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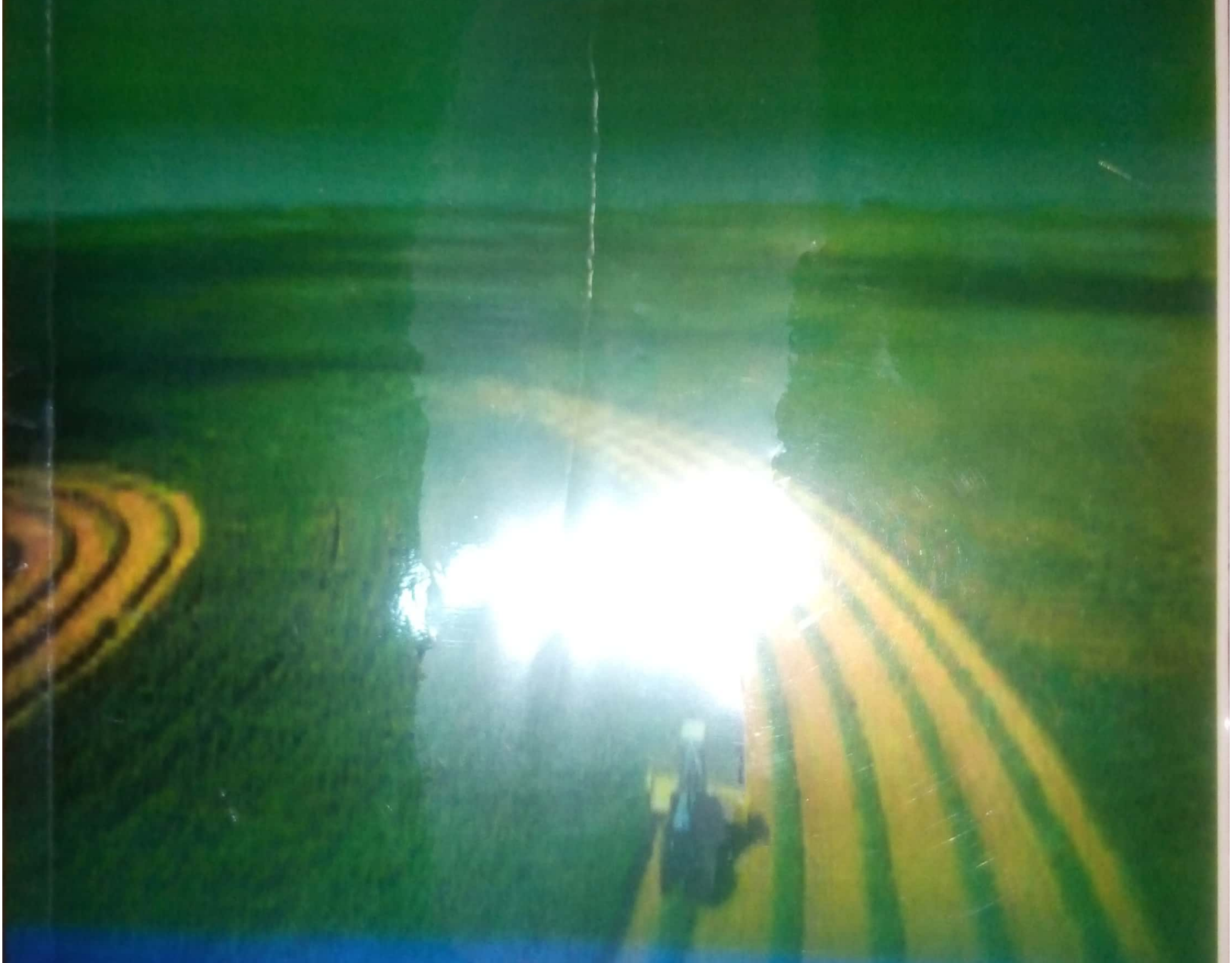

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THE INFLUENCE OF GRADED LEVELS OF *Rhizopus oligosporus* TREATED RICE HUSK ON THE MILK QUALITY AND MILK YIELD OF WEST AFRICAN DWARF GOATS

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ABSTRACT
Thirty two apparently healthy weaned West African Dwarf (WAD) does were fed diets containing graded levels of *Rhizopus oligosporus*-Treated Rice Husk (*RoTRH*) in a Complete Randomized Design (CRD) for a period of ten weeks to evaluate the effects of the experimental diets on the milk quality and milk yield of the animals. The encouraging positive results suggest that *RoTRH* can serve as a very valuable alternative and cheap feed ingredient for feed production. It was concluded from this study that *RoTRH* is a valuable feedstuff for dairy nutrition as its inclusion in the diets of goats served as an effective means of reducing the level of dependence on and competition for conventional feedstuffs between man and livestock.
Keywords: Milk composition, milk yield, nutrient intake, *Rhizopus oligosporus*

