TESTING PRODUCTION OF HYDROPONIC FODDER FOR CATTLE:

SUPPORTING CLIMATE RESILIENCE

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FOR A FRONTIER TECHNOLOGY LIVESTREAMING PILOTS IN NIGERIA

April, 2023

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LIST OF ABBREVIATIONS

AAS	Atomic Absorption Spectroscopy
ADF	Acid Detergent Fibre
ADL	Acid Detergent Lignin
ALP	Alanine Phosphatase
ALT	Alanine Transaminase
AST	Aspartate Transferase
BL	Body Length
BW	Body Weight
CF	Crude Fibre
CP	Crude Protein
DM	Dry Matter
EE	Ether Extract
Gp	Gas Production Volume
Hb	Haemoglobin
HGC	Heart Girth Circumference
HGFs	Hydroponically Grown Fodder
ME	Metabolizable Energy
NDF	Neutral Detergent Fibre
NFE	Nitrogen Free Extract
PCV	Packed Cell Volume
RBC	Red Blood Cell
SEM	Standard Error of Mean
SNF	Solid Non-Fat
WBC	White Blood Cell
XA	Ash Content

ABSTRACT

This study was carried out to assess the nutritive value of the hydroponically grown fodders (HGFs); determine the *in vitro* gas production characteristics of HGFs and some selected forages; evaluate the growth performance and nutrient digestibility of lactating White Fulani cows fed HGF; and determine the haematological indices, serum biochemical responses as well as the milk yield and composition of lactating White Fulani cows fed HGF.

The study was carried out at Paikon Kore grazing reserve, Gwagwalada Area of Abuja, Federal Capital Territory, Nigeria and the laboratory procedures were executed at the Department of Animal Sciences, Faculty of Agriculture, Obafemi Awolowo University and the University of Abuja Specialist Hospital, Gwagwalada, Abuja, Nigeria. A total of Thirty-four (34) lactating White Fulani breed of cows were employed for this study. The animals weighed 252.30 ± 28.97 kg and were randomly distributed into two dietary treatments namely: The hydroponically grown fodder (HGF) group (n = 24) and the Control group (n = 10). The HGF group was offered HGF as a supplemental diet at 2% of their body weight (BW) while the control group were left to graze without supplemental feeding. After this, the animals were assessed for growth performance, haematological indices, serum biochemical responses, and milk yield and quality. All laboratory examinations of samples were executed following standard laboratory procedures and all data collected were subjected to a one-way analysis of variance or two-way analysis of variance of SAS as the case may be. Significantly ($P<0.05$) different means were separated using Duncan multiple range test of the same statistical package**.**

Results obtained showed that HGFs had quality nutritive values and its utilization as feed in cattle production improved the health status of the animals with a 50% reduction in enteric methane emissions. The mean average daily gain (ADG) value (0.585kg/day) obtained for cows

on the HGF diet was significantly ($P<0.05$) higher than the value (0.166kg/day) reported for the grazing animals without fodder supplementation. Milk yield range of 3.0 - 4.6 litre/animal/day was recorded for animals fed HGF after the feeding trial. . The milk composition (milk fat (3.84 vs 1.91%) and Lactose (5.24 vs 3.77%) revealed superior quality for animals on HGF than those on the control diet.

The study concluded that HGFs possesses high nutritive value, making them optimal and fit for ruminant feeding without any deleterious effect on the health status of the animals while conferring improved performance indices. Also, the nutritive contents of HGF are easily digestible and showed better *in vitro* gas production characteristics than selected native pastures.

1.0 Introduction

Most nations in the world are currently facing an unprecedented increase in population and environmental issues which have posed a threat to food security in the respective countries. To feed this growing population, there must be a corresponding increase in food production.

Nutrient-rich foods will be one of the solutions important in ensuring that the global population is nourished. Milk and its products are well-established as foods with high nutrient content recommended to alleviate food insecurity. Global milk production for human consumption is in excess of 800 million tons per year. Milk is produced by ruminants, 81% of 2018 milk production was cow's milk, with 15% from buffalo and 4% from goats, sheep, and camels. To increase milk production, particularly in the sub-Saharan region, increasing productivity in our local breeds of cow is key.

Consequently, the focus of this study is on improving milk production from cow in Nigeria. The breeds of cattle available in Nigeria are classified as the dual purpose (meat and milk) breeds of cattle and the most prominent of them all is the Bunaji (White Fulani) breed. The white Fulani have not been producing desirable volume of milk to the farmers and this production volume worsen with dry season effect. Feeding of high-quality feed to these animals have been suggested as a way of improving productivity.

Dry season feeding for ruminants in Nigeria comes with a lot of challenges, this is because most ruminant farmers rely on the natural pastures and crop residue as the major source of feed for their stocks. Natural pasture is limited in quantity and quality during the dry season. This is attributable to low rainfall and increase in the fibre content of forages. High fibre content decreases digestibility and nutrient availability to the animals. The use of alternative feed resources to supplement the impaired natural pasture during the dry season is on the increase.

Feeding of quality green fodder to ruminants could play an important role in sustainable and economical livestock production particularly the dairy sector. However, various constraints are faced by livestock farmers for production of green fodder. The constraints vary from factors such as small land holdings, unavailability of land for fodder cultivation, scarcity of water or saline water, non-availability of good quality fodder seeds, more labour requirement, requirement of manure and fertilizer, longer growth period (45-60days), fencing to prevent fodder crop from wild animals, natural calamities etc. There is also the aspect of non-availability of constant quality fodder round the year which aggravates the limitations of sustainable livestock farming. Due to these constraints and problems faced by conventional method of fodder cultivation.

Hydroponic is now emerging as an alternative technology to grow fodder for farm animals (Sneath and Mclntosh 2003, Naik *et al*. 2011, Naik *et al*. 2012). Hydroponically grown fodders (HGF) pose to be a feedstuff that can be utilized to ameliorate the dry season feeding in ruminant production. Hydroponics is the method of growing plants without soil, using mineral nutrient rich solutions or in water for a short duration in an environmentally controlled room or house (Myers, 1948). The word hydroponics has been derived from two Greek words *hydro* means 'water' and "*ponic*' means 'working'. Thus, fodder produced by growing plants in water or nutrient rich solution but without using any soil is known as hydroponic fodder or sprouted grains or sprouted fodder (Dung *et al*., 2010).

The benefits of hydroponic green fodder over conventional methods includes faster growth of plant compared to field grown plants. HGF takes 7-8 days to develop from seed to ready-to-feed folder while the conventional fodder grows for 45 – 60 days. Plant density may be greatly increased per unit of growing area compared to field production which allows more seed

to be grown in a smaller amount of space therefore require little land for production and increase output. HGF can be produced round the year irrespective of the failure of monsoon, land availability, natural calamities, labour shortage and so on. HGF requires minimal man power and time, there is little or no weed problem, there is greater control of environmental conditions like temperature, light intensity, light quality, light duration, nutrient composition and concentration and humidity, using of artificial light hydroponics system can be stacked vertically which further increase the plant yield per unit of floor space, fodder is grown without the use of pesticide and herbicides which also have direct benefit to the environment (Naik *et al*., 2012).

Conclusively, the use HGF in ruminant feeding systems will reduce the current clashes between crop farmers and herders. This is because HGF system of feeding mimics the zero grazing system which does not permit animals' encroachment into arable farmlands. The farmers are saddled with the responsibility of supplying the animal on the ranch.

