Trop Anim Health Prod (2015) 47:339–346
DOI 10.1007/s11250-014-0725-z

REGULAR ARTICLES

Feed intake, digestibility, growth performance, and blood profile of pigs fed mixtures of dried and ground fig (*Ficus sur*) fruits and graded levels of maize

Diriba Diba · Yoseph Mekasha · Mengistu Urge · Adugna Tolera

Received: 24 December 2013 / Accepted: 18 November 2014 / Published online: 10 December 2014

Abstract This study was conducted to examine the effect of feeding a mixture of different proportions of *Ficus sur* fruits (FSF) and ground maize grain (MG) on intake, digestibility, growth, and blood profile on Yorkshire pigs. Dietary treatments comprised 100 % FSF and 0 % MG (100FSF), 67 % FSF and 33 % MG (67FSF), 33 % FSF and 67 % MG (33FSF), and 0 % FSF and 100 % MG (0FSF). Noug cake and soybean meal were included to meet nutrient requirement of the animals at isonitrogenous (18 % crude protein (CP)) level with graded levels of energy. Twenty pigs with an average initial weight of 27.75±1.4 kg were grouped according to their body weight, and animals from each group were randomly assigned to four dietary treatments. There was no difference ($P>0.05$) in dry matter, crude protein, and metabolizable energy intakes among the treatments. Organic matter ($P<0.05$), ether extract ($P<0.01$), and nitrogen-free extract (NFE) intakes were higher ($P<0.0001$) for pigs fed with 0FSF than 100FSF. The digestibility of dry matter, crude protein, ether extract, and NFE did not differ ($P>0.05$) among treatments. However, organic matter digestibility ($P<0.05$) was highest for pigs in 0FSF than 100FSF. Conversely, crude fiber digestibility was in the reverse trend. No significant differences were observed in body weight gain among treatments ($P>0.05$). The blood counts and sera metabolites of pigs across the treatments fall within the optimum range. Packed cell volume (PCV) and hemoglobin (Hgb) were higher, but creatinine and cholesterol concentrations were lower in 100FSF than 0FSF indicating better health conditions in pigs fed with FSF. It is, therefore, concluded that feeding FSF has comparable effects with MG on the metabolic performance, growth, and blood profile of pigs.

Keywords *Ficus sur* fruits · Blood profile · Growth performance · Maize grain · Pigs

D. Diba (✉)
Department of Animal Sciences, Wollega University, P.O. Box 395, Nekemte, Ethiopia
e-mail: dnazerawi2010@gmail.com

Y. Mekasha · M. Urge
School of Animal and Range Sciences, Haramaya University, P.O. Box 138, Dire Dawa, Ethiopia

A. Tolera
School of Animal and Range Sciences, Hawassa University, P.O. Box 05, Hawassa, Ethiopia

Y. Mekasha
International Livestock Research Institute, P.O. Box 5689, Addis Ababa, Ethiopia

Introduction

Pigs are important domestic animal with high prolificacy, short gestation periods, and fast growth rates. Thus, they are highly productive and biologically efficient animals (Kyriazakis and Whittemore 2006). In Ethiopia, there is an increasing trend for pig meat due to increasing population and increasing number of foreigners and the effects of globalization associated with behavioral change among youngsters for consumption of pork.

Nutritional problem is the main constraint affecting livestock productivity in Ethiopia (Adugna 2007; Lanyasunya et al. 2005). Pigs are most often dependent on cereal crops such as maize grain, which is a staple food for human beings. However, no research work has been conducted to address the challenges of pig nutrition in Ethiopia. It is, therefore, reasonable to search for alternative feed resources with minimal competition with humans. In this regard, the use of non-conventional local feed resources (Ocampo et al. 2005) like *Ficus sur* fruits (FSF) would be very important to support pig production. *F. sur*, commonly known as fig tree, is widely distributed in different parts of the tropics and its fruits used as livestock feed for centuries. During periods of severe feed shortage in the dry season, animals freely access and utilize ripen and fallen fruits from *F. sur* tree. However, the feeding value of this potential resource has not yet been systematically studied. The objective of this study was, therefore, to investigate the effect of the inclusion of the graded levels of dried and ground FSF in the ration on feed intake, digestibility, growth performance, and blood profile of pigs.

