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Comparative studies on egg, meat, and semen qualities of native and improved chicken varieties developed for backyard poultry production

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Abstract The objective of the present study was to evaluate/compare the sensory attributes of eggs and meat, egg qualities, proximate composition of eggs, and semen qualities of slow growing native (Miri and Mizo-local) and fast growing improved chicken varieties (Gramapriya and Vanaraja) under hill ecosystem of northeastern India. Significantly higher egg weight, egg volume, and albumen volume were observed in Gramapriya followed by Vanaraja, Mizo-local, and Miri chickens. However, yolk volume was significantly higher in Vanaraja and Gramapriya varieties as compared to native chickens. Yolk to albumen ratio was significantly lower in Gramapriya as compared to Vanaraja and Miri chicken. Consumer liking of eggs for aroma, flavor, and overall acceptability of Miri, Mizo-local, and Vanaraja were significantly higher than that of Gramapriya. Genetic groups did not differ significantly in appearance and proximate composition of eggs. No significant differences were observed between various genetic groups for sensory attributes of meat samples. Semen volume was significantly ($p \leq 0.01$) lower while sperm concentration was significantly ($p \leq 0.01$) higher in native chicken as compared to the improved chicken varieties. However, pH, mass activity, sperm motility, and livability did not differ significantly among genetic groups although Mizo-local had significantly higher abnormal sperm count. The study concluded that the genetic groups with different growth rate differed significantly for various egg quality parameters and semen characteristics but not for sensory attributes of meat and proximate composition of eggs.

Keywords Improved varieties · Native chicken · Egg and meat sensory attributes · Semen quality

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Introduction

Poultry production in developing countries, particularly in India, is a classical example for the paradox that sectoral growth of agriculture does not necessarily improve the livelihood of small and marginal farmers of rural and tribal regions. Poultry production in India has evolved from backyard poultry production to highly modernized and industrialized type of farming. The modernization and industrialization of poultry sector has almost untouched the rural and tribal areas, and in fact, the eggs and poultry meat requirement of these areas are mostly being met from a few big poultry farmers of industrialized areas. Hence, poultry production in these areas is still a free range low input and low output backyard farming in nature. Although this kind of poultry farming has various advantages such as self-sustaining and eco-friendly, farming and produce of such farming command better price as compared to modern poultry but it suffers from poor productivity due to low producing germplasm, lack of health coverage, lack of awareness about management of birds, etc. Recently, efforts are being made to improve the productivity of backyard poultry production in rural and tribal areas by replacing the native chickens with improved varieties exclusively developed for backyard farming such as Vanaraja and Gramapriya. Vanaraja is a dual purpose variety and Gramapriya is an egg type variety developed using exotic germplasm for backyard poultry production at Project Directorate on Poultry, Hyderabad, India. Before introducing improved varieties, a few native chicken types were collected and reared for future breeding purposes at the ICAR Research complex for northeastern hill region, Umiam, Meghalaya. The native chickens reared by Mising tribes of northeastern India are called Miri, which are small and compact, and they are known to have early sexual maturity as compared to other native breeds of India (Haunshi et al. 2009). Mizo-local chickens are being reared by Mizo tribes of Mizoram state of India; these birds are heavy built with relatively long shank length. Although there are reports on effect of genotype (Fanatico et al. 2007), system of rearing and feeding on sensory attributes of broiler chicken (Lawlor et al. 2003; Fanatico et al. 2006), but to our knowledge, the reports regarding sensory attributes of eggs and meat and semen quality characteristics of native chicken are scanty. Therefore, the present study was carried out to evaluate slow growing Miri and Mizo-local chickens native to the northeastern hill region of India and to compare them with the fast growing improved crossbred varieties developed for backyard poultry farming for sensory attributes of eggs and meat, egg qualities, proximate composition of eggs, and semen qualities under hill agroclimatic conditions of Meghalaya.