1.1 **Objective**

The general objective of this study is to evaluate the performance characteristics of cows fed HGF in Nigeria.

1.1.1 Specific objectives

The specific objectives of this study are to

a) assess the nutritive value of the hydroponically grown fodders.
b) determine the *in vitro* gas production characteristics of HGF.
c) evaluate the growth performance and nutrient digestibility of lactating White Fulani cows fed HGF.
d) determine the haematological indices and serum biochemical responses of lactating White Fulani cows fed HGF.

e) evaluate the milk yield and composition of lactating White Fulani cows fed HGF.

2.0 MATERIALS AND METHODS

2.1 Experimental Location

This study was carried out at Paikon Kore grazing reserve, Gwagwalada Area of Abuja, Federal Capital Territory, Nigeria. The laboratory procedures were carried out at the Department of Animal Sciences, Faculty of Agriculture, Obafemi Awolowo University and the University of Abuja Specialist Hospital, Gwagwalada, Abuja, Nigeria.

2.2 Hydroponically grown fodder production

2.2.1 Experimental material

Guinea corn (*Sorghum bicolor*), Maize (Zea mays) and Millet (*Pennisetum glaucum*) were purchased at a local market in Paikon kore, Gwagwalada area of Abuja. Detergents, bleach, Nylon, perforated galvanized sheet tray, and weighing scale.

2.2.2 HGF production

Sorghum was selected for the feeding trial because of its comparative advantages in terms of yield and nutritive value. Fodders were produced daily using the standard protocol supplied by M.E Solutions for hydroponic fodder production.

2.3 Experimental animals and their management

A total of thirty-four (34) lactating White Fulani breed of cow were selected for this study. The animals weighed 252.30 ± 28.97 kg and were randomly distributed into two dietary treatments namely: The hydroponically grown fodder (HGF) group (n = 24) and the Control group (n = 10). The HGF were offered hydroponically grown fodders as a supplemental diet at 2% of their body weight (BW) while the control group were left to graze without supplementation. The animals were dewormed using albendazole tablet and water was made accessible *ad libitum* throughout the experimental period.

2.4 Nutritive evaluation of selected hydroponically frown fodders.

The nutritive value of the HGFs were determined through chemical analyses. The Analyses were divided into three namely proximate composition, fibre fractions and mineral composition. Known weight of HGFs and feacal samples were dried in an oven (at 70^{O}C) for 72 hours and the proximate composition of the HGF was determined using the standard procedures of the AOAC (2006). The fibre fractions were determined using the method of Van Soest *et al.,* (2015) while the mineral composition was determined with the aid of an atomic absorption spectrometer (AAS).

The outlined procedure for the proximate composition determination was as follows.

2.4.1 Dry matter

Two grams (2g) of each sample were weighed with the aid of an electronic balance into an aluminum foil crucible, the sample was oven-dried at 80^{O}C for 24 hours and was cooled to room temperature in a desiccator and weighed. The difference in weights before and after drying gave the moisture content, the dry matter was determined with the aid of this formula:

$$\%\ Moisture\ Content\ = \frac{(W1-W2)\times 100}{W1}$$

Where: W_1 =Wet weight of the sample (g)

W_2 = Dry weight of the sample (g); and

$$\%\ Dry\ Matter\ =\ 100 - (\%Moisture\ content)$$

2.4.2 Crude protein

Crude protein was determined using a modified Kjeldahl method of Nitrogen (N) determination. The major steps included digestion, distillation, and titration. Twenty milliliters (20ml) of concentrated sulphuric acid were added to 0.5g of sample wrapped in filter paper (Whatman No.4) in a labeled Kjeldahl flask with 0.35g of digestion mixture (15g dry potassium sulphate +

0.7g Mercuric iodide), heated in a digester (Tecator Digestion System 6 – 1007 Digester) for about two hours. The digest was cooled, and then transferred into a volumetric flask, and it was made up to 50ml with distilled water. Twenty (20) ml of the digested sample was transferred by the pipette into a digestion flask for distillation and titration was done after which the Nitrogen (percent) value obtained was multiplied by a factor of 6.25 to give the percentage crude protein value.

$$\%\, Crude\ Protein\ =\ \%Nitrogen\ x\ 6.25$$

2.4.3 Ether extract

Ether extract was determined by the Soxhlet extraction method using petroleum ether at a boiling point of 40 - 60^{o}C in a pre-weighed flask. Two grams of the feed and feacal samples were put in an extraction thimble, the extraction thimbles were inserted in a Soxhlet bottle where the extraction of the fat was done for three (3) hours. The petroleum ether was distilled off and the residue was oven dried at 75^{O}C for one hour. The distilled sample was cooled in a desiccator, the flask was weighed.

$$\%Ether\ Extract\ = \frac{(W3-W2)\times 100}{W1}$$

Where: W_1 = Weight of Sample (g)

W_2 = Weight of flask (g)

W_3 = Weight of flask + extracted fat (g)

2.4.4 Crude fibre

The crude fiber was determined using an acid/base digestion process to remove protein and soluble carbohydrates. 200 ml of 1.25% boiling sulphuric acid (v/v) was added to 2g of either feed and fecal samples in a 600ml beaker, this mixture was refluxed for 30 minutes on a hot plate and the resultant solution was filtered under suction through fine-meshed linen and the residue was washed with boiling water to remove the acid. Two hundred milliliter (200ml) of 1.25%

boiling sodium hydroxide (w/v), was added to the acid-free residue, also the mixture was refluxed for 30 minutes on a hot plate and the resultant solution was filtered using filter paper (Whatman No.4) and the residue was washed with boiling water. The residue was oven-dried overnight and put into the furnace for 2-3 hours at 600ºC in a Gallenkamp muffle furnace.

Crude fibre was determined by:

$$\%Crude\ fibre = \frac{loss\ in\ weight\ of\ residue\ due\ to\ ashing\ (g) \times 100}{weight\ of\ Sample\ (g)}$$

2.4.5 Ash

Two grams of feed and fecal samples each were weighed into a pre–weighed platinum crucible was burnt at 600^{O}C in a Gallenkamp muffle furnace for three (3) hours, the resultants were cooled to room temperature in a desiccator and were weighed.

$$\%\ Ash = \frac{Weight\ of\ crucible\ with\ ash(g) - Weight\ of\ crucible\ (g) \times 100}{Weight\ of\ Sample\ (g)}$$

2.4.6 Nitrogen-free extract (NFE)

Nitrogen-free extract represents sugar, starch, and soluble hemicellulose, this doesn't account for the above-described fractions. NFE was calculated by subtracting the sum of all the fractions of the constituent from 100. Thus, NFE was given by:

$$\%NFE = 100 - (\%\ Crude\ protein + \%\ Crude\ fibre + \%\ Ether\ extract + \%\ Ash)$$

2.5 Determination of Fibre fractions

2.5.1 Neutral detergent fibre (NDF)

One gram of feed and fecal samples each were weighed into a 500ml beaker for refluxing and 100ml of neutral detergent solution (NDS), 2 ml of dekalin and 0.5 g of anhydrous sodium sulphite were added to the beaker containing the sample and was boiled and refluxed for 60mins. The residues were filtered and washed with hot distilled water and then rinsed with acetone. The

residues were transferred to a crucible of a pre-determined weight. The crucible's content was oven dried at 105°C for 8 hours and transferred into a desiccator for cooling. The weight of the contents in the crucible was determined using a Mettle Toledo analytical balance.

