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MAIZE COBS AND POTATO HASH SILAGE AS ALTERNATIVE FEED FOR GROWER PIGS UNDER SMALLHOLDER PRODUCTION IN GAUTENG PROVINCE OF SOUTH AFRICA

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ABSTRACT: Maize cobs (MaC) and potato hash (PoH) are readily available and can be incorporated into pig diets to reduce feed costs and minimize nutrient losses to the environment but there is scant information on their utility on farm. A study was designed to evaluate pigs' growth performances when fed three diets; a control diet (CON) and a diet containing maize cob and potato hash silage inoculated with an exogenous feed enzyme (xylanase, Natugrain TS L®) (MaCPoHES) and or without an exogenous feed enzyme (MaCPoHS) on farm level. The study was conducted at two smallholder pig farms in Gauteng province, South Africa. The three diets were formulated to contain 16% crude protein (CP)/kg DM (dry matter) and 14 MJ of digestible energy (DE)/kg DM. Sixty large white x landrace cross bred pigs (30±5.0 kg body mass) from each farm were randomly allocated to the three treatment diets in a completely randomized design and fed *ad libitum* for 56 days. The pigs that were fed MaCPoHES from both farms had a better-feed conversion ratio (FCR) compared with pigs fed CON and MaCPoHS. In addition, animals fed CON had higher dry matter intake (DMI) than pigs that were fed MaCPoHS diets. There were treatment x farm interactions for average daily gain (ADG) and FCR. In addition, there were no treatment x farm interactions for initial weight (IW), final weight (FW), average daily feed intake (ADFI) and dry matter intake (DMI) in both farms. However, pigs at Zuurbekom farm had a higher ADG, ADFI and DMI than pigs at Winterveld farm. Pigs fed MaCPoHES diet had a better FCR compared to the control animals on both farms. This suggests that the use of these agricultural by-products in growing pig diets can help reduce feed costs. More studies need to be carried out to determine the optimum inclusion level of maize cobs and potato hash (MaCPoH) in pig diets, their impact on carcass quality and the cost benefit.

Keywords: Smallholder farm, Maize cob, Potato hash, Enzyme, Grower pigs

INTRODUCTION

One of the major challenges facing smallholder pig farmers in the Gauteng Province of South Africa is the increased feed costs driven by the high demand for the cereals. Feed costs account for 70 - 80% of pork production costs (Fialho et al., 1995). This has prompted the need to utilize cheaper and local readily available fibrous feeds from the agro-processing industry (Babayemi, 2008; Bindelle et al., 2008; Adeyemi et al., 2009). Success of increasing the inclusion of fibrous ingredients in pig diets is dependent on the impact on performance in relation to viability. Dietary fibre reduces the digestion and rate of absorption of nutrients, thus increasing the metabolic demand for nutrients (Wenk, 2001).

Furthermore, high fibre in grower pig diets increases the rate of feed passage (Fevrier et al., 1992). However, feeding fibrous diets to pigs also presents a range of potential benefits of those fermentable fibrous substrates that can substitute for expensive energy substrates. Maize cobs (MaC) are an underutilized resource for animal feeds and has the potential to reduce pork production costs (Ndindana et al., 2002; Kanengoni et al., 2004) for smallholder pig farmers in Gauteng. Currently in Gauteng Province, MaC are thrown away or burnt. Dietary inclusion of 30% untreated ground MaC reduced growth performance and nutrient digestibility in growing pigs (Ndindana et al., 2002; Kanengoni et al., 2004; Anguita et al., 2006).

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Approximately 50 tons of potato hash (by-product produced from the processing of chips) is produced in South Africa per day and is dumped for lack of alternative viable uses (Haigh, 1990; Nkosi et al., 2010; Thomas et al., 2010). Some of the limitations for using potato hash (PoH) in pig nutrition are high moisture content (>85%; Nkosi et al., 2010; Thomas et al., 2010); low water-soluble carbohydrates (WSC) contents 18 g/kg DM (Nkosi et al., 2011) and high fibre 60.5 g/kg^{-1} DM (Thomas et al., 2010). Therefore, ensiling MaC and PoH would be a viable method of preserving high moisture by-products such as PoH (Cao et al., 2009). Ensiling high moisture material such as PoH successfully, it is necessary to add dry resources or absorbents such as MaC to improve its DM content and to improve fermentation.

