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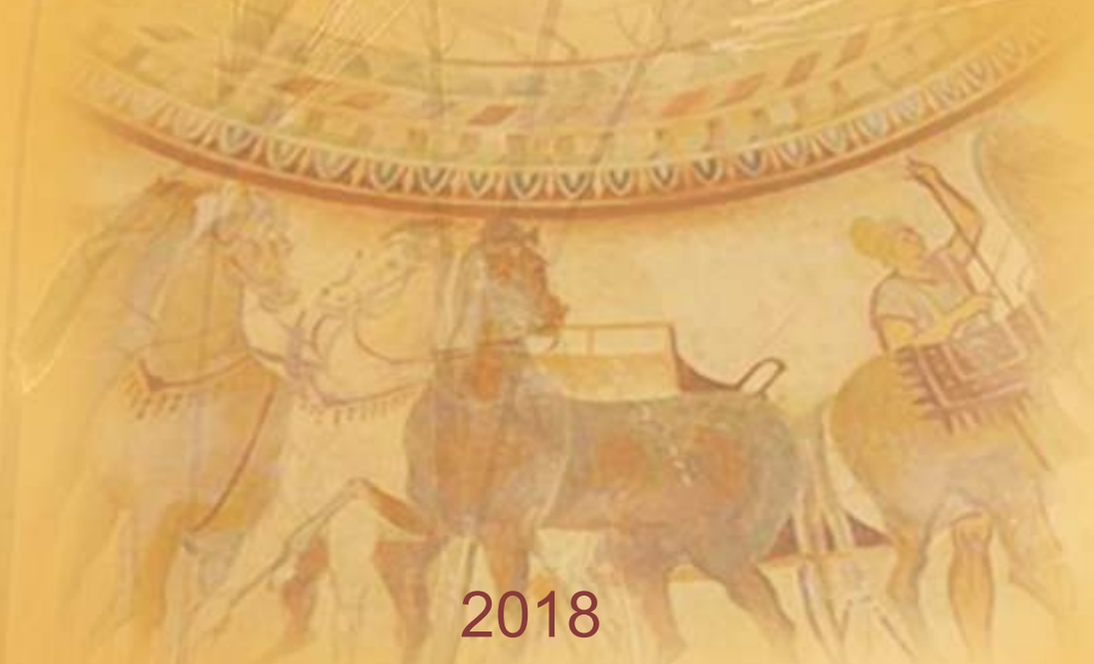

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Nutrition and Physiology

Effect of pawpaw (*Carica papaya*) leaf meal on productive parameters of growing rabbits

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Abstract. *A 56-day feeding trial was conducted to investigate the productive performance, carcass yield and organ characteristics of growing rabbits fed diets containing pawpaw leaf meal (PLM). A total of forty-eight (48) growing rabbits with an average body weight range of 477.01g were randomly divided into four experimental groups of twelve animals each, with four rabbits constituting a replicate. Four experimental diets were formulated and designated as T_1, T_2, T_3 and $T_4$to contain PLM at 0%, 15%, 30% and 45%, respectively. The four treatment groups were assigned the four diets in a Completely Randomized Design (CRD). Each rabbit received an assigned diet for 56 days. The determined chemical composition of the experimental diets ranges from 90.46-92.91% dry matter (DM), 16.70-17.44% crude protein (CP), 15.40-16.45% crude fibre (CF), 3.29-8.09% ash, 2.30-3.11% ether extract (EE), 49.34-52.89% nitrogen free extract (NFE) and 2550.05-2604.10 Kcal/kg metabolisable energy (ME). The proximate analysis of the PLM revealed 87.67% DM, 17.30% CP, 12.86% CF, 8.88% ash, 0.81% EE 47.82% NFE and 2348.05 Kcal/kg ME. The results on productive performance showed significant ($p<0.05$) improvement with the inclusion of PLM in the diets for final body weight, daily weight gain, total feed intake and daily feed intake. Similarly, the live weight at slaughter, dressing percentage, loin, back cut and gastro intestinal weight (GIT) were significantly ($p<0.05$) better and higher for the treatment groups in comparison with the control. It was concluded therefore that PLM is rich in essential nutrients and therefore suitable for inclusion in rabbit ration up to 45% for improved live weight, weight gain, feed intake and carcass and organ yields.*