%NDF will be determined using this equation:

$$\%NDF = \frac{(Weight\ of\ Crucible\ with\ NDF)(g) - (Weight\ of\ empty\ crucible)(g) \times 100}{Weight\ of\ Sample\ (g)}$$

2.5.2 Acid Detergent Fibre (ADF)

One gram of each feed and fecal samples was weighed into a 500ml beaker for refluxing and 100ml of acid detergent solution (ADS) and 2 ml of dekalin was added to the beaker containing the sample and was heated until boiling after which the heat was reduced when it started boiling and was refluxed for an hour. The residues were filtered and washed with hot distilled water and then rinsed with acetone. The residues were transferred to a crucible of a pre-determined weight. The crucible's content was oven dried at 105°C for 8 hours and transferred into a desiccator for cooling. The weight of the contents in the crucible was determined with the aid of a Mettle-Toledo analytical balance.

%ADF was determined using this equation:

$$\%ADF = \frac{(Weight\ of\ Crucible\ with\ ADF)(g) - (Weight\ of\ empty\ crucible)(g) \times 100}{Weight\ of\ Sample\ (g)}$$

2.5.3 Lignin

Ten milliliters (10 ml) of 72% sulphuric acid were added to the crucible containing ADF fraction, the mixture was allowed to stand for 3 hours and stirred at an interval of 30 minutes. The residues were washed with hot distilled water and filtered into the crucible. The residues were oven dried at 105^0C for 8 hours and the weight was recorded. The crucible containing the dried residues was transferred to the Gallenkamp muffle furnace for determination of ash content

at 550 ^{0}C for 3 hours. The crucible that contains the ash was transferred to the desiccator for cooling and the weight of the ash in the crucible was determined with the aid of a Mettle Toledo analytical balance.

The percentage lignin was determined using the following equation:

$$\%Lignin = \frac{(W2-W3(g)\times 100}{W1\,(g)}$$

Where W1= Weight of sample

W2 = Weight of empty crucible + residue before ash content determination

W3 = Weight of empty crucible + residue after ash content determination

2.5.4 Experimental design and statistical analysis

The nutritive value assessment was laid out in a completely randomized design. All data obtained were subjected to a one-way analysis of variance and significantly ($p<0.05$) different means were separated using Duncan multiple range test of Statistical Analysis Software. The Seed type was taken as the single source of variation for this experiment.

2.6 Growth performance of lactating Cows fed HGF.

Selected animals were measured for morphometric parameters to estimate the body weight of the animals. The body length (BL) and heart girth circumference (HGC) were recorded for all animals employed for this trial. The measurements (BL and HGC) were utilized to estimate the initial live weight (ILW) of the animals. The ILW of the animals was used to estimate the feed offered to the animals. Animals were offered HGF early in the morning before grazing.

Data were collected daily on total feed offered and feed refusal/ left-over and the body weight measurements were evaluated fortnightly. Other parameters like feed conversion ratio, average daily gain, and body weight gain were also determined during the 56–day feeding study.

$$\text{Body Weight (kg)} = \frac{Heart\ Girth(cm) \times Heart\ Girth\ (cm) \times Body\ lenght(cm)}{300}$$

2.6.1 Experimental design and statistical analysis

The growth trial was laid out in a completely randomized design with two dietary treatments. All data obtained were subjected to an independent t-test. Dietary treatment was taken as the single source of variation for this experiment.

2.7 Digestibility and Nitrogen Utilization of Lactating Cows fed HGF

The digestibility and nitrogen utilization of the experimental animals was carried out employing three (3) animals from the HGF dietary treatment only. Animals were kept in an individual pens that permit the separate collection of feaces. The pens were equipped with feeders and water troughs for ten (10) days. Animals were adapted for three (3) days after which sample collection was done for the last seven (7) days. The total faeces voided per animal were weighed and aliquot samples were taken per day to the laboratory for the determination of the dry matter. The daily stored samples of faeces for each animal were bulked, mixed thoroughly, ground, and sub-sampled for chemical analysis. The volume of urine produced by each animal was measured daily. Sample of daily urine voided was taken and volatilization of nitrogen from urine was prevented by introducing 0.1N of HCl into the urine. The urine samples were stored in a deep freezer and were analyzed for nitrogen (%) determination. Only the descriptive analysis of data obtained from the digestibility trials were reported.

The digestibility coefficient was calculated as follows:

$$\frac{Nutrients\ intake\ (in\ feed)) - Nutrients\ output\ (in\ feaces)}{Nutrients\ intake\ (in\ feed)} \times 100$$

2.8 *In vitro* Gas Digestibility Procedure

In vitro gas production is a method that allows for the estimation of digestibility, and metabolizable energy (ME) of ruminant feed.

Six (6) feed were incubated with rumen liquor collected from cattle. Three (3) prominent forages were added to the HGFs for the incubation. The amount of gas released during the incubation of these feeds was related to digestibility and ME value. The *in vitro* gas production was done according to the procedure of Menke and Steingass, (1988).

2.8.1 Collection of rumen Liquor

Rumen liquor was collected from the rumen of a freshly slaughtered cattle in an abattoir. The rumen content was stirred for liquor homogeneity and a scoop was used to transfer it into a preheated thermos-flask. Obtained rumen liquor was kept in a thermos-flask and immediately taken to the laboratory for use.

2.8.2 Buffering of liquor

The rumen content collected in the thermos-flask was sieved, using a clean sterile four-layered cheesecloth with a constant supply of carbon dioxide (CO_2) gas to maintain an anaerobic condition for the rumen microbes. McDoughad's buffered solution, contained 9.80 g/l $NaHCO_3$; 8.98g/l $NaHPO_4.12H_2O$; 0.57g/l KCl; 0.47g/l NaCl; 0.06g/l $MgSO_4$ anhydride; 0.04g/l $CaCl_2$ anhydride and 1g of Urea was added to the sieved liquor in ratio 2:1 to make the inoculum (Nahm, 1992)**.** 30ml inoculum obtained was put into 100ml plastic syringes to estimate total gas production and methane production by the rumen microbes using *in vitro* gas production method. (Menke and Steingass, 1988).

2.8.3 Estimation of methane gas

100ml syringes filled with milled diets (200mg) and the inoculum, syringes were clipped tightly to prevent the escape of gas. The syringes containg feed were incubated at a temperature of $39^{o}C$ for 24 hours. After the incubation period, microbial activities were terminated by

introducing 4.0ml of 10.0M Sodium hydroxide (NaOH) solution into the syringe through the silicon tubes to absorb the Carbon (IV) oxide (CO_2) gas, which resulted in the formation of Sodium Carbonate (Na_2CO_3) solution and methane (CH_4) gas was liberated. The net gas produced on incubation of 200mg feed dry matter after 24hrs, together with levels of other chemical constituents, was used to predict the digestibility of organic matter, metabolizable energy, and the short-chain fatty acid (SCFA).