However, the addition of MaC to PoH will increase the fibre level of silage, making it even less suitable as feed for growing pigs. A potentially sustainable solution could be the addition of exogenous enzymes at ensiling to degrade cell walls and increase the availability of WSC to be consumed by lactic acid bacteria (LAB) (McDonald et al., 1991, Meeske et al., 1999). The benefits of exogenous enzymes is improving nutrient digestion in pigs have been documented (Jones et al., 2010; Kerr and Shurson, 2013). The objective of the study was to evaluate growth performance of grower pigs fed ensiled maize cob and potato hash treated with and without an exogenous xylanase feed enzyme (Natugrain TS L®).

MATERIALS AND METHODS

Maize cobs (920 g/kg DM) were collected from the agricultural research council - animal production fields (ARC-AP, Irene, Gauteng, South Africa), and ground to pass through a 10 mm sieve. Potato hash was collected from Simba (Pty) Ltd (Isando) in Kempton Park South Africa and brought to ARC-AP for chemical analysis and silage making. Potato hash and maize cobs were mixed at a ratio of 70:30 to achieve at least a 400 g/kg DM, pre ensiled composition is shown in table 1 . The mixture was ensiled in 210 L drums for 90 days. Diets treated with or without enzyme were formulated and tested on selected farms to demonstrate the technologies in the farmers' environments.

Ethical approval

The agricultural research council animal ethics committee approved the experiment (reference number: APIEC16/005).

Animals, Treatments and Experimental Design

The study was conducted in two district municipalities of Gauteng province (west rand district - Zuurbekom farm and Tshwane district - Winterveld farm). The farms were considered to have significant pig production activity, namely: management (feeding, cleaning), housing, animal health, farm infrastructure and marketing channels within the smallholder pig sector in Gauteng Province. The diets were formulated with inclusion levels of 200 g/kg maize cob potato hash of silage (as fed) as shown in table 2. The diet was formulated to provide 14 MJ/kg digestible energy (DE), 180 g crude protein (CP)/kg DM and 10.0g lysine/kg. This resulted in three treatments namely; control diet without maize cob and potato hash silage (CON), diets containing 200 g/kg maize cobs potato hash silage/kg diet treated with enzyme (MaCPoHES) or without enzyme (MaCPoHS). Sixty crossbred pigs (large white x landrace) aged 64 days old, ± 30 kg live weight were selected from Winterveld farm and 60 crossbred pigs (large white × landrace) aged 60 days old, ± 28 kg live weight were selected from Zuurbekom farm and used for the experiment. The experimental pigs were randomly allocated to three treatments in a completely randomised design. Pigs were housed in groups of five in 8.94 × 5.6 m pens in environmentally controlled house with the temperature ranging from 22 to 25 °C for eight week.

Measurements

Pigs were weighed individually at the start and weekly for eight week. The pigs had free access to feed and feed intake was measured daily by subtracting refusals from feed offered. Refusals were not analysed but they were visually examined to see if the pigs were selecting against maize cobs. Selection was high in the first week, after which the pigs consumed all feed offered. Average daily gain (ADG), average daily feed intake (ADFI) and feed conversion ratio (FCR) were calculated over the period each group of animals were in the trial from the body weight and feed intake values.

