ± 0.46	5.11 ± 0.40	0.8488
Haugh unit	73.31 ± 4.62	72.21 ± 4.71	75.41 ± 3.05	71.84 ± 3.31	0.9218

Values presented are mean ± ± SEM (standard error of the mean). [a–b] Mean values within rows with different letters are significantly different ($P < 0.05$). mm stands for millimeters and g for grams.

could suggest that fertility in kabir hens improve with increasing levels of PGRM in their diet above 0.5 %. This may be attributed to fact that *P. ginseng* affects sexual effectiveness and increases fertility through its effect on sex hormones and their receptors (Kim, 2012; Park et al., 2017). A receding trend could be observed with the hatchability, which could indicate that inclusion of P. PGRM in the diets of kabir hens above 0.5 %, results in high levels of ginseng saponins (ginsenosides) in the eggs, which might have had an anti-nutritional effect on the developing embryos.

The results of this study showed that there was an improvement in CM and HW of the offspring resulting from kabir hens fed PGRM. The improvement in CM and HW could indicate that the level of ginsenosides present in the yolk played a significant role in providing the adaptogenic and growth promoting effects portrayed by the offspring. These results clearly indicate that the antioxidant and antimicrobial properties of *P. ginseng* had a significant role to play in reducing the HW and CM of the groups treated with PGRM.

5. Conclusions

In conclusion, PGRM fed as an additive in diets of Kabir hens led to an improvement in the EL, EW, HDEP, Ema, YC, HW, CM and hatchability. Therefore, we recommend the use of PGRM at the level of 5 g/kg for an improvement of egg production and hatchability. We also recommend that PGRM be used at an inclusion level of 7.5 g/kg to improve egg yolk quality.

Ethical approval

The study followed the National Ethical Committee Guidelines (N°FWA-IRB00001954) and International (European Committee Council Directive of November 24, 1986 (86/69/EEC), Guide for the care and

Table 4
Effects of graded levels of *P. ginseng* root meal on the fertility and hatchability percent of Kabir hens (FP & HP).

Parameter	T0 (0 %)	T1 (0.5 %)	T2 (0.75 %)	T3 (1 %)	p-value
Fertility percent (%)	60.95 ± 6.49	44.21 ± 7.17	63.24 ± 13.24	64.05 ± 7.38	0.4514
Hatchability percent (%)	40.06 ± 9.02 [a]	65.14 ± 5.13 [a]	12.94 ± 5.24 [b]	24.71 ± 4.70 [b]	0.0159

Values shown are mean ± ± SEM (standard error of mean). [a–b] Mean values within rows with different letters are significantly different ($P < 0.05$). g stands for grams.

Table 5
Effects of *P. ginseng* root meal additive on survival and growth of chicks from Kabir hens.

Parameter	T0 (0 %)	T1 (0.5 %)	T2 (0.75 %)	T3 (1 %)	p-value
Embryo mortality (%)	24.00 ± 4.00	7.50 ± 3.500	10.50 ± 1.500	8.00 ± 4.00	0.0725
Chick mortality (%)	6.25 ± 1.03 [a]	4.25 ± 0.85 [a]	0.00 ± 0.00 [b]	5.25 ± 1.37 [a]	0.0031
Hatching weight (g)	38.71 ± 0.62 [a]	35.31 ± 0.75 [b]	41.00 ± 3.60 [a]	40.50 ± 2.53 [a]	0.0019
Chick weight (g)	130.1 ± 6.24	119.0 ± 5.91	124.6 ± 20.59	126.5 ± 17.74	0.05

Values shown are mean ± ± SEM (standard error of the mean). [a–b] Mean values within rows with different letters are significantly different ($P < 0.05$). g stands for grams.

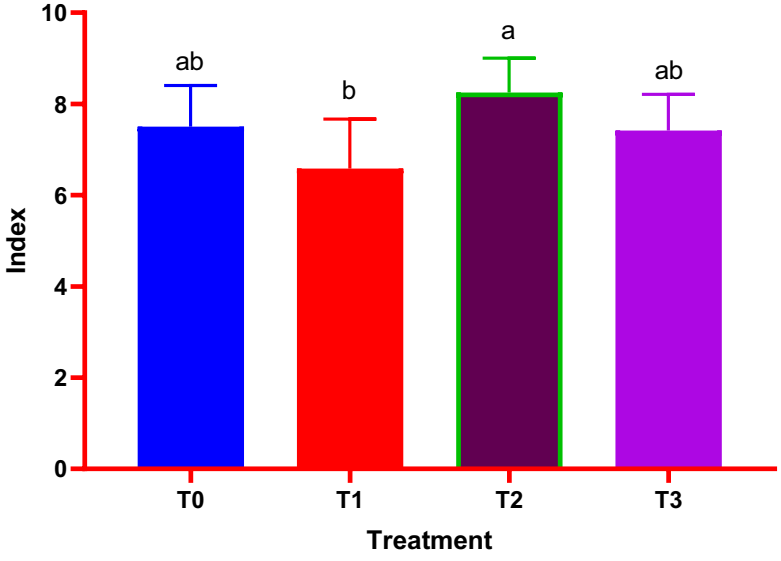

Fig. 6. Bar chart showing the mean yolk colour index of eggs for treatments.

use of Laboratory Animals, U.S. (1996). All efforts were made to minimize both mechanical injury inflicted on the chickens and number of chicken used for the experiment. "This article does not contain any studies with human participants performed by any of the authors"

CRediT authorship contribution statement

Ndaleh Wozerou Nghonjuyi: Writing – original draft, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Divine Ewane:** Writing – review & editing, Conceptualization. **Ma-Tabe Ekpo Bisong:** Writing – review & editing, Methodology, Formal analysis, Data curation. **Nguimdo Mbusop Tiziano:** Investigation, Data curation.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

NDALEH WOZEROU NGHONJUYI reports administrative support, article publishing charges, equipment, drugs, or supplies, statistical analysis, travel, and writing assistance were provided by University of Buea. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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