Equation 2.1 ME (Mj/kgDM) = 2.20 + 0.136Gp + 0.057CP

Equation 2.2 OMD (%) = 14.88 + 0.889Gp +0.45CP + 0.0651XA

Equation 2.3 SCFA = 0.0239Gp – 0.0601

(*Where ME = Metabolizable Energy; DM = Dry matter; OMD = Organic matter digestibility; CP= crude protein in percentage; Gp is the net gas production in ml from 200mg dry sample after 24hr for incubation and after correction for the day-to-day variation in the activity of rumen liquor using the Hohenheim standard*).

2.8.4 Experimental design and statistical analysis

The *in vitro* gas production evaluation was laid out in a completely randomized design. All data obtained were subjected to one-way analysis of variance and significantly ($p<0.05$) different means were separated using Duncan multiple range test of Statistical Analysis Software. Fodder-type variation was taken as the source of variation for this experiment.

2.9 Haematological and Serum Biochemical Responses of Lactating Cows fed HGF

2.9.1 Blood samples collection and analysis

Blood samples were collected from the experimental animals via the jugular vein of the animals a week before the commencement of the experiment and day-56 of the feeding trial. Prior to feeding in the morning, bleeding was done to assess the blood profile of the animals.

About 5mL of the blood was obtained from each animal and divided into two. 2.5mL into a plain and EDTA bottles respectively. Blood in the plain bottles were then centrifuged at 3,500 rev/min in the laboratory using a Gallenkamp laboratory centrifuge to obtain the serum. The centrifugation was carried out according to Mitruka and Rawnsley's procedure. The separated sera were decanted into bijoh (plain) bottles and stored at -10^0C temperature. The serum metabolites (glucose, total protein, albumin, urea, bilirubin and liver function) were determined according to the Randox procedure of chemical analysis. The readings were carried out using a photo spectrometer in the laboratory and globulin values were estimated.

2.9.2 Experimental design and statistical analysis

The study was laid out in a randomized complete block design (RCBD). All data obtained were subjected to a two-way analysis of variance and significantly ($P<0.05$) different means were separated using Duncan multiple range test of Statistical Analysis Software. The dietary treatments were used as the main source of variation while the time of sample collection was introduced as a block in this experiment.

2.10 Milk Yield and Composition of Lactating Cows fed HGF

Cows in their mid-lactation period earlier selected for this research were employed for this study. Milk was harvested between 07:00 – 08:30hr daily by hand. The total amount of milk yielded was recorded as each day's milk volume. Prior to each day's milking, the calves were separated from the dams at night, the calves get returned to their dams after each day's milk.

2.10.1 Milk sampling

Samples (5ml) from daily milk yield were collected on day 50 of the feeding trial to evaluate the milk composition. The samples were analyzed for milk temperature and lactose content, milk fat, solid non-fat (SNF), and milk protein.

3.0 RESULTS AND DISCUSSION

3.1 Proximate Composition of HGF

Table 1 shows the proximate composition of the HGF fed to the lactating cows. The results showed that the DM content of feed ranged from 24.22g/100g – 29.91g/100g, the values vary significantly ($P<0.05$). Maize had the highest DM content (29.91%) while the lowest value was reported for millet. The high value of DM reported for maize may be attributable to the stronger seed coat and low surface area of its seed for water imbibition. The crude protein (CP) values differ significantly ($P<0.05$) and ranged from 17.65% (Maize) to 21.60% (Sorghum). The CP values obtained for HGFs are higher than the values reported by National Research Council (NRC, 2007) as requirement (8% CP) for rumen functioning, this indicates that HGFs can supply adequate protein needed for maintenance and production.

The crude fibre (CF) values vary significantly ($P < 0.05$) and ranged from 19.15% (Millet) to 23.13% (Maize), high crude fibre content reported for maize fodder may be due to the high cell wall content of the seed and the bogus intertwined fodder mat. Ether extract (EE) content which is an indication of the oil content in a feed was significantly lowest in maize fodder and highest in Sorghum (4.68%). The ash content for maize and millet was significantly ($P < 0.05$) higher than sorghum, this indicates higher inorganic matter contents for maize and millet than sorghum. The Nitrogen free extract (NFE) values obtained in this study were similar and ranged from 46.31% to 46.88%, NFE indicates the percentage composition of water-soluble carbohydrates (WSC) in a feed, the WSC signifies possible energy availability for the animals.

3.2 Mineral composition of HGF

Lack of minerals in the diet of animals will lead to a poor appetite, a dull coat, poor growth and reduced fertility. An animal will lick all kinds of objects and even try to eat them in search of extra minerals (Pica). Presented in Table 2 is the mineral composition of HGF. Six (6) elements were determined. There were no significant ($P>0.05$) differences for values of calcium and phosphorus obtained for the fodders. Calcium is a necessary constituent of the bones and teeth and is essential for regular heart action and muscular activity and phosphorus (P) is an essential part of blood and of all cells in the body. P is involved in chemical reactions which release energy in the body. Bones and teeth contain relatively large amounts of phosphorus as well as calcium. Calcium and phosphorus are interrelated in their functions and metabolism.

The other four (4) microminerals (Zinc, manganese, magnesium and iron) reported in the study vary significantly ($P<0.05$) among the fodders, however, the minerals performed similar functions like activators and co-enzymes during several metabolisms in the animal body. Zinc has been reported to function in free radical destruction, membrane stability of red blood cells, metabolism of essential fatty acids, carbohydrate metabolism, protein synthesis, metabolism of nucleic acids, among others (McCall *et al*., 2000 and Stefanidou *et al.,* 2006).

3.3 Fibre Fractions of HGF

Presented in Table 3 is the fibre fractions of the HGFs. The Neutral detergent fibre (NDF) values obtained in this study ranged from 52.85% (millet) - 65.54% (maize). NDF indicates the bulkiness of a feed which is directly related to the intake of the feed, also the high NDF value reported for maize fodder may be attributed to the high crude fibre content reported in Table 1. The highest value for acid detergent fibre (ADF) was recorded for maize fodder (48.63%) while the least ADF content was recorded for millet (35.41%), the high ADF suggests a possible low digestibility for animals. The Acid detergent lignin (ADL) values ranged from 11.12% (millet) to

13.79% (maize). The cellulose content which is a major cell wall constituent reported for this study was significantly higher for maize and sorghum (34.84% and 32.88% respectively) than millet.

Table 1: Proximate Composition (%) of Hydroponically Grown Fodders

Parameters (%)	Maize	Millet	Sorghum	SEM	P value
Dry matter	29.91[a]	24.22[c]	27.53[b]	0.83	<0.0001
Crude protein	17.65[c]	19.22[b]	21.60[a]	0.58	<0.0001
Crude fibre	23.13[a]	21.22[b]	19.35[c]	0.57	0.0005
Ether extract	3.40[c]	4.12[b]	4.68[a]	0.19	<0.0001
Ash	8.94[a]	9.13[a]	7.78[b]	0.22	0.0015
Nitrogen free extract	46.88	46.31	46.60	0.19	0.5359

[a, b, c, d]: Means within each row with different superscripts are significantly different (P< 0.05) SEM: Standard error of the mean; P value: Probability value.