Materials and methods

Study site

The experiment was conducted at Haramaya University (HU), 9° 26′ N latitude and 42° 3′ E longitude, eastern Ethiopia. The altitude of the area is about 1980 m.a.s.l., and the mean annual rainfall is about 910 mm with a range of 560–1260 mm. The mean maximum and minimum temperatures are 23.4 and 8.25 °C, respectively (Haramaya University Meteorological Station 2012 summary report).

Experimental design and treatments

The experiment was laid out in a randomized complete block design with four treatments and five replications (Table 1). Dietary ingredients were composed of dried *F. sur* fruits (FSF) and maize grain (MG) while noug (*Guizotia abyssinica*) seed cake and soybean meal were included to meet the nutrient requirements of pigs at isonitrogenous levels but with the graded levels of energy. Treatments comprised 100 % FSF and 0 % MG (100FSF), 67 % FSF and 33 % MG (67FSF), 33 % FSF and 67 % MG (33FSF), and 0 % FSF and 100 % MG (0FSF) as described in Table 1.

Table 1 Gram ingredients and their chemical compositions in formulating the experimental diets

Ingredients (g)	Diets (DM basis)			
	100FSF	67FSF	33FSF	0FSF
Ficus sur fruit	1080	724	356	0
Noug seed cake	435.6	396	360	315
Soybean meal	234	216	194	180
Maize grain	0	356	724	1080
Chemical composition (%)				
DM	91.5	91.2	90.9	90.6
Crude protein	18.2	18.3	18.4	18.5
Ash	6.68	6.56	6.27	5.96
Crude fiber	17.3	14.5	11.5	8.15
Ether extract	7.15	7.04	6.91	6.81
Nitrogen-free extract	52.5	54.2	58.2	62.5
Calculated ME (MJ/kg DM)	11.6	11.7	11.8	12.1

FSF Ficus sur fruits, *g* gram, *DM* dry matter

Animals and management

Twenty growing Yorkshire male pigs with an average initial live weight of 27.75±1.4 kg (mean±SD) were selected from the university pig production and training center for the study. The pigs were dewormed with *ivermectin* injection, vaccinated against foot and mouth disease (FMD), and sprayed with *diazinon* at a 2-week interval for the control of external parasites. The pigs were grouped according to their initial body weight and randomly assigned to four dietary treatments within each group. They were housed in individual pens and adapted to the experimental diets for a week before the commencement of the actual experiment, which lasted for 3 months.

Feeds and feeding management

Mature and dry FSF was collected from different trees in Horro district, western Ethiopia, during the dry season (February to April 2012), bulked, packed in clean sacks, and transported to HU. It was sun dried for 4 days to remove extra moisture and ground in a grain mill at HU dairy farm, sacked, and stored in a dry room.

During the feeding trial, the animals were offered the measured quantity of diet. The daily diet offer was increased fortnightly based on their average live weight change. Clean water was offered ad libitum. The amount of feed offered and leftover were recorded every day. Daily feed intake was calculated as the difference between feed offered and leftover on dry matter (DM) basis. Organic matter (OM), crude protein (CP), crude fiber (CF), ether extract (EE), nitrogen-free extract (NFE), and metabolizable energy (ME) intakes were also calculated following a similar method.

Growth performance

The individual live weight of the animals was measured every fortnight before offering the morning feed using a balance with sensitivity of 10 g and maximum weighing capacity of 100 kg. The last fortnight weight of the animals was taken as a final live body weight. As all the experimental units were healthy and safe until the end of the experiment, the total weight gain was calculated as the difference between the final and initial weights of the animals. The average daily weight gain (ADG) was calculated by dividing the total weight gain by the number of feeding days.

Digestibility experiment

This experiment was conducted at the end of the growth study. Feed intake was recorded following a similar procedure used in the growth experiment. The samples of feed offer and leftover were collected, bulked, and sub-sampled at the end of the trial for chemical analysis. To determine the nutrient apparent digestibility, total fecal collection method was employed using the same pigs used in the growth experiment. Animals were adapted to carrying fecal collection bags for 3 days followed by 5 days of fecal collection. The quantity of feces collected each morning was recorded for each animal, thoroughly mixed, and about 20 % was sampled and kept at −20 °C in deep freeze pending chemical analysis. The frozen feces was thawed, thoroughly mixed, sub-sampled, and divided into two portions. One of the portions was oven dried at 105 °C for 24 h for partial DM determination. The remaining samples were dried at 65 °C to constant weight in a forced draft oven and ground to pass through 1-mm sieve size for chemical analysis.