Chemical composition analysis

Diets were analysed in triplicate, in the animal and poultry science laboratory at the University of KwaZulu-Natal, Pietermaritzburg. Dry matter content was determined by oven drying the samples at 65 °C for 48 hours. The ash content was determined after incineration of the sample at 550°C for 4 hours according to method 990.05 (AOAC, 1990). Dry samples were ground through a 1 mm screen (Wiley mill, Standard Model 3, Arthur H. Thomas

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Co., Philadelphia, PA, USA) for chemical analyses. The neutral detergent fibre (NDF) and acid detergent fibre (ADF) contents were determined following the procedures of Van Soest et al. (1991) using ANKOM Fibre Analyser (Ankom, Macedon, NY, USA). Separate samples were used for ADF and amylase-treated neutral detergent fibre (aNDF) analyses and both included residual ash. The GE was determined with bomb calorimetry (MS-1000 modular calorimeter, Energy Instrumentation, Centurion, South Africa).

Table 1 - Chemical composition of maize cob and potato hash pre ensiled (n=3)

Nutrient (g/kg dry matter)	MaC	PoH	MaCPoH
Dry matter	963	161	361
Crude protein	27	98	148
aNDF	493	489	456
Acid detergent fiber	896	178	143
pH	–	5.05	6.4
WSC	–	4.35	75

aNDF= amylase-treated neutral detergent fiber; WSC= Water soluble carbohydrates; MaC= Maize cob; PoH= potato hash; MaCPoH= 30:70 fresh weight basis.

Table 2 - Composition of experimental diets fed to growing pigs

Ingredients (%)	Experimental diet[1]		
	Control	MaCPoHS	MaCPoHES
Molasses	1.4	1.2	1.2
Soyabean meal (oilcake)	18.8	20.0	20.0
Wheat Bran	5.0	–	–
Maize	71.0	54.6	54.6
Monocalcium Phosphate	1.3	1.5	1.5
Feed Lime	1.3	1.1	1.1
Lysine	0.4	0.8	0.8
Salt	0.4	0.4	0.4
MaC + PoH	–	20.0	20.0
Vitamin–mineral premix[2]	0.4	0.4	0.4
Calculated composition (%)			
Dry matter	88.2	78.5	78.5
Crude protein	16	15.5	15.5
Crude fibre	4.4	12.6	12.6
DE, MJ/kg	13.5	13.1	13.1
Laboratory composition (%)			
Dry matter	92.34	79.66	77.68
Organic matter	72.89	75.08	72.46
Ether extract	2.50	2.15	2.34
Crude protein	15.92	16.90	17.48
NDF	10.52	12.72	12.48
ADF	3.38	5.39	6.23
GE, MJ/kg	17.03	16.15	16.63

MaCPoH = maize cobs + potato hash, DE= digestible energy, NDF = neutral detergent fiber, ADF= acid detergent fiber, GE MJ/Kg DM = gross energy mega joules/kilogram dry matter

Statistical analyses

The data was analyzed using ANOVA and repeated measures of SAS (2008), testing for differences in each diet over time and between diets. Duncan's multiple range test was used to compare differences among the treatment groups. The data also was tested for normality and homogeneous treatment variances and where necessary suitable adaptation to testing procedure incorporated.

Effects of treatments on growth performance of grower pigs were analysed with the model.

$Yij = \mu + ti + \beta j + \varepsilon ij$

Where

Yij is the individual observations of the ith treatment and the jth replicate,

μ is the general effect,

ti is the effect of the ith treatment,

βj is the effect of the jth replicate,

εij is the random variation or experimental error.

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RESULTS AND DISCUSSION

Data on table 1 was comparable to 170 g/kg DM in potato pulp reported by Okine et al. (2005) and 956 g/kg DM maize cob reported by Kanengoni et al. (2014). This indicates that is difficult to ensile PoH therefore, a suitable absorbent is needed (Wilkinson, 2005). Therefore, absorbent maize cob was used to improve its DM during ensiling. The DM content of 361 g/kg in MaCPoH in the present study revealed that MaCPoH silage had acceptable moisture content according to the range of 120 and 450 g/kg (McDonald et al., 1991). Growth performance measurements of grower pigs from two different farms in Gauteng province fed diets containing ensiled maize cob and potato hash treated with enzyme (MaCPoHES) or without enzyme (MaCPoHS) are shown in table 3. After 56 days of the feeding trial, there were no differences (P>0.05) in final weight, ADG and ADFI between treatments on both farms. This was different to findings by Frank et al. (1983), Ndindana et al. (2002) and Kanengoni et al. (2004) who reported a reduction in average daily gain when diets containing maize cobs were fed to growing pigs compared to the control diet.