Keywords: rabbits, pawpaw leaves, feed intake, body weight, carcass and organ parameters

Introduction

Rabbit is a pseudo-ruminant which utilizes fibre better than the other monogastric animals (pig and poultry) due to its enlarged caecum which enables a unique type of digestion known as ceacotrophy or coprophagy (bacteria digestion). This may further explain why rabbits can survive on a variety of forage and convert them rapidly into useful animal protein. Meat from rabbit is tender, highly nutritious, easily digestible, and extremely low in cholesterol and sodium, hence suitable for people with various health conditions. Rabbits are highly prolific animals capable of increasing the animal protein intake in developed and developing countries. Their reputation for fast growth, short gestation period, early maturity, easy management, remarkable capacity to convert roughages into meat, low cost of production (Jiwuba et al., 2016), high dressing percentage, ability to adapt to a wide range of climatic conditions, high meat quality and their small body sizes make them vital as they are seen as the future of food security in Nigeria. However, the production of rabbit could be further enhanced by the incorporation of feedstuffs with reported phytogenic properties like Pawpaw leaf meal.

Pawpaw (*Carica papaya*), belongs to the family *Caricaceae* and is of Central and South America origin, but is highly cultivated in the tropics and sub-tropics. Pawpaw is a herbaceous plant that bears highly nutritious and delicious fruits, and also serves as a major source of papain, a protease used effectively as a natural digestive aid which breaks down protein, cleanses the digestive tract and can be used to soften meat. The leaves are high in antioxidants; vitamins - C, A and E; B vitamin pantothenic acid and folate; magnesium, potassium and fiber. The relatively high fiber content makes it a suitable feedstuff for rabbits and helps to lower the cholesterol level in humans and animals. The fruit is an excellent source of beta carotene that prevent damages caused by free radicals that may cause cancer in humans or animals (Aravind et al., 2013). Earlier reports by Onyimonyi and Onu (2009), and Ogbuokiri et al. (2014) indicated that incorporation of pawpaw leaf meal (PLM) in the diet of finishing and starter broilers improved performance, feed intake, weight gain, feed conversion ratio (FCR), carcass and organoleptic indices, respectively. Saulawa et al. (2015) reported no effect on feed intake, FCR, dressing percentage and carcass indices of weaner rabbits fed diets supplemented with Pawpaw leaf meal. This study was therefore designed to determine the effects of feeding Pawpaw leaf meal on the productive performance, carcass yield and organ characteristics of growing rabbits.

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Material and methods

Location of experiment: The experiment was carried out at the Rabbit Unit, Federal College of Agriculture, Ishiagu, Ebonyi state, Nigeria. The College is located at about three kilometers (3km) away from Ishiagu main town. The College is situated at latitude 5.56°N and longitude 7.31°E, with an average rainfall of 1653mm and a prevailing temperature condition of 28.5°C and relative humidity of about 80% (Jiwuba et al., 2016).

Sources and processing of experimental material: Fresh leaves

of Pawpaw were harvested within the College environment and air dried for some days to a moisture content of about 10%. The air dried leaves were processed and milled using hammer mill. Other feed ingredients were procured from Farm associate, Enugu, Enugu State, Nigeria.

Experimental animals and management: Forty-eight growing rabbits weighing 477.01 g on average were randomly divided into four experimental groups of 12 animals each, with four rabbits constituting a replicate. Each rabbit was housed in a standard hutch measuring 120 by 150cm and raised 120cm above the ground level. The four treatment groups were assigned the four diets in a Completely Randomized Design (CRD). Each rabbit received an assigned diet for 56 days. Each animal was vaccinated against prevalent diseases. They were also dewormed using kepromec (Ivermectin) at the rate of 0.1ml per rabbit subcutaneously and given accaricide bath using Roys' Amitraz 20 at the rate of 1ml in 2 liters water prior to the experiment.

Experimental diet: Four (4) experimental diets were tested: T_1, T_2, T_3 and T_4 with the addition of Pawpaw leaf meal (PLM) - 0%, 15%, 30% and 45%, respectively (Table 1). Diet T_1 did not contain PLM thereby serving as the control diet.