Chemical analysis

The chemical analysis for each sample was performed in replicates. Dry matter, ash, CF, and EE of the feed samples were determined following the procedure of AOAC (1995). The N content of the samples was determined by the micro-Kjeldahl method, and CP was calculated as N×6.25. The NFE was determined by difference as 100−(%Ash+%CP+%CF+%EE). The metabolizable energy (MJ/kg DM) of the samples was estimated by conversion factors from its apparent DM digestibility as ME=0.17×DDM%−2.0 (Moran 2005).

Blood profile

Blood samples were taken from all animals in each treatment after fasting for 8 h (Theml et al. 2004). About 10 ml of blood was taken from the veins on the ear into heparinized vacutainer tube (5 ml) for the determination of packed cell volume (PCV) and blood cell counts (red and white blood cells), while the remaining 5 ml into anticoagulant-free (plain) tubes for sera metabolites. For PCV determination, fresh blood from the vacutainer tube was filled into a capillary tube of about 75 mm in length and 1.07–1.24 mm in diameter up to the labeled point (Weiss and Wardrop 2010), and one end of the tube was closed with a pliable sealing compound. A micro hematocrit centrifuge (Sussex, UK) having an 8-cm radius was used to spin the specimen in the capillary tubes for 5 min. The PCV was read from PCV tube reader (model AIC 1490). The blood in the plain tube was centrifuged (centrifuge model RCF K40R) to separate the plasma, which was collected into a separate plain tube, sealed, and stored at −20 °C until analysis. Blood urea and glucose were analyzed following El-Kadi et al. (2006) and Pandya et al. (2013) approaches, respectively. Creatinine was determined according to the method followed by Okah and Ibeawuchi (2011), globulin and cholesterol by spectrophotometer (Abdullahzadeh 2012), and total protein concentrations by refractometer (Briend-Marchal et al. 2005).

Red blood cell (RBC) and white blood cell (WBC) counts were determined according to the Neubauer counting chamber (Thrall et al. 2012). Smears for differential leukocyte counts were stained by the Leishman technique, and the different cells of leukocyte series were enumerated by the longitudinal counting method. Hemoglobin (Hgb) concentration was determined according to the procedure followed by Thrall et al. (2012). The mean cell volume (MCV), mean cell hemoglobin (MCH), and mean cell hemoglobin concentration (MCHC) were calculated from the PCV, Hgb, and RBC count (Svoboda et al. 2005) as follows:

$$\mathrm{MCV} = \mathrm{PCV}/\mathrm{RBC}; \quad \mathrm{MCH} = \mathrm{Hgb\ concentration}/\mathrm{RBC}; \quad \mathrm{MCHC} = \mathrm{Hgb(g/dl)}/\mathrm{PCV\ fraction}; \quad \text{where PCV was taken in infraction; RBC was number of red blood cells in a liter of blood; Hgb = hemoglobin.}$$

Statistical analysis

Data on feed intake, digestibility, growth performance, blood constituents, and sera metabolites were stratified into treatments and weight group (block) and analyzed using the general linear model (GLM) procedure of the Statistical Analysis System (2008). Tukey test was used to separate the means.

Results

Chemical composition of feed ingredients

The chemical composition of feeds used in the current experiment is presented in Table 1. There was no significant difference in chemical compositions and ME content between FSF and MG, although NFE content was relatively higher in MG, whereas DM, ash, CF, and EE contents were relatively higher in FSF.

Feed intake

There was increasing trend ($P>0.05$) in DM and CP intake with the decreasing level of FSF inclusion in the diet (Table 2). However, OM intake was significantly ($P<0.05$) higher for pigs fed with 0FSF than those fed with 67FSF and 100FSF. Crude fiber intake increased with increasing inclusion level of FSF ($P<0.001$). Ether extract intake was higher ($P<0.01$) for groups fed with 0FSF than those fed with 67FSF and 100FSF,

Table 2 Dry matter and nutrient intake by pigs fed with mixtures of dried and ground *Ficus sur* fruits and maize grain

Intake (g/day)	Treatments				SEM	SL
	100FSF	67FSF	33FSF	0FSF		
DM	1290.8	1315.3	1335.5	1350.7	24.61	ns
OM	1147.4b	1170.8b	1201.9ab	1236.5a	22.07	*
CP	226.1	226.3	226.6	226.7	1.12	ns
CF	222.2a	191.2b	152.9c	111.0d	3.80	***
EE	87.7b	88.5b	90.3ab	95.2a	1.39	**
NFE	672.4b	708.3b	769.1a	790.1a	12.32	***
ME (MJ/head/day)	8.34	9.10	9.64	10.81	0.31	ns