Table 2: Mineral Composition of HGFs

Parameter(s)	Maize	Millet	Sorghum	SEM	P value
Calcium (%)	0.23	0.25	0.24	0.01	0.2559
Phosphorus (%)	0.33	0.34	0.35	0.01	0.6550
Magnesium (%)	0.23[b]	0.26[a]	0.27[a]	0.00	0.0005
Iron (mg/kg)	114.70[ab]	97.63[b]	121.57[a]	4.59	0.0636
Zinc (mg/kg)	57.53[a]	44.03[b]	56.63[a]	2.46	0.0104
Manganese (mg/kg)	30.17[b]	33.47[b]	45.50[a]	2.53	0.0033

[a, b, c, d]: Means within each row with different superscripts are significantly different (P< 0.05) SEM: Standard error of the mean; P value: Probability value.

Table 3: Fibre Fractions of HGFs

Parameters (%)	Maize	Millet	Sorghum	SEM	P value
Neutral detergent Fibre	65.54[a]	52.85[c]	61.26[b]	1.88	<0.0001
Acid detergent Fibre	48.63[a]	35.41[c]	44.05[b]	1.97	<0.0001
Acid detergent lignin	13.79[a]	11.17[b]	11.12[b]	0.47	0.0026
Cellulose	34.84[a]	24.29[b]	32.88[a]	1.65	<0.0001
Hemicellulose	16.91	17.43	17.21	0.21	0.6575

[a, b, c, d]: Means within each row with different superscripts are significantly different (P< 0.05) SEM: Standard error of mean; P value: Probability value.

3.4 *In vitro* gas production characteristics of HGF and selected forages

Presented in Table 4 is the total gas production volume for incubated HGF and some selected fodders. The total gas volume was highest ($P<0.05$) for maize and millet (36.00 and 35.33ml/200mg) followed by sorghum fodder (32.67ml/200mg) at 24 hours of incubation. The lower value reported for sorghum fodder may be due to the relatively high ether extract content than other fodders. However, all HGFs recorded higher ($P<0.05$) gas volume than the native pastures (Guinea grass, Elephant grass and Lablab had 19.5, 14 and 17.5ml/200mg respectively). Higher gas volume produced from the incubation of HGFs indicated rapid degradation/digestibility of HGFs by the rumen microorganism. High gas volume is an indication of good digestibility, from the result it can be said that HGFs demonstrated 100% superiority to the native pastures in terms of rumen degradation.

Figure 1 shows the graphical representation of the gradual gas production volume over the period of 24 hours. It presented the distinctive trend of gas production for the HGF above the native pastures from the onset of incubation. Also, the result presented in Table 5 showed that maize, millet and sorghum fodders had similar methane volumes (28.27, 31.4 and 28.27% respectively) from the total gas produced while Guinea grass, Elephant grass and Lablab recorded 51.3, 50 and 53.4% respectively of methane (CH_4) volume in the total gas produced. Methane is regarded as energy loss to the animals and implies that HGF was able to reduce methane emissions from enteric fermentation by 50% when compared to the native pastures. CH_4 is one of the greenhouse gases (GHG) that contribute to climate change. Reducing enteric emission of CH_4 is crucial to the climate-smart livestock production system. From this study, feeding of HGF in cattle posed as a way of reducing CH_4 emission from cattle.

Other *in vitro* gas characteristics parameters such as metabolizable energy, organic matter digestibility (OMD) and short-chain fatty acids (SCFAs) indicated that HGFs had higher ($P<0.05$) values than the native forages, these parameters are directly linked to HGFs potential of providing higher energy to the animals. *In vitro* OMD reveals the proportion of organic matter in the feed that apparently gets digested in the rumen, the higher OMD values recorded for HGFs indicated the superiority of HGFs to native pasture in terms of digestibility. Also, the higher SCFA values recorded for HGF signify their potential at increasing the milk quality in dairy production, this is because the SCFAs are present in the regulatory functions of the lipids, cholesterol and glucose metabolism.

Table 4: *In vitro* Gas Production Volume of HGFs and Selected Forages

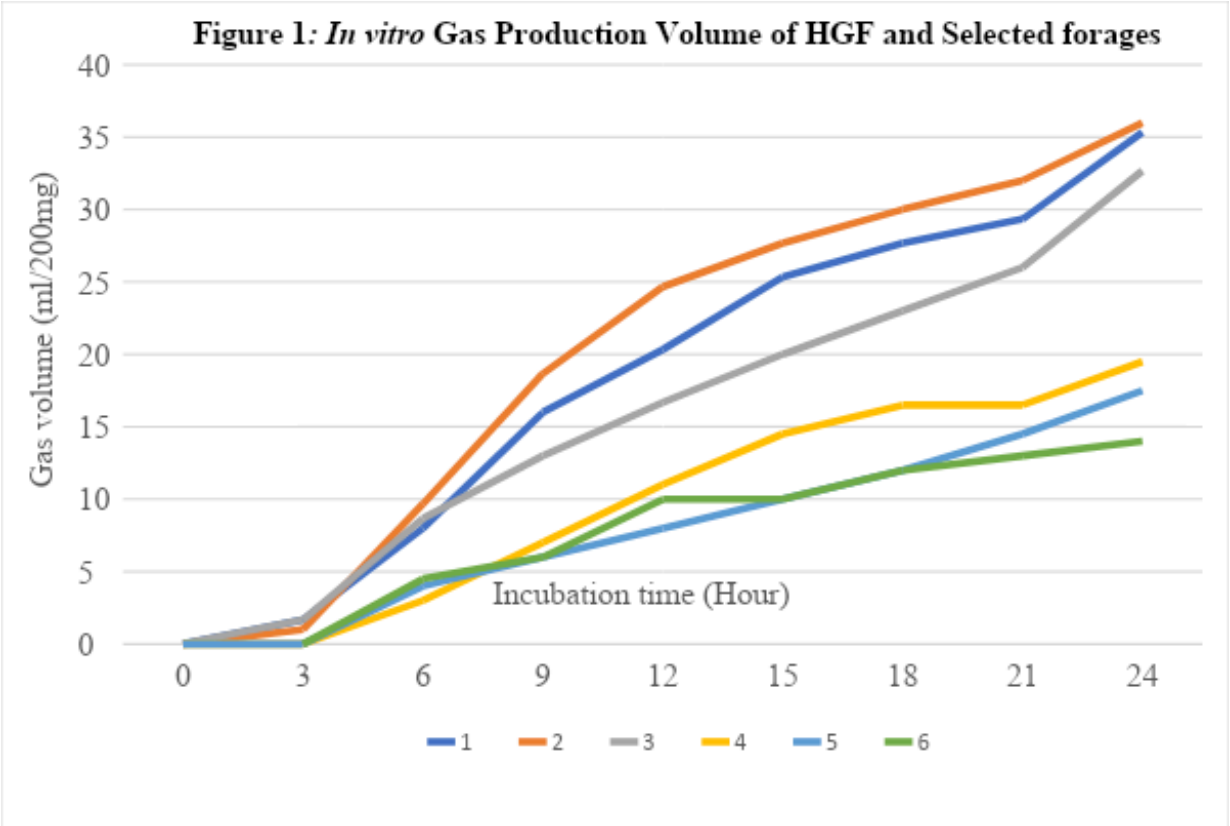
	Feed							
Incubation time (Hour)	**1**	**2**	**3**	**4**	**5**	**6**	**SEM**	**P value**
0	0.00	0.00	0.00	0.00	0.00	0.00	-	-
3	1.67^{a}	1.00^{b}	1.67^{a}	0.00^{c}	0.00^{c}	0.00^{c}	0.19	<0.0001
6	8.00^{b}	9.67^{a}	8.67^{ab}	3.00^{d}	4.00^{cd}	4.50^{c}	0.64	<0.0001
9	16.00^{b}	18.67^{a}	13.00^{c}	7.00^{d}	6.00^{d}	6.00^{d}	1.25	<0.0001
12	20.33^{b}	24.67^{a}	16.67^{b}	11.00^{d}	8.00^{e}	10.00^{d}	1.47	<0.0001
15	25.33^{b}	27.67^{a}	20.00^{c}	14.50^{d}	10.00^{e}	10.00^{e}	1.70	<0.0001
18	27.67^{b}	30.00^{a}	23.00^{c}	16.50^{d}	12.00^{e}	12.00^{e}	1.75	<0.0001
21	29.33^{b}	32.00^{a}	26.00^{c}	16.50^{d}	14.50^{e}	13.00^{f}	1.83	<0.0001
24	35.33^{a}	36.00^{a}	32.67^{b}	19.50^{c}	17.50^{d}	14.00^{e}	2.20	<0.0001
CH_4	10.00^{ab}	11.33^{a}	8.00^{cd}	10.00^{ab}	9.33^{bc}	7.00^{d}	0.40	0.0019