Table 1. Composition of the experimental diets

Ingredient	Diets			
	T1 (0%)*	T2 (15%)	T3 (30%)	T4 (45%)
Maize	43.00	42.00	40.00	38.00
Wheat offal	13.00	9.00	5.00	00.00
Palm kernel cake	21.00	13.00	6.00	00.00
Fish meal	1.00	1.00	1.00	1.00
Soya bean meal	18.00	16.00	14.00	12.00
Pawpaw leaf meal	0.00	15.00	30.00	45.00
Bone meal	2.00	2.00	2.00	2.00
Lime stone	1.00	1.00	1.00	1.00
Premix	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Total	100	100	100	100

* % of pawpaw leaf meal added

Data collection: Data were collected daily for feed intake and weekly for weight gain using weighing scale of 30kg capacity and 0.001kg sensitivity. The feed intake of each rabbit was determined by the difference between the feed supplied and the left over in the feeding trough the next day. While body weight changes were measured on a weekly basis and the difference between initial and final weight of the rabbits constituted the live body weight gain. Feed conversion ratio was calculated.

At the end of the feeding trial, three rabbits were randomly selected from each treatment based on the average group weight for carcass analysis. After that, the animals were slaughtered subject to the welfare requirements during slaughter (Broom, 2017). The internal organs (heart, lungs, kidney, GIT and liver) were carefully removed from the bodies and weighed. The dressed carcass and cut parts were also weighed and recorded.

The dressed weight and dressing percentage were calculated as follows:

Dressed weight = Live Weight - Offal weight

where,

Offal weight = Gastro intestinal weight (GIT) + Internal organs weight,

Dressing Percentage (DP) % = (Dressed weight/Live weight) x 100.

Chemical analysis: All feeds and experimental material (PLM) were analyzed for proximate compositions using the method of AOAC (2000) and metabolizable energy (ME) calculated using the formula: ME = (3.5 x Crude protein) + (8.5 x Crude fat) + (3.5 x Nitrogen Free Extract) x 10.

Data Analysis: The results were analyzed using the Statistical Package for Social Science Window 17.0. One-way analysis of variance (ANOVA) was employed to determine the means and standard error. Significant differences between the treatment means were separated using the Duncan Multiple New Range Test (Duncan, 1955).

Results and discussion

Proximate compositions

The results of the proximate analysis of experimental diets and PLM are shown in Table 2. The dry matter range of 90.46–92.91% in this study compared well with the range of 90.95–93.29% reported by Jiwuba et al. (2016) for weaner rabbits. The crude protein values in this study ranged between 16.70 and 17.66%, which falls within the requirement for growing rabbits (16% CP) as recommended by NRC (1977) and Lebas (2013) and 16-18% as recommended by Fielding (1991). The crude fiber range of 15.40-16.45% reported in this study which did not follow a particular trend with increasing or decreasing levels of PLM in the diets is in comparison with the recommended values of 14-18% and 14-16% reported by Mayer (1955) and Gidenne and Lebas (2002) for growing rabbits. Adequate supply of dietary fiber reduces digestive problems, promotes intestinal motility and enhances growth in weaned rabbits. Hence, diets low in fiber promote an increased incidence of intestinal

problems, like enterotoxaemia and lower growth rates (Mayer, 1955; Gidenne and Jehl, 1999). The energy values found also failed to follow a particular trend. The reported range of 2550.05-2604.10 kcal/kg is in agreement with the recommended values of 2500.00 kcal/kg, 2400-2800 kcal/kg and 2500-2800 kcal/kg as recommended by NRC (1977), Aduku and Olukosi (1990) and Pond et al. (1995), respectively, for growing rabbits. Rabbits, however, adjust their feed intake as a function of their dietary energy concentration. The ash values of 3.29–8.09% followed a particular pattern increasing with increasing levels of PLM; hence indicating that the mineral requirements of the rabbits were met, since ash is a reflection of the mineral content of the diet. The highest value of ash observed in T_4 may be attributed to high levels of minerals which abound in pawpaw leaves. It is worthy to note that the values for the control diet compared favourably well with the treatment groups. The results of the proximate analysis of the PLM revealed 87.67% DM, 17.30% CP, 12.86% CF, 8.88% ash, 0.81% ether extract (EE), 47.82% NFE and 2348.05 kcal/kg metabolisable energy.