Means with different letter superscripts within a row are significantly different

DM dry matter, *OM* organic matter, *CP* crude protein, CF crude fiber, *EE* ether extract, *NFE* nitrogen-free extract, *ME* metabolizable energy, *FSF Ficus sur* fruits, *100FSF* 100 % FSF and 0 % MG, *67FSF* 67 % FSF and 33 % MG, *33FSF* 33 % FSF and 67 % MG, *0FSF* 0 % FSF and 100 % MG, *SEM* standard error of mean, *SL* significance level, *ns* non-significant

*$P<0.05$; **$P<0.01$; ***$P<0.001$

and a similar trend was observed for NFE intake ($P<0.001$). The ME intake did not differ ($P>0.05$) among treatment diets.

Digestibility

The apparent digestibility of DM, CP, EE, and NFE did not show significant difference ($P>0.05$) among treatments (Table 3). However, OM digestibility was higher ($P<0.05$) for 0FSF than for 67FSF and 100FSF. Conversely, CF digestibility was higher ($P<0.05$) for 100FSF compared to 0FSF.

Live body weight change

The body weight parameters and feed conversion efficiency (FCE) of pigs fed with the mixtures of FSF and MG are presented in Table 4. There was no significant difference ($P>0.05$) in initial and final body weight, total body weight gain, ADG, and FCE among the dietary treatments.

Blood profile and serum metabolites

The effect of the feeding mixtures of FSF and MG on blood profile and serum metabolites is presented in Table 5. The PCV was slightly higher ($P<0.01$) for pigs in 100FSF than 0FSF. There was no difference ($P>0.05$) among treatments in total RBC count. The Hgb concentration was significantly ($P<0.01$) higher in pigs fed with 100FSF diet compared to those with 33FSF and 0FSF. There was no difference in WBC count, MCV, and MCHC among dietary treatments. Likewise, no difference was observed in glucose, total protein, and albumin among the treatments. Although blood urea and globulin content did not vary, blood creatinine showed increasing trend ($P>0.05$) in magnitude as the inclusion of FSF increased. The cholesterol level was ($P<0.01$) higher for pigs fed with 0FSF ration than those fed with 100FSF.

Table 3 Apparent nutrient digestibility by pigs fed with mixtures of ground *Ficus sur* fruits and maize grain

Nutrient digestibility (%)	Treatments				SEM	SL
	100FSF	67FSF	33FSF	0FSF		
Dry matter	80.1	80.3	81.0	83.2	1.87	ns
Organic matter	83.2b	84.5b	85.4ab	90.5a	1.32	*
Crude protein	78.4	80.0	79.2	81.4	2.00	ns
Crude fiber	70.1a	64.4ab	55.3ab	53.2b	3.59	*
Ether extract	91.6	86.6	86.4	86.0	1.55	ns
Nitrogen-free extract	88.5	89.4	89.4	91.9	0.86	ns

Means with different letters in a row are significantly different

*FSF Ficus su*r fruits, *100FSF* 100 % FSF and 0 % MG, 67FSF 67 % FSF and 33 % MG, *33FSF* 33 % FSF and 67 % MG, *0FSF* 0 % FSF and 100 % MG, *SEM* standard error of mean, *SL* significance level, *ns* non-significant

*$P<0.05$

Table 4 Growth performance of pigs fed with different levels of ground *Ficus sur* fruits and maize grain mixtures

Parameters	Treatments				SEM	SL
	100FSF	67FSF	33FSF	0FSF		
IBW (kg)	25.2	29.1	28.5	28.2	1.40	ns
FBW (kg)	45.8	48.4	49.8	50.8	1.44	ns
TWG (kg)	20.6	19.7	21.3	22.6	0.92	ns
ADG (g)	228.9	236.7	241.1	251.1	10.2	ns
FCE (%)	0.18	0.17	0.18	0.18	0.01	ns

IBW initial body weight, *FBW* final body weight, *TWG* total weight gain, *ADG* average daily gain, *FCE* feed conversion efficiency, *FSF Ficus sur* fruits, *100FSF* 100 % FSF and 0 % MG, *67FSF* 67 % FSF and 33 % MG, *33FSF* 33 % FSF and 67 % MG, *0FSF* 0 % FSF and 100 % MG, *SEM* standard error of mean, *SL* significance level, *ns* non-significant

*$P<0.05$

Discussion

Feed intake

The study showed that there was no difference in DMI among treatments. This shows that FSF has comparable palatability with MG, which could be associated with desirable flavor, fragrance, and sweet taste of FSF. The FSF was readily accepted by the pigs at the first offer. Pigs naturally have a wider appetite (Lekule and Kyvsgaard 2003), and their intake is not negatively influenced by new feed ingredient. The CP intake was similar among the treatments as the animals were offered with isoproteinaceous supplement levels. The higher OM intake of pigs fed with 0FSF could be due to the lower ash content of maize compared to that with 100FSF.