Materials and methods

Experimental animals

Straight run day old chicks of Miri (70) and Mizo-local (79) and improved varieties such as Vanaraja (106) and Gramapriya (62) were hatched and reared on deep litter system using sawdust as litter material with standard feeding, healthcare, and management practices in open sided house up to 18 weeks of age. Subsequently, they were transferred to individual cages and reared in cages till the experiment was completed. The study was conducted at Umiam, which is located at 91° 55’ E longitude and 25° 40’ N latitude in the state of Meghalaya. The study site is located at the height of 1,010 m above mean sea level which falls in high rainfall area and receives rain in the range from 2,239 to 2,953 mm annually. The chicks were provided with chick starter ration (2,800 Kcal/kg ME. and 20% CP on calculated basis) up to 8 weeks of age and grower ration (2,500 Kcal/kg ME and 16% CP on calculated basis) from 9 to 18 weeks of age and layer ration (2,600 Kcal/kg ME and 18% CP on calculated basis) from 19 weeks onwards. The diet in all three stages consists of maize, soybean meal, ground nut cake (solvent extracted), rice polish, fish meal, salt (500 g per 100 kg), and vitamin premix. The layer ration was supplemented with Oyster shell grit to make the calcium content to 3.0% of the ration. Male birds were provided with layer ration without shell grit.

Egg quality parameters

Egg quality parameters viz egg weight, shape index, whole egg, albumen and yolk volume, yolk to albumen ratio, percent albumen, and percent yolk volume were studied at 40 weeks of age. A total number of 30 eggs from each genetic group were used for the egg quality analysis. The weights of eggs were recorded by Mettlor and Toledo balance (nearest to 0.01 g accuracy). The volumes of various constituents of eggs were recorded in milliliters. Lengths and breadths of eggs were measured using Vernier calipers (least count 0.01 mm). Shape index was calculated as per the formula described by Schultz (1953).

Sensory evaluation of egg samples

For sensory evaluation, eggs laid on the same day from all genetic groups at the age of 40 weeks were selected randomly and kept at room temperature for 1 day. Subsequently, all eggs were hard boiled in same container for similar duration after marking them accordingly. The hard boiled eggs were peeled to remove the shells and shell membranes, and they were subjected to evaluation for sensory attributes like appearance, aroma, flavor, and overall acceptability. Nine-point hedonic scale (from extremely dislike to extremely like) was used to judge the sensory attributes. A total of 25 voluntary persons who consume eggs regularly were asked to judge various sensory attributes of whole eggs (divided in to two halves). The proximate principle analysis to estimate the moisture, crude protein, ether extract, and total ash content of six eggs from each genetic group was carried out as per the standard procedure of AOAC (1995).

Sensory evaluation of meat samples

Native and improved chickens were slaughtered at 15 weeks of age. The meat chunk from breast portion was taken randomly and cooked to internal temperature of 75°C for 2 min. Cooked meat samples were subjected for sensory evaluation using 9-point hedonic scale by a panel of 20 voluntary consumers for sensory attributes such as appearance, texture, flavor, juiciness, and overall acceptability.

Semen collection

Cocks from each genetic group were housed in individual cages, and they were allowed to acclimatize to the cage system of rearing for about 1 month. Semen was collected following standard practice of massage method (Lake et al. 1985). Cocks were trained three to four times by massaging the back and milking the cloaca before collecting semen samples. Total 36 ejaculates from each genetic group (six samples of semen from each cock) collected at an interval of 4 days were used for the study. The collection and examination of the semen was done by single investigator throughout the study to avoid investigator's biasness. Immediately after collection, tubes containing the ejaculated semen were placed in a water bath at 37°C, and the samples were evaluated for below mentioned various seminal parameters.

Semen evaluation

The volume of the semen ejaculate was assessed by drawing the collected sample in to 1 ml pipette with an accuracy of 0.05 ml and pH indicator strips (Merck) with a range from 5.0 to 7.5 were used to assess the pH immediately after collection. Mass activity was evaluated by gently spreading small drops of freshly collected semen on a warm slide with a glass rod (tip) and examined under low power (10×) of bright-field microscope and were graded from 1 to 5. Individual motility was recorded as percentage of progressively motile spermatozoa after the extension of semen. The neat semen was extended at 37°C with normal saline, and a drop of this diluted semen was kept on a clean, grease free, prewarmed glass slide, and cover slip was applied to examine under high power magnification (40×) of a phase contrast microscope (Olympus). The percentage of spermatozoa with normal, vigorous, and forward linear motion was subjectively assessed to the nearest 5% at five different areas of the sample on each slide. The concentration of spermatozoa (millions per milliliter) in the neat semen was determined by the hemocytometer method adopting the RBC counting procedure (Salisbury et al. 1985). Special attention was paid while diluting the sample with 1% buffered formal saline, and volume was cross-checked by diluting neat semen at 1:200 ratio with the help of micropipettes. Homogeneity of the semen sample was ensured by palm shaking the tube containing the semen sample and also at the time of charging the hemocytometer. The total spermatozoa per ejaculate were calculated by multiplying the concentration by the volume.