INTRODUCTION
Goats have been reported by Mirazaei 2011 as being among the smallest domesticated ruminants and have served mankind longer than cattle or sheep. The goat (*Capra aegagrus*) is a very important source of milk which under good management and improved genetic potential for milk yield and composition is capable of yielding high quantities of qualitative milk at a more profitable cost when compared to the dairy cow especially in the tropical regions like Nigeria. Malau-Aduli et al 2001 have reported goats to be a more efficient milk producer than cattle, sheep and buffaloes based on live weight. According to Ozung et al 2011, goats produce more milk compared to cows and other ruminants, because of better feed utilization efficiency, higher lactation persistency, mammary tissue comprising of greater proportion of the body weight and a more pronounced milk ejection reflex. In Nigeria, the West African Dwarf goats are kept by smallholder farmers mainly for meat production since these goats are well known for multiple births with twins and triplets. These goats according to Tona et al 2015 have low genetic potential for milk production and hence a low milk

offtake which has been attributed to the small body size and thus making milk obtained from them usually used for household consumption.

According to Ademosun 1992, inadequate nutrition is of major concern among other constraints responsible for the setbacks in the development of dairy goats in Nigeria. Maize and other conventional feed ingredients are both expensive and subjects of strong competition between livestock and human population. According to Belewu et al 2014, the natural pastures and crop residues available for ruminants during the dry season after crop harvest are usually fibrous and devoid of most essential nutrients including proteins, energy, minerals and vitamins which are required for increased rumen microbial fermentation and improved performance of the host animal. These crop residues and natural pastures which constitutes plant biomass are lignocellulose materials comprises on average 23 % lignin, 40 % cellulose and 33 % hemicellulose by dry weight as reported by Sa-Pereira et al 2003. Huge quantities of lignocellulosic by-products are generated through forestry and timber industries, paper-pulp industries, agro-industries and other agricultural practices and they pose an environmental pollution problem. Successful significant efforts have been made to convert these lignocellulosic by-products to valuable products such as biofuels, chemicals and improved animal feeds Howard et al 2003. One of such lignocellolosic by-products of great importance and produced in abundance in the tropics and sub-tropics is Rice (*Oryza sativa*) husk. They contain enough cellulose to make them excellent sources of energy for ruminants but they are poor quality feeds due to low digestibility, poor palatability, low protein content and bulkiness. As such, this research work seeks to study the influence of graded levels of *Rhizopus oligosporus* -Treated rice husk on the milk quality and yield of West African Dwarf goats.

MATERIALS AND METHODS

Feed ingredients used in formulating the diets namely Palm Kernel Cake (PKC), bone meal, vitamin/mineral premix, salt and salt lick were obtained from feed millers in Ilorin, Kwara State. The cassava peels were obtained from cassava processsors in and around Ilorin metropolis. Rice husk was collected from Rice millers in Minna metropolis, Niger State, Nigeria and confirmed to be Rice husk at the Department of Crop Production Laboratory, Federal University of Technology, Minna, Niger State. It was soaked in water for twenty-four hours after which the excess water was strained using a muslin cloth. The soaked Rice husk was then packaged in polythene bags at 1kg per bag ready for autoclaving at 121°C, 15psi for 30 minutes so as to get rid of any microbes that could be present in the husk. The fungus used was *Rhizopus oligosporus* which was obtained from the Department of Microbiology, University of Ilorin, Kwara State, Nigeria. The freshly prepared Potato Dextrose Agar (PDA) was amended with streptomycin^R to suppress any bacterial growth and later autoclaved at 121°C, 15psi for 15 minutes to sterilize it.

The fungus was sub-cultured on (PDA) by transferring the spores aseptically from the cultures to the freshly prepared PDA-containing Petri-dishes and were later incubated at ambient temperature for four days to stimulate fungal growth. Suspension of actively growing mid-log phased culture of *R. oligosporus* was individually adjusted to 5×10^4 spores/ml with distilled water in line with the methods of Sani *et al.* 1992. Twenty milliliters from the suspension was used to inoculate one kilogram of cooled autoclaved rice husk in layers in a container, covered and incubated at room temperature for eight days when the fungus had enveloped the substrate. Fungal growth was terminated by oven-drying the inoculated substrate at 80°C for twenty four hours. Four different diets were formulated for the animals designated as T_1, T_2, T_3 and T_4. T_1 was the control diet with 0 % inclusion of *RoTRH* while T_2, T_3 and T_4 had the Palm Kernel Cake (PKC) fraction replaced with *RoTRH* at 10 %, 20 % and 30 % respectively.