Table 2. Proximate composition of the experimental diets and pawpaw leaf meal

Parameters	Diets				PLM
	T1 (0%)*	T2 (15%)	T3 (30%)	T4 (45%)	
Dry matter	92.12	90.82	90.46	92.91	87.67
Crude protein	17.44	16.70	16.84	16.70	17.30
Crude fiber	16.20	16.45	15.75	15.40	12.86
Ash	3.29	4.41	5.78	8.09	8.88
Ether extracts	2.30	3.11	2.75	2.65	0.81
Nitrogen free extract	52.89	50.15	49.34	50.07	47.82
Metabolizable energy (kcal/kg)	2587.05	2604.10	2550.05	2562.20	2348.05

* % of pawpaw leaf meal added

Productive performance

The productive performance of growing rabbits was significantly improved with increasing levels of PLM in the diets (Table 3). Rabbits fed diet containing 30% PLM (T_3) recorded significantly ($P<0.05$) higher daily weight gain (24.46g/day) in comparison with 19.02, 21.16 and 22.32g/day for T_1, T_2 and T_4, respectively. Final body weight and total weight gain followed a similar pattern with the daily weight gain. The diets containing PLM showed ($p<0.05$) an improved and better body weight gain when compared to the control group. The enhanced body weight changes may be attributed to the PLM. Pawpaw leave is high in papain, chymopapain, vitamins and other biologically active compounds (Battaa et al., 2015; Nath and Dutta, 2016) which may have enhanced digestion and nutrient utilization, which are essential for growth in rabbits. PLM have also been reported (Aravind et al., 2013) to contain some natural substances that can promote health and alleviate illness, thus resulting in positive effect on productive performances of the rabbits. Total feed intake and daily feed intake were significantly ($P<0.05$) increased in T_2, T_3 and T_4 as compared to control group (T_1). This may be attributed to the flavour (aroma), taste and palatability of the treatment diets conferred by the PLM. Pawpaw leaf meal may have been shown to increase feed palatability which in turn increased feed intake. This is in agreement with earlier report by Schlolant (1983) who opined that the quantity of feed consumed is largely dependent on the palatability of the diet. The feed conversion ratio (FCR) was statistically ($p>0.05$) similar across the treatment groups. Numerically, T_3 recorded the best FCR which is a reflection of the best performance recorded in this treatment group.

Table 3. Productive performance of growing rabbits fed diet containing pawpaw leaf meal

Parameters	Diets				SEM
	T1 (0%)*	T2 (15%)	T3 (30%)	T4 (45%)	
Initial body weight (g)	470.78	465.84	480.91	490.50	33.21
Final body weight (g)	1535.94^{c}	1650.80^{b}	1850.7^{a}	1740.58^{ab}	64.09
Total weight gain (g)	1065.16	1184.96	1369.80	1250.08	62.35
Daily weight gain (g/day)	19.02^{c}	21.16^{b}	24.46^{a}	22.32^{ab}	1.73
Total feed intake (g)	8140.66^{b}	8790.00^{a}	8995.83^{a}	8735.79^{a}	81.55
Daily feed intake (g/day)	145.37^{b}	156.96^{ab}	160.64^{a}	156.00^{ab}	12.62
Feed conversion ratio	7.64	7.42	6.57	6.99	0.75

* % of pawpaw leaf meal added
** $^{a-c}$ means within a row with different superscripts are significantly different ($P<0.05$)

Carcass characteristics

The results of the carcass yield of rabbits fed diets containing pawpaw leaf meal are shown in Table 4. The live weight at slaughter, dressing percentage, loin weight and back cut were significantly ($p<0.05$) different across the groups. Hind limb, fore limb, thoracic cage, head and pelt were not significantly ($P>0.05$) influenced. The

dressing percentage (DP) reported in this study ranged between 66.28 and 75.60% with the highest in T_3 (75.60%) and the lowest in T_1 (66.28%). The result obtained is in agreement with Fernandez and Fraga (1996), who reported that high slaughter weights will result in improvement in the entire desirable carcass characteristics measured and increased fat deposits. The highest (P<0.05) value of live weight at slaughter, dressing percentage, loin and back for rabbits fed with diets containing PLM is attributed to increase in the growth rate. In earlier reports by Lebas and Laplace (1991), they noted that variation in nutritional status and requirement of growing rabbits modify the anatomical equilibrium of the carcass, composition of carcass tissues and components of the muscle. The dressing percentages (66.28- 75.60%) is higher than the ranges of 50.03-58.51% and 52.05 - 53.36% found by Sobayo et al. (2008) and Olafadehan (2011), respectively. The differences in the results could be attributed to disparity in the nutrition, live weights, health status, age and breeds of the experimental rabbits and also location and environmental area. Loin is one of the most economically important portions of the carcass because it provides one of the greatest potions of edible meat. The lower value of loin weight recorded for rabbits fed the control diet may be attributed to the absence of PLM in the diet. However, the higher significant (p<0.05) values observed for the loin and back cut weights for T_2, T_3 and T_4 when compared with the control group (T_1) may be attributed to the presence of PLM, which may have supported the growth of this cut parts in the rabbits.