This result also differed with findings by Nkosi et al. (2010) and Thomas et al. (2010) who reported a lower growth performance when growing pigs were fed total ensiled mixed ration of potato hash and ensiled potato hash with or without inoculants compared to the control diet. The differences between these other studies and the current study could be attributed to ensiling both by-products and adding enzyme to the diets. The pigs that were fed MaCPoHES from both farms had a better (P<0.05) FCR compared with pigs that were fed control CON and MCPH. In addition, pigs that were fed CON diet had higher (P<0.05) DMI than pigs that were fed MaCPoHS diets. There were treatment × farm interactions for ADG and FCR. In addition, there were no treatment x farm interactions for final weight, ADFI and DMI in both farms. However, pigs at Zuurbekom farm had a higher (P<0.05) ADG, ADFI and DMI than pigs at Winterveld farm. This could be due to factors such as the different experimental conditions (location of the farm) and the differences in pig genotype. The MaCPoHES treatment had a better FCR (P<0.05) than CON on both farms. This is consistent with the study by Rahnema and Borton (2000) who reported improved gain to feed ratio when pigs were fed different levels of potato chips scraps. Therefore, the results of the current study demonstrate that ensiling of MaC with PoH treated with exogenous enzyme improved intake and growth parameters of the growing pigs under farm conditions.

Table 3 - Growth performance of pigs fed on maize cobs and potato hash diets

Parameter[1]	Location						SEM	Diet	Farm	Diet × farm
	Winterveld			Zuurbekom						
	CON	MaCPoHS	MaCPoHES	CON	MaCPoHS	MaCPoHES				
IW (kg)	30.40	30.36	30.25	27.80	28.98	28.01	5.76	0.99	0.17	0.92
FW (kg)	61.75	60.98	63.57	66.62	64.15	65.59	7.96	0.79	0.31	0.32
ADG (kg)	0.75^{b}	0.73^{b}	0.82^{b}	0.92^{a}	0.80^{b}	0.87^{a}	0.09	0.60	0.0003	0.03
ADFI (kg)	2.79^{b}	2.69^{b}	2.78^{b}	3.16^{a}	2.89^{b}	3.17^{a}	0.03	0.95	<.0001	0.52
DMI (kg)	2.75^{a}	2.36^{bc}	2.25^{c}	2.86^{a}	2.50^{b}	2.57^{b}	0.02	<.0001	<.0001	0.41
FCR	3.46^{a}	3.12^{ab}	3.14^{a}	2.78^{b}	3.05^{ab}	2.97^{b}	0.37	0.0003	0.56	0.02

^{a,b} Within a column means with different superscripts differ (P<0.05). CON= Control, MaCPoHS= maize cob potato hash silage, MaCPoHES= maize cob potato hash silage with enzyme, IW= initial weight, FW= final weight, ADG= average daily gain, ADFI= average daily feed intake, DMI= dry matter intake, FCR= feed conversion ratio.

CONCLUSION AND RECOMMENDATION

It was concluded that diets containing MaCPoH treated with or without exogenous enzyme may be an alternative feed source for growing pigs as indicated by higher intake. The MaC and PoH combination at a ratio of 30:70 produced better silage, indicated by an improved performance by the pigs. More studies need to be carried out to determine the optimum inclusion level of MaCPoH in pig diets, their impact on carcass quality and the cost benefit.

DECLARATIONS

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Author's contribution

All authors contributed equally to this work.

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Competing interest

The authors declare that they have no competing interests.

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