The increased CF intake with increasing FSF level might be due to the higher CF content of FSF than MG and the microbial degradation of the fiber portion of the diet (Williams et al. 2005). This had positive contribution for body weight gain (Kasprzak et al. 2012). Musamba (2011) in his review noted that the optimum level of dietary fiber reduces the energy expenditure of pigs on physical activity and hence contribute to body weight gain. However, the higher level of dietary fiber in pigs' diet was reported to reduce their intake and live body weight gain (Bindelle et al. 2007).

The EE and NFE intake increased as the FSF level decreased from 100FSF to 0FSF with the increasing inclusion of MG in the diet. The higher NFE intake with decreasing FSF level in the diet could be due to relatively higher NFE content in MG compared to FSF. However, the absence of a significant variation among treatments in ME (MJ/head/day) intake indicates the potential of FSF as an energy supplement.

Apparent nutrient digestibility

The absence of difference in DM digestibility (DMD) among treatments, despite the relatively higher CF content of FSF, might be due to the fiber digestion ability of pigs in their large intestine (Williams et al. 2005). The DMD for the feeds used in the present study (80.1–83.2 %) was higher than 77.68–79.96 % reported by other researchers (Fatufe et al. 2007) for pigs fed with cassava peel meal, palm kernel meal, and other mixed ingredients. However, it was less than 82–84 % reported for pigs that consumed different roughages including banana sheaths, copra meal, sweet potato vines, duckweed, and Tofu residues as a fiber source mixed with other concentrate ingredients (Nguyen et al. 2002).

The similarity in the values of CPD between treatments could be attributed to the isonitrogenous levels of the protein source diets in the mix. Nevertheless, the very slight variation observed was probably due to the difference in the digestibility of the protein sources arising from differences in the proportion of the feeds in the dietary mixture, rumen microbes, and products related to their metabolism.

The highest value for CFD in 100FSF diet compared to all other treatments could be due to the higher CF content of the FSF (14.5 %) compared to MG (2 %). This is because, among other factors, the nutrient composition of a given diet affects its digestibility (McDonald et al. 2002).

Growth performance

Even though OMD was highest for 0FSF than 100FSF, the efficiency of pigs to utilize feeds might have narrowed the gap in the body weight change of the animals fed with these dietary treatments (Lekule and Kyvsgaard 2003). The lack of difference in ADG and total body weight change (TWG) among treatments shows that FSF is comparable to MG in supplying nutrients for the acceptable level of ADG in growing pigs.

The ADG and TWG recorded in the current study was less than the values reported by Opapeju et al. (2006) for the same breed of pigs. However, Ani et al. (2013) reported comparable ADG for pigs fed with diets containing graded levels of soybean hull. On the other hand, Ohh et al. (2002) reported lower ADG for pigs fed with mash and pellet diets.

Blood profile

The PCV percentages for all treatments fall within the normal range (40.4–45.2 %) documented previously (Radostits et al. 2006). Arun et al. (2013) reported 28.4–61.3 % for pigs of different breeds. Eze et al. (2010) noted that 36–47 % PCV is to be considered as a standard values for the same pig breeds. Even though these results indicate normal PCV range, the higher value obtained for pigs in 100FSF than for pigs in

Table 5 Blood hematologic characteristics and serum metabolites in pigs fed with mixtures of different proportions of *Ficus sur* fruits and maize grain