Livability and abnormal sperm

Percentage of live and dead spermatozoa was estimated by differential staining technique using eosin–nigrosin stain (Campbell et al. 1953). Briefly, a drop of fresh semen was placed on a clean warm glass slide and mixed with two drops of 5% eosin and five drops of 10% nigrosin. Smears were prepared from this mixture and dried in air. In each slide, 200 spermatozoa were examined under oil immersion (100×) microscope. Both fully and partially stained spermatozoa were counted as dead. These slides were also used for estimating the percent abnormal spermatozoa on the basis of observable abnormalities of head, neck, mid-piece, and tail region of the spermatozoa.

Statistical analysis

Means and standard errors of various parameters were calculated using standard statistical procedures as described by Snedecor and Cochran (1989). Test of significance for various traits between genetic groups was determined using one way analysis of variance using MS Excel package. Means of various traits were compared between four genetic groups by Duncan's multiple range test.

Results

The results of egg quality parameters, sensory evaluation, and proximate composition of eggs of native and improved chicken varieties are given in Table 1. There were significant differences between genetic groups for egg weight, egg volume, albumen volume, yolk volume, yolk to albumen ratio, and percent albumen and yolk volume recorded at 40 weeks of age. Egg weight, egg volume, and albumen volume were significantly ($p \leq 0.01$) higher in egg type improved variety (Gramapriya) followed by dual purpose variety (Vanaraja), Mizo-local, and Miri chickens. Yolk volume was significantly higher ($p \leq 0.01$) in improved varieties as compared to native chickens and again in improved variety, Vanaraja had significantly ($p \leq 0.01$) higher yolk volume as compared to Gramapriya. However, shape index parameter did not differ significantly between various genetic groups although eggs of improved varieties had numerically better shape index. There were significant differences among improved varieties for percent albumen and yolk volume and yolk to albumen ratio traits. Vanaraja had significantly ($p \leq 0.01$) higher percent yolk volume, lower percent albumen volume, and higher yolk to albumen ratio than those of Gramapriya variety. However, native chickens did not differ significantly for percent yolk and albumen volumes and yolk to albumen ratio.

No significant differences were observed between genetic groups for appearance of eggs. It was observed that consumer liking for aroma of Mizo-local, Miri, and Vanaraja eggs were significantly ($p \leq 0.01$) better than that of Gramapriya. Further, flavor and overall acceptability of Miri eggs were significantly ($p \leq 0.01$) better than that of

Table 1 Egg quality parameters of native and improved chicken varieties (mean ± SE)