1: Maize; 2: Millet, 3: Sorghum, 4: Panicum maximum, 5: Lablab; 6: Pennisetum purpurem.
$^{a, b, c, d}$: Means within each row with different superscripts are significantly different (P< 0.05)
SEM: Standard error of the mean; P value: Probability value.

Table 5: *In vitro* Gas Characteristics of HGF and Selected Forages

	Feed							
Incubation time (Hour)	**1**	**2**	**3**	**4**	**5**	**6**	**SEM**	**P value**
Methane (ml/200mg)	10.00^{ab}	11.33^{a}	8.00^{cd}	10.00^{ab}	9.33^{bc}	7.00^{d}	0.40	0.0019
Methane (%)	28.27^{b}	31.48^{b}	28.27^{b}	51.30^{a}	53.36^{a}	50.00^{a}	3.00	<0.0001
ME (Mj/KgDM)	8.05^{ab}	8.23^{a}	7.91^{b}	5.36^{d}	5.60^{c}	4.80^{e}	0.35	<0.0001
OMD (%)	60.07^{b}	61.49^{a}	58.71^{c}	41.69^{e}	43.74^{d}	40.02^{f}	2.24	<0.0001
SCFA (µmol/200mgDM)	0.78^{a}	0.80^{a}	0.72^{b}	0.41^{c}	0.36^{d}	0.27^{e}	0.56	<0.0001

1: Maize; 2: Millet, 3: Sorghum, 4: Panicum maximum, 5: Lablab; 6: Pennisetum purpurem.
ME: Metabolizable Energy, OMD: Organic matter digestibility, SCFA: Short-chain fatty acid.
$^{a, b, c, d}$: Means within each row with different superscripts are significantly different (P< 0.05)
SEM: Standard error of the mean; P value: Probability value.



1: Maize; 2: Millet, 3: Sorghum, 4: Panicum maximum, 5: Lablab; 6: Pennisetum purpurem

3.5 Haematological Indices of Lactating White Fulani Cows fed HGF

Table 6 shows the haematological indices of the lactating cows fed HGF. The haematological indices are indicators used to evaluate the immune status and nutrient absorption and efficiency in animals. The mean value (23.71%) for packed cell volume (PCV) obtained for the HGF group before the experiment was below the normal physiological range (24 -46%) (Talal *et al*., 2020), however, the PCV values (26.87%) improved after the experiment for the HGF. Low PCV values are indication of anaemia (low red blood cell content) for the animals. Similarly, the red blood cell (RBC) value (4.90×10^{12}/l) reported for animals in the HGF group was below the normal physiological range (5-10 $\times 10^{12}$/l) before the commencement of the feeding trial. The low RBC value confirmed the anaemic status of the animals before the experiment, the RBC value (5.42×10^{12}/l) improved after the feeding trial. This improvement in the RBC values suggests the feeding of HGF as a healthy feed with the capacity of improving the health status of the animals.

The White blood cell (WBC) values reported for the dietary treatment were within the normal physiological range (4 -12 $\times 10^{9}$/l) (Talal *et al*., 2020) and the values were similar to the values (6.25 - 10.85 $\times 10^{9}$/l) reported by Ewuola *et al*. (2017). The RBC indices, mean corpuscular volume (MCV), Mean corpuscular Haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) values for both groups before and after the experiment were within the ranges reported by Talal *et al.,* 2020 for cattle. However, the MCHC value (31.79g/dl) obtained for animals in HGF before the experiment was significantly ($P<0.05$) lower than the value (33.73%). The higher MCHC value reported for animals on HGF after the feeding trial indicated sufficient amount of healthy RBC for the animals.

WBC differential counts (lymphocytes, monocytes and neutrophils) obtained before and after the experiments were within the range of value reported by Talal *et al*., 2020. However,

values of lymphocytes recorded for animals on HGF before the feeding trial was significantly ($P<0.05$) higher than values recorded after the feeding trial. Reduction in the lymphocytes value may be due to the reduction in the grazing time of the animals on the HGF diets. Animals are likely to be exposed to different disease causal organisms during grazing. The significantly ($P<0.05$) reduced monocytes values obtained for animals fed HGF after the experiment indicated improved immune responses of the animals.

3.6. Serum Biochemical Responses of Lactating White Fulani Cows fed HGF

The blood glucose level (35.89 – 88.43mg/dl) for animals obtained in this study were within the range of (37 -103mg/dl) reported by Talal *et al.* (2003) for clinically healthy cattle, however, there was significant ($P<0.05$) increment in the blood glucose obtained after the feeding trial for animals on HGF. This increment may be attributed to the high metabolizable energy and SCFA of the HGF which impacted the glucose anabolism in the body. Also, animals on HGF diets had significantly ($P<0.05$) higher blood glucose than animals on the control diet at the end of the feeding trials.

The total protein observed for the cows before and after the feeding trials were within the range of 6.0 – 8.7g/dl reported by Talal *et al*. (2020). The mean values of total protein obtained in this study were higher than the values reported by Ewuola *et al*. (2017). Serum proteins are not related to calories contained in the diets, serum protein only depicts the availability of protein for the body's functioning. The serum albumin and globulin range (2.92 - 3.25g/dl and 4.13 – 4.47g/dl respectively) obtained from this study were within the normal physiological range reported by Talal *et al*., 2020. Differences in serum biochemical parameters may be caused by nutrition, environment and hormonal factors. The liver function enzymes (ALT, ASP and ALP) obtained in this study were within the normal physiological range, this revealed that feeding of HGF does not have any deleterious effect on liver function.