Table 1 ***RoTRH*-containing diets fed to West African Dwarf goats**

Ingredients (%)	Experimental diets			
	T_1	T_2	T_3	T_4
Cassava peels	62.00	62.00	62.00	62.00
Palm kernel cake	35.00	25.00	15.00	5.00
RoTRH	0.00	10.00	20.00	30.00
Bone meal	1.00	1.00	1.00	1.00
Salt	1.00	1.00	1.00	1.00
Vitamin/Mineral premix	1.00	1.00	1.00	1.00
Total	100.00	100.00	100.00	100.00

Key: *RoTRH* - *Rhizopus oligosporus* – Treated Rice husk, T_1 - Control, T_2 - 10 % *RoTRH*, T_3 - 20 % *RoTRH*, T_4 - 30 % *RoTRH*

Table 2: Nutritional compositions of experimental diets containing graded levels of *RoTRH*

Parameters (%)	T_1	T_2	T_3	T_4	$\pm$SEM
Dry matter	91.35^a	90.72^b	91.38^a	90.41^c	0.13
Crude protein	11.37^a	9.84^b	9.64^c	8.09^d	0.35
Crude fiber	23.55^d	25.15^c	25.94^b	26.89^a	0.37
Ether extract	2.79^a	2.30^c	2.57^b	1.58^d	0.14
Ash	10.93^d	13.53^c	15.82^a	14.84^b	0.55
NFE	42.70^a	39.90^b	37.41^d	39.07^c	0.58
NDF	47.84^a	42.95^b	39.01^c	33.28^d	1.61
ADF	36.76^a	34.79^b	32.36^c	30.54^d	0.72
ADL	18.63^b	18.77^{ab}	18.79^{ab}	18.99^a	0.04
Hemicelluloses	11.07^a	8.16^b	6.65^c	2.75^d	0.91
Cellulose	18.13^a	16.02^b	13.57^c	11.54^d	0.76
TDN	73.84^a	61.41^b	64.69^{ab}	63.42^b	0.08

Key: T_1 - Control, T_2 - 10 % *RoTRH*, T_3 - 20 % *RoTRH*, T_4 - 30 % *RoTRH*, TDN - total digestible nutrients, NFE - nitrogen free extract, NDF - neutral detergent fiber, ADF - acid detergent fiber, ADL - acid detergent lignin, SEM - Standard Error of Means, ^{abc}Means in the same row without common letters are different at $p < 0.05$

Milk samples were analysed for total solids, solid not fats (SNF), fat, protein, ash and pH. All analysis was according to the methods of AOAC (1990). Data collected were subjected to analysis of variance (ANOVA) by means of general linear procedure (GLM) of SAS 9.2 Version 6. SAS Institute, Cary, North Carolina, USA based on the complete ramdomized design (CRD). Where means were significant, they were separated using Duncan Multiple Range Test of the statistical package SAS 9.2. at 5 % level of significance.

RESULTS AND DISCUSSION

The nutrient intake of lactating WAD goats fed diets containing graded levels of *RoTRH* in this study is presented in Table 3.

Table 3: Dry Matter and Nutrient Intake of lactating WAD Goats Fed Diets Containing Graded Levels of *RoTRH*

Nutrient Intake (g/animal/day)	T_1	T_2	T_3	T_4	$\pm$SEM
Dry matter	2067.18	2027.26	2055.71	2055.28	7.160
Crude protein	235.04^a	199.48^b	198.17^b	166.27^c	0.813
Crude fiber	486.82^a	509.85^c	533.25^b	552.66^a	1.685

Ether extract	57.67^{a}	46.63^{c}	52.83^{b}	32.47^{d}	0.200
Ash	225.94^{d}	274.28^{c}	325.21^{a}	305.00^{b}	0.782
NDF	988.93^{a}	870.70^{b}	801.93^{c}	683.99^{d}	3.055
ADF	759.89^{a}	705.28^{b}	665.23^{c}	627.68^{d}	3.423
ADL	385.11^{ab}	380.52^{b}	386.27^{ab}	390.30^{a}	2.630
Hemicellulose	228.84^{a}	165.42^{b}	136.70^{c}	56.52^{d}	1.333
Cellulose	374.78^{a}	324.77^{b}	278.96^{c}	237.18^{d}	0.792
NFE	882.68^{a}	808.88^{b}	769.04^{c}	802.99^{b}	1.297