S. number	Parameters	Slow growing native chickens		Fast growing improved chickens	
		Miri	Mizo-local	Gramapriya	Vanaraja
1	Egg weight (40 weeks; g)	38.68 ± 1.27^{a}	43.96 ± 0.61^{b}	58.65 ± 1.33^{c}	54.65 ± 0.84^{d}
2	Shape index	75.06 ± 0.66^{a}	75.23 ± 0.62^{a}	77.61 ± 0.60^{a}	75.72 ± 0.78^{a}
3	Egg volume (ml)	34.76 ± 0.75^{a}	38.76 ± 0.75^{b}	51.14 ± 1.06^{c}	48.5 ± 0.75^{d}
4	Albumen volume (ml)	22.12 ± 0.76^{a}	25.54 ± 0.56^{b}	35.14 ± 1.22^{c}	30.29 ± 0.65^{d}
5	Yolk volume (ml)	12.65 ± 0.31^{a}	13.22 ± 0.25^{a}	16.00 ± 0.42^{b}	18.50 ± 0.89^{c}
6	Percent albumen volume	63.39 ± 1.13^{ab}	65.86 ± 0.39^{ac}	68.47 ± 1.20^{c}	62.50 ± 1.19^{b}
7	Percent yolk volume	36.61 ± 1.13^{ab}	34.14 ± 0.39^{ac}	31.53 ± 1.20^{c}	37.49 ± 1.19^{b}
8	Yolk to albumen ratio	0.58 ± 0.03^{ab}	0.52 ± 0.01^{ac}	0.47 ± 0.027^{c}	0.62 ± 0.039^{b}
9	Shell color	Creamy white	Creamy white	Dark brown	Light brown
Sensory attributes of whole eggs					
1	Appearance	7.81 ± 0.26^{a}	7.23 ± 0.23^{a}	7.30 ± 0.15^{a}	7.30 ± 0.21^{a}
2	Aroma	7.12 ± 0.30^{a}	7.25 ± 0.33^{a}	5.92 ± 0.33^{b}	7.08 ± 0.27^{a}
3	Flavor	7.31 ± 0.22^{a}	7.00 ± 0.41^{ab}	6.17 ± 0.35^{b}	6.91 ± 0.25^{ab}
4	Overall acceptability	7.62 ± 0.24^{a}	7.00 ± 0.36^{ab}	6.46 ± 0.32^{b}	7.33 ± 0.21^{ab}
Proximate composition of whole eggs					
1	Moisture (%)	74.89 ± 0.35	75.75 ± 0.90	75.14 ± 1.10	74.42 ± 0.32
2	Crude protein (%)	11.06 ± 0.39	10.99 ± 0.57	12.09 ± 0.60	12.11 ± 0.14
3	Ether extract (%)	12.85 ± 0.34	12.06 ± 0.36	11.72 ± 0.54	11.96 ± 0.24
4	Total ash (%)	1.12 ± 0.08	1.14 ± 0.06	0.95 ± 0.06	1.10 ± 0.08

Means with different superscripts in a row differ significantly ($p \leq 0.01$)

Gramapriya eggs. On the other hand, no significant differences were observed between Miri, Mizo-local, and Vanaraja eggs for flavor and overall acceptability of eggs. Similarly, Gramapriya, Mizo-local, and Vanaraja varieties did not differ significantly for flavor and overall acceptability of eggs. However, proximate analysis of eggs revealed a nonsignificant difference between various genetic groups for moisture, crude protein, ether extract, and total ash content of eggs. Results of sensory evaluation of meat samples of native and improved chicken varieties are given in Table 2. No significant differences were observed between various genetic groups for appearance, flavor, texture, juiciness, and overall acceptability of meat.

Seminal parameters of native and improved chicken varieties are presented in Table 3. Semen volume was significantly ($p \leq 0.01$) higher in improved variety (Gramapriya) as compared to native chickens while sperm concentration was significantly ($p \leq 0.01$) higher in native chickens than those of improved varieties. However, semen pH, mass activity, individual motility, live, and dead sperm count and number of spermatozoa per ejaculate did not differ significantly between different genetic groups, although abnormal sperm count was significantly higher in Mizo-local chicken.

Discussion

Egg quality parameters

The egg quality traits are known to be influenced by genetics, age, feeding, management, and environmental factors. In the present study, we have observed that egg weight, egg volume, albumen, and yolk volume were significantly higher in

Table 2 Sensory attributes of meat samples of native and improved chicken varieties (mean ± SE)

Genetic group	Appearance	Flavor	Juiciness	Texture	Tenderness	Overall acceptability
Miri	7.11 ± 0.27	6.89 ± 0.25	6.21 ± 0.43	6.21 ± 0.37	6.00 ± 0.39	6.84 ± 0.29
Mizo-local	6.84 ± 0.32	6.42 ± 0.29	6.58 ± 0.36	6.89 ± 0.31	7.16 ± 0.31	6.74 ± 0.36
Gramapriya	7.32 ± 0.22	6.79 ± 0.30	6.32 ± 0.31	6.89 ± 0.33	6.79 ± 0.34	7.21 ± 0.31
Vanaraja	7.26 ± 0.17	6.89 ± 0.25	6.42 ± 0.38	7.21 ± 0.22	7.11 ± 0.30	7.11 ± 0.2

Table 3 Semen qualities of native and improved chicken varieties (mean ± SE)