Blood parameters	Treatment diets				SEM	SL
	100FSF	67FSF	33FSF	0FSF		
Blood cells and Hgb						
PCV (%)	45.2a	44.8a	42.4ab	40.4b	0.864	*
RBC (10^6/μl)	7.40	7.32	6.76	6.50	0.216	ns
Hgb (g/dl)	13.0a	12.2ab	11.6b	11.4b	0.289	*
MCV (fl)	61.3	61.4	62.3	62.1	2.636	ns
MCH (pg)	17.6	16.7	17.0	17.5	0.469	ns
MCHC (g/l)	28.8	27.3	27.4	28.2	0.987	ns
WBC (103/μl)	6.40	6.20	7.20	7.80	0.756	ns
Blood serum metabolites						
Creatinine (mg/dl)	1.03	1.07	1.15	1.17	0.053	ns
Urea (mg/dl)	42.60	40.20	40.8	41.40	1.663	ns
Cholesterol (mg/dl)	72.2b	72.6b	81.8ab	89.0a	2.790	*
Glucose (mg/dl)	99.6	101.8	104.6	110.2	6.763	ns
Total protein (g/dl)	7.92	7.82	7.77	7.71	0.144	ns
Albumin (g/dl)	4.79	4.78	4.73	4.68	0.114	ns
Globulin (g/dl)	3.13	3.04	3.04	3.03	0.043	ns
Albumin:globulin	1.53	1.58	1.53	1.57	0.029	ns

PCV packed cell volume, *RBC* red blood cells, *Hgb* hemoglobin, *MCV* mean corpuscular volume, *MCH* mean corpuscular hemoglobin, *MCHC* mean corpuscular hemoglobin concentration, *WBC* white blood cells, *FSF Ficus sur* fruits, *MG* maize grain, *100FSF* 100 % FSF and 0 % MG, *67FSF* 67 % FSF and 33 % MG, *33FSF* 33 % FSF and 67 % MG, *0FSF* 0 % FSF and 100 % MG, *SEM* standard error of mean, *SL* significance level, *ns* non-significant

*$P<0.01$

0FSF indicates that pigs in the former treatment were in a better hemoconcentration and well rescued of anemia. Similarly, highest Hgb values were obtained for pigs in 100FSF than those fed with 0FSF. The findings indicate that FSF contains more iron than that of MG. The Hgb concentration obtained in the present study was in the normal range of 4–13 g/dl as documented for pigs by Radostits et al. (2006). Lee et al. (2010) reported that Hgb concentration of 7 g/dl was a minimum borderline for pigs. Thus, the result of the present study was certainly above the amount suggested as minimum. The results for WBC in the current study were consistent with literature (Arun et al. 2013).

The serum creatinine levels (1.03–1.17 mg/dl) for all the treatment diets in this study were at normal levels (1.0–2.7 mg/dl) as reported for pigs (Radostits et al. 2006) suggesting normal kidney physiology for these animals even though serum creatinine alone cannot be used as a single measure of renal function (Johnson 2005). The serum urea content (40.2–42.6 mg/dl) was within a range (21.4–64.2 mg/dl) indicated to be normal range for pigs by Radostits et al. (2006). He et al. (2012) indicated that higher serum urea levels were observed in lean types than obese pigs, and this could be considered as an indication of carcass quality in pigs that received 100FSF diets (42.6 % urea) than 0FSF (41.4 % urea).

The serum cholesterol content of pigs in the present study declined from 0FSF to 100FSF (89 mg/dl to 72.2 mg/dl) indicating that pigs grown on 100FSF diets had better cardiac function than those raised on 0FSF diets provided all other factors affecting the pigs' cardiovascular system were normal. The highest serum cholesterol level for the pigs that received 0FSF diets was still less than the reports of other researchers (93.17–110.56 mg/dl, Kapelański et al. 2004) and 114–115 mg/dl (Adesehinwa et al. 2008).

The glucose level consistently decreased with increase in the level of FSF (99.6 to 110.2 mg/dl). These figures seem lower as compared to 115.08–138.72 mg/dl reported by Buleca et al. (2010) but higher than 87.02–92.02 mg/dl (Adesehinwa et al. 2008). Radostits (2006) suggested the normal physiological range to be within 85–150 mg/dl serum glucose level for pigs of different breeds kept on different diets. Hence, all the pigs grown on all of the treatment diets in the present study had normal serum sugar level, and no indication of stress or diabetes mellitus were suspected. The similarity in the total blood protein profile of pigs could be attributed to the isonitrogenous level of the treatment diets. The albumin to globulin ratios were also not less than 1.00 that indicated the globulin concentration was not abnormally raised as in the cases of hepatic and renal disorders.

Conclusion

The present study showed that FSF contained comparable nutrients to MG. Even though there was a significant difference in some parameters of nutrient intake and apparent digestibility among the treatments, their ultimate effect on growth performance of the pigs was not apparent. All the blood counts and serum metabolites for all dietary treatments were within the normal range. PCV and Hgb were higher but creatinine and cholesterol concentrations were lower in 100FSF than 0FSF (100MG) indicating promising health conditions in pigs that consumed FSF. Therefore, from a biological point of view, we can conclude that FSF can replace MG and used as an alternative energy supplement for pigs at least in smallholder pig production systems of tropical Africa where MG is staple food for human beings.