Table 6: Haematological Indices of Experimental Animals fed HGF

Parameter(s)	Time	HGF	Control	SEM	P value
PCV (%)	Before	23.71	25.00	1.45	0.7866
	After	26.87	25.60	1.64	0.7217
	P value	0.3213	0.9049		
RBC ($\times 10^{12}$/l)	Before	4.90	5.30	0.32	0.6646
	After	5.42	5.58	0.31	0.8165
	P value	0.3979	0.7740		
WBC ($\times 10^{9}$/l)	Before	7.67	7.30	0.98	0.8788
	After	6.18	8.34	0.81	0.2422
	P value	0.3598	0.6870		
Hb (g/dl)	Before	7.99	7.98	0.48	0.8409
	After	8.55	8.30	0.54	0.6294
	P value	0.5901	0.8469		
MCV (fL)	Before	49.09	47.50	0.79	0.3820
	After	48.64	47.37	0.99	0.5970
	P value	0.7812	0.9583		
MCH (g/dl)	Before	15.55	14.78	0.25	0.1875
	After	16.41	15.67	0.35	0.3364
	P value	0.1010	0.3364		
MCHC (g/dl)	Before	31.79	31.03	0.20	0.3262
	After	33.73	33.03	0.28	0.2728
	P value	<0.001	0.0152		
Platelets (%)	Before	239.13	138.20	50.05	0.3626
	After	161.57	168.67	51.97	0.9615
	P value	0.4291	0.8448		
Lymphocytes (%)	Before	67.71	63.33	1.92	0.4725
	After	52.93	53.80	2.10	0.8487
	P value	0.0010	0.1459		
Monocytes (%)	Before	14.71	17.67	1.73	0.3138
	After	25.13	23.40	0.74	0.4276
	P value	<0.0001	0.0707		
Neutrophils (%)	Before	16.29	16.00	1.33	0.9502
	After	21.40	23.40	1.60	0.5603
	P value	0.1007	0.1347		

HGF: Cattle fed HGF, Control: Grazing Cattle without HGF supplementation, SEM: Standard error of mean; P value: Probability value

Table 7: Serum Biochemical Response of Lactating White Fulani Cows fed HGF

Parameter(s)	Time	HGF	Control	SEM	P value
Glucose (mg/dl)	Before	35.89	41.41	3.03	0.0768
	After	88.43	44.40	7.40	0.0146
	P value	0.0151	0.7468		
Total Protein (g/dl)	Before	7.56	7.38	0.23	0.7089
	After	7.33	7.56	0.17	0.6002
	P value	0.5886	0.6742		
Albumin (g/dl)	Before	3.25	2.92	1.02	0.1209
	After	3.20	3.20	0.68	1.0000
	P value	0.7981	0.3400		
Globulin (g/dl)	Before	4.39	4.46	0.17	0.8511
	After	4.13	4.47	0.15	0.4784
	P value	0.4035	0.9894		
Total Bilirubin (mg/dl)	Before	2.54	2.38	0.18	0.6956
	After	2.30	2.00	0.20	0.5835
	P value	0.5090	0.5122		
Direct Bilirubin (mg/dl)	Before	1.66	1.52	0.08	0.2349
	After	1.31	1.63	0.09	0.9199
	P value	0.0329	0.6516		
ALP (U/L)	Before	28.13	44.04	3.07	0.0227
	After	29.19	22.4	4.32	0.4470
	P value	0.8555	0.0281		
AST (U/L)	Before	117.71	96.33	6.53	0.0836
	After	117.27	144.80	10.77	0.3054
	P value	0.9739	0.0399		
ALT (U/L)	Before	44.60	41.00	2.27	0.4536
	After	37.71	37.00	1.72	0.9109
	P value	0.1127	0.5552		

ALP: Alkaline Phosphatase, AST: Aspartate aminotransferase, ALT: Alanine transaminase, P value: Probability value, *HGF: Cattle fed HGF, Control: Grazing Cattle without HGF supplementation, SEM: Standard error of the mean; P value: Probability value*

3.7 Apparent Nutrient Digestibility of Lactating White Fulani Cows fed HGF

Presented in Table 8 is the apparent nutrient digestibility of lactating cows fed HGF. Dry matter intake and dry matter digestibility are said to be dependent on the cell wall constituents, especially neutral detergent fibre, acid detergent fibre and lignin (Bakshi and Wadhwa, 2004). The dry matter digestibility recorded in this study ranged from 70.37 – 77.91% were higher than the values (59.76 – 64.31%) reported by Soyelu and Aderibigbe (2020) for zero-grazed White Fulani cattle. However, the apparent digestibility of crude protein range of values reported in this study were similar to the values reported by Soyelu and Aderibigbe (2020). In general, the high digestibility values recorded in this study are indications that the HGF were well degraded in the rumen and the absorption by the animals was optimal.

3.8 Growth Performance of Lactating Cows fed HGF

Presented in Table 9 is the growth performance of experimental animals. ADFI reported for this study was 19.07 kg/day/cow, this high value might be attributed to the low crude fibre content, low dry matter content and presumed high palatability of the hydroponic fodder. Babayemi and Bamikole, (2006) stated the impact of palatability on feed intake. Positive weight gain was reported for all experimental units, this indicates that the HGF was sufficient for basal metabolism and growth. The results obtained for the average daily gain (ADG) varied significantly between the dietary treatments, HGF recorded higher ($P<0.05$) values than animals on the control diet.

Mean values of ADG (0.585kg/day) obtained in this study for animals supplemented with HGF were similar to the range of values reported (0.40 -0.66 kg/day) by Jokthan *et al*. (2013) for White Fulani bulls during a fattening programme. Also, the mean feed conversion ratio (20.31) obtained for animals on HGF was similar to the range of values reported by Jokthan *et al.*, 2013

and Soyelu and Aderibigbe (2020). The high ($P<0.05$) crude protein intake (Table 1) might be responsible for the better conversion recorded by animals on HGF and the high average daily gains.

Table 8: Apparent Nutrient Digestibility of Lactating White Fulani Cows fed HGF

Parameter (s)	**Values % (Mean (range))**
DDM	74.34 (70.37, 77.91)
DCP	77.09 (71.66, 80.43)
DCF	74.26 (73.59, 75.27)
DEE	77.33 (74.56, 80.34)
DASH	28.35 (15.75, 48.17)
DNFE	86.36 (84.11 90.28)
DNDF	61.55 (60.22, 62.27)
DADF	54.02 (49.35, 61.09)
DHEMICEL	73.86 (71.66, 76.36)
DCELL	82.07 (81.04, 82.81)
DADL	15.71(13.09, 19.83)
Nitrogen	
Urinary	1.09 (0.98, 1.18)

DDMI: Digestibility Coefficient of dry matter; DCPI: Digestibility coefficient of crude protein; DCFI: Digestibility coefficient of crude fibre; DEEI: Digestibility coefficient of ether extracts; DASH: Digestibility coefficient of ash; DNFE: Digestibility coefficient of nitrogen free extract; DNDFI: Digestibility coefficient of Neutral detergent fibre DADFI: Digestibility coefficient of Acid detergent fibre; DHEMICELI: Digestibility coefficient of Hemicellulose; DADLI: Digestibility of Acid detergent lignin.