Table 4. Carcass yield of growing rabbits fed diets containing pawpaw leaf meal

Parameters	Diets				SEM
	T1 (0%)*	T2 (15%)	T3 (30%)	T4 (45%)	
Live weight at slaughter (g)	1405.07^{c}	1411.41^{b}	1663.92^{a}	1524.69^{ab}	58.27
Dressed weight (g)	931.26	1021.72	1264.48	1113.13	85.24
Dressing (%)	66.28^{c}	72.39^{b}	75.60^{a}	73.01^{b}	0.37
Hind Limb (%)	15.07	16.70	18.87	16.78	0.73
Fore Limb (%)	9.19	9.31	9.59	9.23	0.39
Thorax (%)	10.67	9.34	10.47	9.92	0.41
Loin (%)	5.69^{b}	6.21^{ab}	7.05^{a}	6.23^{ab}	0.23
Back (%)	14.62^{c}	16.75^{b}	18.60^{a}	17.30^{ab}	0.49
Head (%)	11.08	11.53	11.04	10.00	0.47
Pelt (%)	8.82	8.52	8.96	8.97	0.37

* % of pawpaw leaf meal added
** a-c means within a row with different superscripts are significantly different (P<0.05)

Table 5. Organ characteristics of growing rabbits fed diets containing pawpaw leaf meal

Parameters	Diets				SEM
	T1 (0%)*	T2 (15%)	T3 (30%)	T4 (45%)	
Liver (%)	2.89	3.15	3.01	3.07	0.08
Heart (%)	0.33	0.34	0.34	0.31	0.01
Kidney (%)	0.80	0.78	0.53	0.82	0.03
Lungs (%)	0.51	0.63	0.63	0.53	0.02
GIT (%)	15.90^{c}	15.20^{c}	20.17^{a}	17.74^{b}	0.50

* % of pawpaw leaf meal added
** a-c means within a row with different superscripts are significantly (P<0.05) different

Organ yields

The weights of the internal organs (Table 5) apart from GIT, showed no significant (p>0.05) difference across the groups. The non-significant (p>0.05) difference established for the liver, heart, kidney and lungs is an indication that the physiological and anatomical functions of these organs were not influenced by the experimental diets. This further indicated that the PLM may not have anti-nutritive factors at the levels that may hamper the normal physiological and anatomical functions of the organs of the rabbits. Furthermore, the lower numerical values of the kidney weights of rabbits fed the treatment diets imply the safety of PLM to the health of the rabbits. However, the digestive tract weight (GIT) of rabbits fed T_3 and T_4 diets were significantly (p<0.05) higher to those fed T_1 and T_2 diets. This may suggest that, addition of PLM at levels 30-45% may enhance feed utilization of rabbits by increasing the absorptive area of the small intestine in an action most likely to that of bacterial probiotics.

Conclusion

The results showed that pawpaw leaf meal could best be included in the diets of growing rabbits at 30% dietary level. Inclusion at 30% produced the best performance in all the parameters evaluated without deleterious effect on weight gain, feed intake and

carcass yield, and organ characteristics. This may be attributed to presence of biological compounds which abound in pawpaw leaf meal.

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Instruction for authors

Preparation of papers

Papers shall be submitted at the editorial office typed on standard typing pages (A4, 30 lines per page, 62 characters per line). The editors recommend up to 15 pages for full research paper (including abstract references, tables, figures and other appendices)

The manuscript should be structured as follows: Title, Names of authors and affiliation address, Abstract, List of keywords, Introduction, Material and methods,Results, Discussion, Conclusion, Acknowledgements (if any), References, Tables, Figures.

The title needs to be as concise and informative about the nature of research. It should be written with small letter /bold, 14/ without any abbreviations.