Key: T_1 - Control, T_2 - 10 % *RoTRH*, T_3 - 20 % *RoTRH*, T_4 - 30 % *RoTRH*,, NDF - Neutral Detergent Fiber, ADF - Acid Detergent Fiber, ADL - Acid Detergent Lignin, NFE - Nitrogen Free Extract, SEM - Standard Error of Means, ^{abc}Means in the same row without common letters are different at $p < 0.05$

The results show that the Dry matter intake was $p > 0.05$ among all the animals in the treatment groups. The crude protein intake was $p > 0.05$ between animals fed T_2 and T_3 diets but they were both $p < 0.05$ from those fed T_1 and T_4 diets. The ADL intake was $p < 0.05$ between animals fed T_2 diet and T_4 diet. They were however both $p > 0.05$ to animals in T_1 and T_3 groups. The NFE intake was $p > 0.05$ among animals fed T_2 and T_4 diets but both were $p < 0.05$ from animals in other treatment groups. There other nutrients intakes were $p < 0.05$ among animals in all the treatment groups. According to Ahamefule and Elendu 2010, feed intake is affected by palatability, gut fill and retention time in the rumen. Basically, the high nutrient contents of the diets might be responsible for the increased nutrients intake reported in this experiment. Higher protein contents of diets have been reported to positively enhance intake of other nutrients. The degradation of the secondary metabolites could have equally enhanced palatability and by extension the feed intake. The high crude fiber intake with increase in the dietary levels of the *RoTRH* might be due to the increased solubility of the crude fiber fractions hence making it readily absorbable by the system.

The milk yield and composition of lactating *WAD* goats fed diets containing graded levels of *RoTRH* are presented in Table 4.

Table 4: Lactation Performance of WAD goats Fed Diets Containing Graded Levels of *RoTRH*

Parameters	T_1	T_2	T_3	T_4	± SEM
Yield (g/day)	130.63^c	110.20^d	132.22^a	120.76^b	0.108
FCM (g/day)	154.34^a	124.75^c	149.47^b	148.29^b	0.080
Milk protein (%)	4.32^b	4.36^b	4.62^a	4.46^{ab}	0.049
Total solids (%)	14.65	14.63	14.99	14.82	0.134
Fats (%)	5.21^a	4.88^b	4.87^b	5.52^a	0.090
Ash (%)	0.84	0.93	0.90	1.10	0.030
Solid not fats (%)	9.45^b	9.75^{ab}	10.09^a	9.31^b	0.107
Lactose (%)	4.45	4.66	4.93	4.65	0.056
pH	6.34	6.31	6.36	6.29	0.049
Ca (mg/100ml)	135.17	135.15	137.16	137.52	1.093
P (mg/100ml)	87.85	88.29	87.93	88.25	0.697
Na (mg/100ml)	80.54	80.29	78.89	79.55	0.641
K (mg/100ml)	161.49	161.02	162.13	163.13	12.915
Mg (mg/100ml)	29.80	29.92	30.47	30.89	0.271

Key: T_1 - Control, T_2 - 10 % *RoTRH*, T_3 - 20 % *RoTRH*, T_4 - 30 % *RoTRH*, Ca - Calcium, P - Phosphorus, Na - Sodium, K - Potassium, Mg - Magnesium, SEM - Standard Error of Means, ^{abc}Means in the same row without common letters are different at $p < 0.05$