S. number	Semen characteristics	Miri	Mizo-local	Gramapriya	Vanaraja
1	Volume of semen (ml)	0.198 ± 0.025[a]	0.245 ± 0.028[ac]	0.347 ± 0.028[b]	0.297 ± 0.044[bc]
2	pH of semen	7.06 ± 0.07[a]	6.99 ± 0.06[a]	6.90 ± 0.061[a]	7.18 ± 0.091[a]
3	Mass activity (graded 0 to 5)	1.64 ± 0.21[a]	1.50 ± 0.23[a]	2.09 ± 0.196[a]	2.13 ± 0.23[a]
4	Individual motility (%)	57.95 ± 5.47[a]	48.50 ± 5.14[a]	45.22 ± 5.19[a]	52.36 ± 6.05[a]
5	Live sperms (%)	76.87 ± 3.79[a]	74.09 ± 4.28[a]	75.38 ± 4.22[a]	74.76 ± 5.54[a]
6	Dead sperms (%)	20.68 ± 3.08[a]	26.05 ± 4.25[a]	24.29 ± 4.13[a]	24.94 ± 5.53[a]
7	Abnormal sperms (%)	1.78± 0.37[a]	3.50± 0.64[b]	2.30± 0.44[ab]	1.29± 0.40[a]
8	Sperm concentration (millions/ml)	3,091.67± 391.57[a]	2,711.54± 192.42[a]	1,719.17± 206.60[b]	1,649.17± 184.95[b]
9	Number of spermatozoa/ejaculate (millions)	427.05± 54.41[a]	545.48± 105.63[a]	503.47± 80.87[a]	421.57± 64.52[a]

Means with different superscripts in a row differ significantly ($p \leq 0.01$)

improved varieties as compared to native chicken. Improved varieties are fast growing birds developed for backyard farming, and they are significantly superior to native chickens for the body weight trait (Haunshi et al. 2009). Therefore, egg weight, egg volume, albumen, and yolk volume were significantly higher in improved varieties as compared to those of native chickens in absolute terms. Further, native chickens are known to produce eggs of smaller size, and hence, their constituents were significantly lower than those of improved varieties. Yolk volume was significantly higher in Vanaraja as compared to the Gramapriya, Mizo-local, and Miri chicken, while there were no differences among native chickens for yolk volume although albumen volume was significantly higher in Mizo-local as compared to Miri chicken. However, percent albumen volume was significantly higher in Gramapriya followed by Mizo-local, Miri, and Vanaraja. Similarly, percent yolk volume was significantly lower in Gramapriya as compared to Vanaraja and Miri chicken. It was established that smaller the size of eggs higher will be the proportion of yolk and smaller will be the proportion of albumen (Tharrington et al. 1999). The interesting observation made in this study was that although the egg size of Vanaraja variety was significantly higher than those of native chickens, the proportion of yolk of Vanaraja eggs was significantly higher or similar to that of native chickens. Therefore, yolk to albumen ratio was significantly higher in Vanaraja as compared to Gramapriya and Mizo-local chicken.

Sensory attributes of eggs

Traditionally, there is a common perception among local people that eggs and meat of native chicken taste better and nutritionally superior as compared to those of exotic chicken such as eggs of white leghorn and meat of broiler chicken. Hence, meat and eggs of native chicken fetch almost the double price as compared to those of exotic chickens. Further, there is a higher demand for brown shelled eggs as compared to white shelled eggs. Improved varieties which are look-alike to native chickens are being introduced to improve the productivity of backyard farming in the region. So it is very important that meat and egg qualities of native chickens are to be retained in the improved varieties in order to maintain the price advantage of native chickens in improved varieties. In the present study, no clear cut trend was observed between native chickens and improved varieties as far as sensory attributes of eggs are concerned, although the appearance of eggs was the same across genetic groups. The fact that eggs of Gramapriya (egg type improved variety) received poor response because of its typical aroma vis a vis eggs of other varieties was somewhat unexpected. The egg type improved variety differed with the Miri native chicken in flavor and overall acceptability of eggs and it scored least for its aroma among all genetic groups. However, to our knowledge, reports to compare the results of the present study for the effect of genotype particularly of native chicken on sensory attributes of egg are scanty in literature. So eggs of dual purpose improved variety (Vanaraja) may have market value similar to that of eggs of native chicken because of similar aroma, flavor, and overall acceptability, perhaps eggs of this variety may fetch better than that of local chickens due its bigger size and brown colored shells.