Acknowledgments We would like to thank Haramaya University for the research facilities and the Swedish International Development Agency (SIDA) for the financial support.

Conflict of interest The authors declare that they have no conflict of interest.

References

Abdullahzadeh, F., 2012. The effect of tomato pomace on carcass traits, blood metabolites and fleece characteristic of growing Markhoz goat. Journal of American Science 8, 848–852

Adesehinwa, A. O. K., Dairo, F. A. S. and Olagbegi, B. S., 2008. Response of Growing Pigs to Cassava Peel Based Diets Supplemented With Avizyme® 1300: Growth, Serum and Hematological Indices. Bulgarian Journal of Agricultural Science, 14, 491–499

Adugna, T., 2007. Feed resources for producing export quality meat and livestock in Ethiopia. Examples from selected woredas from Oromia and SNNP regional states. Hawassa University, Ethiopia, PP: 1–88

Ani A.O., Ezemagu I.E. and Ugwuowo L.C., 2013. Growth Performance of Weaner Pigs Fed Soybean Hull Based Diets. Online Journal of Animal and Feed Research, 3, 137–142

AOAC., 1995. Official Methods of Analysis of AOAC International, 16th edition. Standard compendium of laboratory methods for analyzing foods and related substances; AOAC, Gaithersburg, MD.

Arun, K. D., Kundu, A., Kundu, M.S., Sunder, J. and Jeyakumar, S., 2013. Comparative study on haematological traits of endangered Andaman wild pig and other indigenous pig breeds available at Andaman and Nicobar Islands, India; Veterinary World, 6, 794–798

Bindelle J. , Ilunga Y. , Delacollette M. , Muland Kayij M. , Umba di M'Balu J. , Kindele E., Buldgen A., 2007. Voluntary intake, chemical composition and in vitro digestibility of fresh forages fed to Guinea pigs in periurban rearing systems of Kinshasa (Democratic Republic of Congo); Tropical Animal Health and Production, 39, 419–426

Briend-Marchal A., Médaille, C. and Braun, J.P. 2005. Comparison of total protein measurement by biuret method and refractometry in canine and feline plasma. Revue Méd. Vét., 12, 615–619

Buleca, J. Jr., Húska, M., Reichel, P., Tučková, M. and Mardzinová, S., 2010. Characteristics of Energetic Metabolism Parameters in Mangalica Pig Breed; STOČARSTVO, 64, 107–111

El-Kadi, S. W., R. L. Baldwin VI, N. E. Sunny, S. L. Owens, and B.J. Bequette. 2006. Intestinal protein supply alters amino acid, but not glucose, metabolism by the sheep gastrointestinal tract. J. Nutr., 136, 1261–1269.

Eze, J. I., OnunkwoShoyinka,, J. I., Chah, S. V. O., Ngene, F. K., Okolinta, A. A., Nwanta, J. A. and Onyenwe, I. W., 2010. Haematological Profiles of Pigs Raised Under Intensive Management System in South-Eastern Nigeria; Nigerian Veterinary Journal, 31, 115–123

Fatufe, A. A, Akanbi, I. O., Saba, G. A., Olowofeso, O. and Tewe, O. O., 2007. Growth performance and nutrient digestibility of growing pigs fed a mixture of palm kernel meal and cassava peel meal; Livestock Research for Rural Development, 19(12) 2007; www.lrrd.org/lrrd19/12/fatu19180.htm

Johnson, D., 2005. Evaluation of Renal Function Guidelines: use of serum creatinine concentration to assess level of kidney function, The CARI (Caring for Australians with Renal Impairment) Guidelines; PP: 1–18, Queensland, Australia

Kapelański, W., Salomea G., Maria B., Jolanta K., Anna H. and Joanna W., 2004. Relations between blood serum biochemical indicators and weight gain and fat and lean meat content of carcass in pigs; Animal Science Papers and Reports, 22, 429–434

Kasprzak, M. M., Helle N. L. and Knud E. B. K., 2012. Effects of Isolated and Complex Dietary Fiber Matrices in Breads on Carbohydrate Digestibility and Physicochemical Properties of Ileal Effluent from Pigs. Journal of Agricultural and Food Chemistry, 60, 12469–12476