The milk yield results which were all within the range of 119.73 g/d to 134.93 g/d reported by Ukanwoko and Ibeawuchi 2014 were all $p < 0.05$ among the animals in all treatment groups. It has been reported by Luka and Kibon 2014 that milk yield is affected by parity. Milk yield in this experiment might have been affected by parity as all the does were in their first parity and all had single births. According to Ezekwe and Machebe 2005 and Ahamefule et al 2012, low milk yield of WAD goats could be due to genetic variation within the species as a result of non-improvement of WAD goats for milk production. The variations in the values recorded might also be as a result of variations in the nutritional conditions the animals were subjected to. Aplocina and Spruzs 2012 reported that milk productivity depends mainly on the quantity and quality of feedstuffs. The milk protein values recorded in this study were within the range of 4.31 % and 4.40 % reported for WAD goats by Ahamefule et al 2007 and lower than 3.27 % reported by Zahraddeen et al 2007 and 3.17 % to 3.67 % reported by Tona et al 2017 for WAD goats. The milk protein percentage for animals fed T_1 and T_4 diets were $p < 0.05$ from each other but were $p > 0.05$ to the milk protein from milk samples of animals fed T_2 and T_3 diets. The higher values obtained in this study could be as a result of the microbial protein content of the feed. The fats contents of milk samples from animals fed T_1 (Control) was $p > 0.05$ to those fed T_4 diet. Likewise there was $p > 0.05$ between the fats contents of milk from animals fed T_2 diet and T_3 diet. The milk fat content of this experiment corresponded to the findings of Zahraddeen et al 2007 but lower than 3.62 % to 3.67 % reported by Tona et al 2017 for WAD goats. According to the reports of Ogunbosoye and Babayemi 2010 that a positive correlation exists between milk fat and milk protein, it is believed that the behavior of the milk protein was influenced by that of the milk fat in this study. The ash content of the milk samples was similar to the values reported by Ahamefule et al 2004 but lower than 0.70 % reported by Zahraddeen et al 2007 for WAD goats. It was also within 0.73 % to 0.97 % reported by Ogunbosoye and Babayemi 2010 for WAD goats. There was $p > 0.05$ for ash content among milk samples from animals fed the treatment diets. The higher ash content of the milk samples from animals fed diets containing graded levels of the *RoTRH* when compared to those fed the control diet might be due to transfer of the liberated minerals from the *RoTRH* into the milk samples. This corroborates the assertion of Belewu et al 2007 that pre-digested substrates possessed enhanced mineral contents which may have been transferred into the milk.

The Solid-Not-Fat content was $p > 0.05$ to 9.97 % reported by Ahamefule et al 2007 for intensively-managed WAD goats and within the 9.88 % to 10.43 % reported by Tona et al 2017 for WAD goats. While the solid-not-fat content of the milk samples from animals fed T_1 and T_4 diets were $p < 0.05$, they were both $p > 0.05$ to that of milk from animals fed T_2 and T_3 diets. The impressive solid-not-fat content of the milk samples might be as a result of the nutritional effect of the diets in corroboration of the report of Payne 1990 that good nutrition particularly with high energy intake has a major effect on milk composition by stimulating high milk yield and solid-non-fat percentage by dilution, while underfeeding gives the exact opposite effect. The lactose content of 4.29 % reported by Zahradeen et al 2007 and 4.18 % reported by Ukanwoko and Ibeawuchi 2014 for goats were $p > 0.05$ for milk samples from all the animals in the study. Lactose is the main determinant of milk volume and the similar relationship between synthesis of lactose and the amount of water drawn into milk makes lactose a stable milk component as stated by Pollott 2004. According to Ahamefule et al 2012 the concentration of lactose in milk cannot be easily altered by nutrition. In his study on Nguni and Boer goat breeds, Mbengwa et al 2008 reported a decline in milk lactose content as the lactation period progressed. The various milk minerals determined in this study (calcium, phosphorus, sodium, potassium and magnesium) were all $p > 0.05$ among the different milk samples. They all increased with increase in the dietary levels of the *RoTRH*. Duncan 1998 reported that calcium and phosphorus in milk are known to be bounded to casein which is the major fraction of milk protein. Thus, the milk protein, milk calcium and milk phosphorus are positively correlated; the increase in milk protein results in an increase in these minerals and vice versa. This perhaps explains the behavior of the calcium and phosphorous contents of the milk. The general increase in the mineral composition of the milk might not be unconnected with the mineral contents of the *RoTRH* ingredients included in the experimental diets. This agrees with the findings of Belewu et al 2007. The total solids in this experiment were $p > 0.05$ among the animals in all the treatment groups. However, they were slightly higher than the range of 12.45 % to 14.36 % reported by Ukanwoko and Ibeawuchi 2014 for *WAD* goats but higher than 11.63 % reported by Zahraddeen et al 2007 and 13.50 % to 14.10 % reported by Tona et al 2017 for the same species of goats.

The behavioural nature of the milk components in this study could also be due to the nature of the dietary fiber. It has been reported by Sahlu et al 2004 that diets with majority of its carbohydrate and fiber fraction being majorly soluble carbohydrates such as grains tend to be insufficient physically to promote salivation, mastication and rumen function and are rapidly fermented thereby leading to a high acetate: propionate ratio and subsequent milk fat depression. The fiber content of the T_4 diet might have had a greater degree of physical sufficiency for salivation, mastication, rumen function and less rapid fermentation leading to a higher acetate: propionate ratio and consequently increased milk fat content, milk protein and solid-non-fat contents when compared with the milk samples from other treatments in line with the reports of Sahlu et al 2004. The high fat and protein contents recorded in some samples in this experiment is advantageous to the cheese industries as they place a high premium on milk with high milk fat and milk protein contents. This is in line with the findings of Belewu et al 2007.

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