Proximate composition of eggs

Species difference for composition of eggs of poultry has been very well established. However, breed or strain differences for proximate composition of eggs was not available in the literature. Proximate analysis of eggs revealed that there were no significant differences between various genetic groups for moisture, crude protein, ether extract, and total ash content of eggs. However, values were within normal range and were in concordance with the findings of Bharti et al. (2000) for proximate composition of white leghorn chicken eggs.

Sensory evaluation of meat samples

Earlier studies established that sensory attributes of poultry meat were affected by genotype, age of the bird, feeding, rearing practices, etc. In the present study, we did not observe statistical difference between various genetic groups for appearance, flavor, texture, juiciness, and overall acceptability. Since no replications were made in the sensory experiment, the differences among genetic groups for sensory attributes of meat if at all detected would not have been tested statistically. However, overall acceptability of meat of native chicken was numerically better than those of improved varieties. Fanatico et al. (2006) observed that there was significant effect of genotype on tenderness of meat of slow, medium and fast growing broilers raised for 81, 67, or 53 days, respectively. Therefore, effect of age might have affected the texture and tenderness of broiler meat rather than genotype per se since age of birds play important rule in texture, tenderness, and juiciness of meat. Results of another study by Fanatico, et al. (2007) revealed that consumer panel did find no significant difference in overall liking, appearance, texture, or flavor of the breast meat or thigh meat of slow and fast growing birds, although trained descriptive panel could find meat of the slow growing birds of more dark meat fat flavor than that of the fast growing birds. Further, Castellini, et al. (2008) concluded that genetics and age at slaughter play major role in sensory attributes of the meat. However, they observed that the sensory perception is affected by various factors including the type of people (trained or untrained) and their dietary habit. So, in the present study, consumer panel could not find any significant difference in sensory characters of meat of slow and fast growing birds.

Semen quality parameters

Semen volume was significantly higher in Gramapriya birds followed by Vanaraja, Mizo-local, and Miri birds. Semen volumes of native chickens observed in this study were comparable to those of Nigerian local chickens (Abu et al. 2006) and naked neck, frizzle, and normal feathered local chickens of Nigeria (Nwachukwu et al. 2006). The significant difference observed in semen volume and sperm concentration between native and improved chicken varieties is mainly due to the fact that the native chickens are small in size and improved varieties are higher in body weight as there is a positive correlation between body size and volume of semen while there is negative correlation between body size and concentration of spermatozoa. Similar observation was made by Peters et al. (2008) in Nigerian native chicken and exotic chicken strains. However, there was no significant difference within native and improved varieties for semen volume and sperm concentration. Nevertheless, number of spermatozoa per ejaculate did not differ significantly between native and improved varieties. Our results of sperm motility were in agreement with those reported by Churchil et al. (2007) for average sperm motility of IWN (45.63) and IWP (56.86) strains of white leghorn. The individual motility of sperms were comparable with the those reported for Nigerian local chickens by Abu et al. (2006), however, live sperms, sperm concentration per milliliter of native chickens, recorded were higher than those reported by Abu et al. (2006) in Nigerian local cocks.

There were no significant differences between different genetic groups for pH, mass activity, individual motility, live, dead, and abnormal sperm count. The semen pH observed in the present study is in agreement with those reported Peters et al. (2008) who did not see significant effect of strain on pH of semen. The percentage of abnormal spermatozoa was lowest in Vanaraja followed by Miri, Gramapriya, and Mizo-local chicken. Higher percentage of dead spermatozoa observed in this study was comparable to the ones reported by Abu et al. (2006) in Nigerian local cocks. The higher percentage of dead spermatozoa observed might have been due to housing of birds in cages which were otherwise accustomed to free range or deep litter system of rearing and that might have resulted in the stress to the birds and hence affected the live sperm count.

The study concluded that slow growing native and rapid growing improved/exotic varieties did not differ in proximate composition and appearance of eggs and sensory attributes of meat except for egg weight, egg volume, albumen volume and yolk volume, percent albumen and yolk volume, aroma, flavor, and overall acceptability of eggs. Slow growing and fast growing varieties did differ in sperm concentration and semen volume but the number of spermatozoa per ejaculate remained the same in both groups.

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