Table 9: Growth Performance of Lactating White Fulani cows fed HGF

Parameter(s)	HGF	Control	SEM	P value
Average initial live weight (kg)	260.04 ± 27.34	241.47 ± 29.01	5.91	0.1239
Average final live weight (kg)	292.80[a] ± 30.48	250.77[b] ± 28.30	7.32	0.0024
Total weight gain (kg)	32.76 [a] ± 12.52	9.29[b] ± 4.66	3.12	<0.0001
Average daily gain (kg/day)	0.585 [a] ± 0.22	0.166[b] ± 0.08	0.06	<0.0001
Feed conversion ratio	20.31± 6.77	-	-	-
Average daily feed intake(kg/day)	19.07 ± 2.43	-	-	-

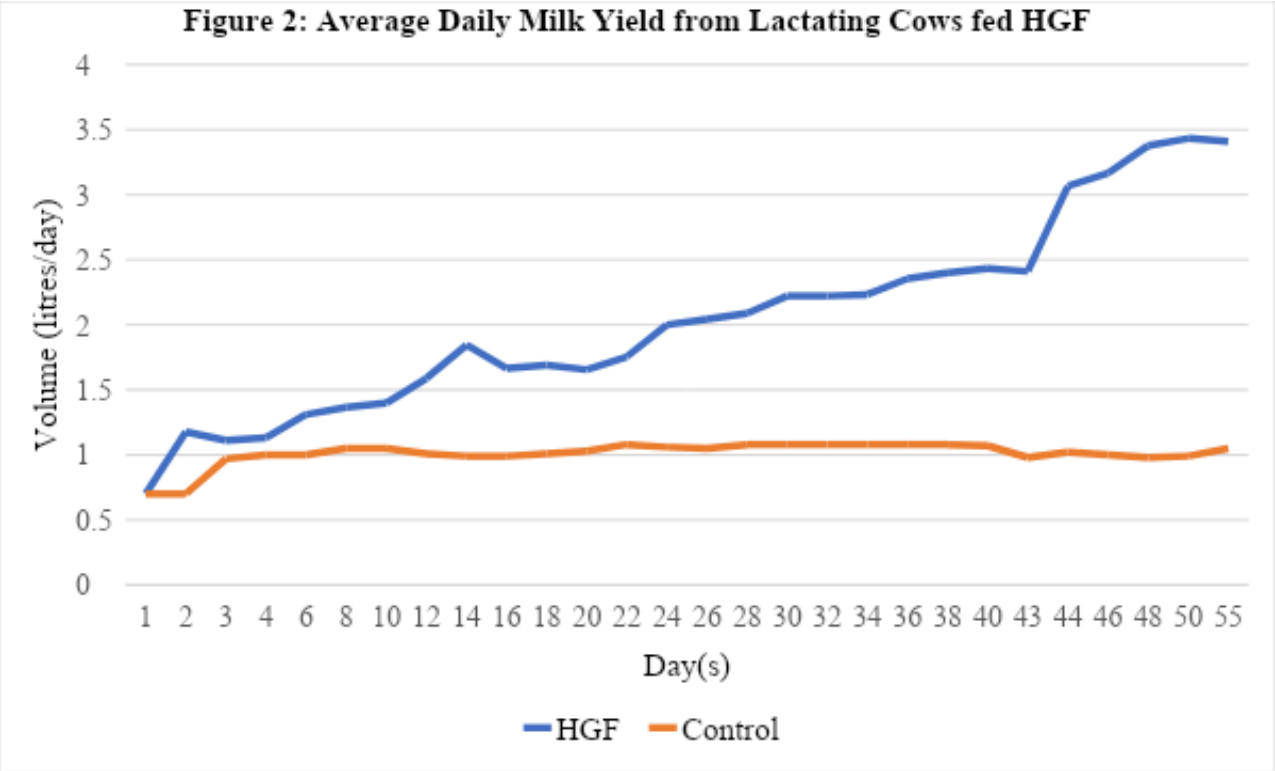
[a, b, c, d]: Means within each row with different superscript are significantly different (P< 0.05) HGF: Cattle fed HGF, Control: Grazing Cattle without HGF supplementation, SEM: Standard error of mean; P value: Probability value.

3.9 Milk Yield and Composition of Lactating White Fulani cows fed HGF

Figure 2 shows the graphical representation of the daily changes in the milk yield of cows fed HGF. For the Baseline data we gathered from the farmers, it was obtained that the average daily milk yield was 0.7 litre/day/cow. However, these values were influenced by the season of the year. The research took place in the peak of the dry season (December 2022 – February 2023). It can be observed that there was an upward progression in the milk yield of the cows on the HGF diet, this was different for the control diet as the animals maintained the threshold of 1 l/day/cow.

Table 10 presents the average milk composition and yield from cows fed with or without HGF. The daily milk yield (3.00 – 4.60l/day/cow) for animals supplemented with HGF was significantly ($P<0.05$) higher than the values (0.80 – 1.20 litres/day/cow) observed for animals on the control diet. Milk yield values obtained in this study for cows fed supplemented HGF were higher than values (1.47 – 2.23 l/day) reported for grazing White Fulani cows supplemented with concentrate (Tona *et al*., 2017). The increase in milk yield values reported for animals on HGF can be attributable to the high nutritive value of the fodder presented in Table 1.

Furthermore, Table 10 highlighted the superiority of the milk composition for cows fed HGF to the cows on the control diet. All milk quality parameters observed except for temperature and salts/minerals were significantly ($P<0.05$) higher than values reported for cows without HGF supplementation. The improved quality of the milk can be attributable to the high nutritive value of the fodder and its capacity for easy digestibility and utilization by the animals. The high fermentable carbohydrate and SCFA reported for the HGF may be responsible for the high protein and fat value content of the milk obtained from the animals in the dietary treatment.



HGF: Cattle fed HGF, Control: Grazing Cattle without HGF supplementation.

Table 10: Milk Yield and Composition of Lactating White Fulani cows fed HGF

Parameters	HGF	Control	SEM	P value
Milk Volume				
Day 1 (litre/day)	0.70	0.70		-
Day 56 (litre/day)	3.49 (3.00, 4.60)	0.99 (0.80, 1.20)		<0.0001
Milk Quality				
Fat (%)	3.80[a]	1.91[b]	0.27	0.0016
Solid-Non-fat	9.87[a]	8.26[b]	0.24	0.0031
Corrected lactometer reading	34.45	33.35	0.69	0.5249
Temperature (°C)	28.14	28.83	0.35	0.4270
Protein (%)	3.56[a]	3.00[b]	0.08	0.0028
Lactose (%)	5.24[a]	3.77[b]	0.17	<0.0001
Salts (%)	0.76	0.75	0.02	0.5667

HGF: Cattle fed HGF, Control: Grazing Cattle without HGF supplementation, P value: Probability value.

4.0 CONCLUSION AND RECOMMENDATION

From the result of this study, it can be concluded that:

1. HGFs have high nutritive values, making them optimal and fit for ruminant feeding.
2. The nutritive contents of HGF are easily digestible and gives better *in vitro* gas production characteristics than some selected native pastures.
3. Feeding of HGF has a positive impact on the environment as it can reduce enteric methane emission for grazing cattle by 50%
4. All growth performance indices for cows fed HGF were better than the animals on the control diet.
5. Feeding of HGF improved milk yield (400% increase) and composition of lactating white Fulani cows.

Recommendation

a) HGF poses as a driver to turn around the beef and dairy sectors in Nigeria, hence its production and feeding should be promoted.

b) The sustainability plan and a business model for delivering HGF to farmers should be developed in Nigeria.

c) Development and further exploration of a "Hydroponically grown fodders" value chain should be activated to combat climate change and the incessant clashes between the crop farmers and the herders.

d)

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