Names and affiliation of authors The names of the authors should be presented from the initials of first names followed by the family names. The complete address and name of the institution should be stated next. The affiliation of authors are designated by different signs. For the author who is going to be corresponding by the editorial board and readers, an E-mail address and telephone number should be presented as footnote on the first page. Corresponding author is indicated with *.

Abstract should be not more than 350 words. It should be clearly stated what new findings have been made in the course of research. Abbreviations and references to authors are inadmissible in the summary. It should be understandable without having read the paper and should be in one paragraph.

Keywords: Up to maximum of 5 keywords should be selected not repeating the title but giving the essence of study.

The introduction must answer the following questions: What is known and what is new on the studied issue? What necessitated the research problem, described in the paper? What is your hypothesis and goal ?

Material and methods: The objects of research, organization of experiments, chemical analyses, statistical and other methods and conditions applied for the experiments should be described in detail. A criterion of sufficient information is to be possible for others to repeat the experiment in order to verify results.

Results are presented in understandable tables and figures, accompanied by the statistical parameters needed for the evaluation. Data from tables and figures should not be repeated in the text. **Tables** should be as simple and as few as possible. Each table should have its own explanatory title and to be typed on a separate page. They should be outside the main body of the text and an indication should be given where it should be inserted.

Figures should be sharp with good contrast and rendition. Graphic materials should be preferred. Photographs to be appropriate for printing. Illustrations are supplied in colour as an exception after special agreement with the editorial board and possible payment of extra costs. The figures are to be each in a single file and their location should be given within the text.

Discussion: The objective of this section is to indicate the scientific significance of the study. By comparing the results and conclusions of other scientists the contribution of the study for expanding or modifying existing knowledge is pointed out clearly and convincingly to the reader.

Conclusion: The most important consequences for the science and practice resulting from the conducted research should be summarized in a few sentences. The conclusions shouldn't be numbered and no new paragraphs be used. Contributions are the core of conclusions.

References:

In the text, references should be cited as follows: single author: Sandberg (2002); two authors: Andersson and Georges (2004); more than two authors: Andersson et al.(2003). When several references are cited simultaneously, they should be ranked by chronological order e.g.: (Sandberg, 2002; Andersson et al., 2003; Andersson and Georges, 2004).

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The following order in the reference list is recommended:

Journal articles: Author(s) surname and initials, year. Title. Full title of the journal, volume, pages. Example:

Simm G, Lewis RM, Grundy B and Dingwall WS, 2002. Responses to selection for lean growth in sheep. Animal Science, 74, 39-50

Books: Author(s) surname and initials, year. Title. Edition, name of publisher, place of publication. Example:

Oldenbroek JK, 1999. Genebanks and the conservation of farm animal genetic resources, Second edition. DLO Institute for Animal Science and Health, Netherlands.

Book chapter or conference proceedings: Author(s) surname and initials, year. Title. In: Title of the book or of the proceedings followed by the editor(s), volume, pages. Name of publisher, place of publication. Example:

Mauff G, Pulverer G, Operkuch W, Hummel K and Hidden C, 1995. C3-variants and diverse phenotypes of unconverted and converted C3. In: Provides of the Biological Fluids (ed. H. Peters), vol. 22, 143-165, Pergamon Press. Oxford, UK.

Todorov N and Mitev J, 1995. Effect of level of feeding during dry period, and body condition score on reproductive performance in dairy cows,IXth International Conference on Production Diseases in Farm Animals, September 11–14, Berlin, Germany.

Thesis:

Hristova D, 2013. Investigation on genetic diversity in local sheep breeds using DNA markers. Thesis for PhD, Trakia University, Stara Zagora, Bulgaria, (Bg).

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Animal welfare

Studies performed on experimental animals should be carried out according to internationally recognized guidelines for animal welfare. That should be clearly described in the respective section “Material and methods”.

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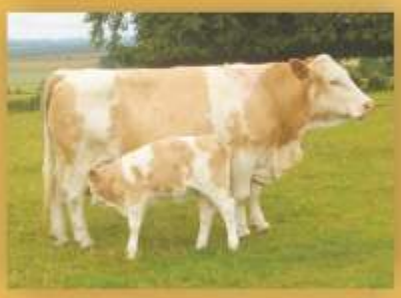

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