Kyriazakis, I. and Whittemore, C. T., 2006. Science and practice of pig production. Third Edition. Blackwell Publishing, Oxford, UK

Lanyasunya, T.P., Musa, H.H., Yang, Z.P., Mekki, D., Mukisira, E.A., 2005. Effects of poor nutrition on reproduction of dairy stock on smallholder farms in the tropics. Pakistan Journal of Nutrition, 4, 117–122

Lee, S.H., Shinde, P.L., Choi, J.Y., Kwona, I.K., Lee, J.K., Pak, S.I., Cho, W.T. and Chae, B.J. 2010. Effects of tannic acid supplementation on growth performance, blood hematology, iron status and faecal microflora in weanling pigs; Livestock Science, 131, 281–286

Lekule F. P. and Kyvsgaard N. C., 2003. Improving pig husbandry in tropical resource-poor communities and its potential to reduce risk of porcine cysticercosis; *Acta Tropica 87, 111-/117*

McDonald P., Edwards, R. A., Greenhalgh J. F. D. and Morgan, C.A., 2002. Animal Nutrition. 6th eds. pp: 583–591, London

Moran, J., 2005 How energy is measured. In: TROPICAL DAIRY FARMING. Feeding Management for Small Holder Dairy Farmers in the Humid Tropics. Landlinks Press, Australia

Musamba S. L., 2011. Effect of Reduced Feeding Allowances on the Nitrogen Retention and Growth of Indigenous Pigs. A thesis submitted in partial fulfilment of the requirements of the degree of Master of Philosophy in Agriculture, University of Zimbabwe, Zimbabwe.

Nguyen, N. X. D., Luu H. M. and Peter U., 2002. Tropical fibre sources for pigs—digestibility, digesta retention and estimation of fibre digestibility in vitro, Animal Feed Science and Technology, 102, 109–124

Ocampo, L. M., Leterme, P., Buldgen A., 2005. A Survey of Pig Production Systems in the Rain Forest of the Pacific Coast of Colombia, Tropical Animal Health and Production, 37, 315–326

Ohh, S. H., Han, K. N., Chae, B. J., Hanl, In K. and Acda, S. P., 2002. Effects of Feed Processing Methods on Growth Performance and Ileal Digestibility of Amino Acids in Young Pigs; Asian-Aust J. Anim. Sci., 15, 1765–1772

Opapeju, F. O., Nyachoti, C. M., House, J. D., Weiler, H. and Sapirstein, H. D., 2006. Growth performance and carcass characteristics of pigs fed short-season corn hybrids; J. Anim. Sci., 84, 2779–2786

Okah, U. and Ibeawuchi, J. A., 2011. Growth performance and haematological characteristics of West African dwarf (wad) sheep fed graded levels of dietary pigeon pea seed meal. Journal of Agricultural Technology, 7, 1255–1263

Pandya, A. V., Joshi, D., Vora, S. and Vishwakarma A., 2013. Estimation of the Type and Quantity of Sugar in Milk. Journal of Chemical, Biological and Physical Sciences, 3, 2623–2627

Radostits, O. M.,Clive G., Kenneth, W. H. and Peter, D. C., 2006. Veterinary medicine. A textbook of the disease of cattle, sheep, goats, pigs and horses; PP-2047-2050, Saunders, Edinburgh

SAS (Statistical Analysis System), 2008. The Little SAS® Book: A Primer, 4th eds., Statistical analysis system institute Inc., NC. USA.

Svoboda M., Eichlerová K., Horák V., Hradeck J., 2005. Development of Haematological Indices in Melanoma-bearing Libûchov Minipigs. ACTA VET. BRNO, 74, 603–611

Theml, H., Diem, H. and Haferlach, T., 2004. Color Atlas of hematology, Second edition, PP: 208

Thrall, M. A., Weiser, G. Allison R., and Campbell, T. W. 2012. *Veterinary Haematology and Clinical Chemistry*, Blackwell publishing ltd., USA.

Weiss, D. J. and Wardrop K. J., 2010. *Schlam's Veterinary Haematology* Blackwell publishing ltd., USA.

Williams B. A., Boscha M. W., Awatia A., Konstantinov S. R., Antoon S. H., Akkermans D.L., M Verstegen V., Tamminga S., 2005. In vitro assessment of gastrointestinal tract (GIT) fermentation in pigs: Fermentable substrates and microbial activity. Anim. Res. 54, 191–201