Farmer Demand and Willingness-To-Pay for Sweet Potato Silage-Based Diet as Pig Feed in Uganda

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Abstract:

This study was undertaken to assess farmer demand and willingness-to-pay for sweet potato silage-based diet as pig feed by smallholder farmers in Uganda. Information for the study was collected through secondary data review and semi-structured questionnaire interviews to assess farmer WTP. Semi-structured interviews were conducted with 256 respondents randomly drawn from 16 purposive clusters formed at a radius of 3 km around 16 farmers piloting sweet potato silage based diets for pig feed. The results show that pig farming is mainly the responsibility of women, with farmers' mean willingness to pay price ranging from 679 to 697 Ugandan shillings, for a kilogram of sweet potato silage based diet. At the mean prices, annual demand for silage is 17,679 tons with a market potential estimated between 12.0 to 12.3 billion Uganda shillings. The study concludes that at the mean willingness to pay prices, there is a huge market potential that can be exploited by SMEs venturing in the livestock feed industry.

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INTRODUCTION

A substantial amount of sweet potato vines and roots produced in Uganda is often wasted. This wastage presents an excellent opportunity for small and medium sized enterprises (SMEs) to invest in sweet potato silage business for pig feeding (Asindu et al., 2017). Pork has become an increasingly important animal source food in the diets of many Ugandans (Dione et al., 2015). In the 1960s, pork accounted for only 1-2% of the per capita consumption of meat (11-12 kg /year); whereas currently it accounts for at least one third of the 10 kg consumed per capita/year (FAOSTAT, 2010). This high demand for pork has resulted in increased pig production that is evidenced by a sharp pig population increase in the last 30 years from 0.12 Million in 1970s to 3.2 Million in 2008 (UBOS, 2009). This trend makes pig production to now continuously gain ground as an important livelihood source for smallholder farmers in Uganda. High feed costs have however become a major constraint representing 60 to 80% of the total cost of production with the most expensive among all feeds being commercial concentrates (Ouma et al., 2014). In a bid to minimize high feed costs and create a balanced feed ration, smallholder pig farmers have resorted to the use of locally available on-farm feeds notably sweet potato vines, peelings and non-marketable roots which are highly preferred because of their palatability and ability to supply much needed carbohydrates, proteins as well as vitamins to pigs. However, due to the high perishability and seasonality compounded with lack of awareness of processing technologies for conserving the vines during the dry season, the use of sweet potatoes as animal feed has been greatly limited to only the wet production seasons thus creating situations of feed scarcity during the dry season.

CIP and ILRI through the RTB ENDURE project have been testing sweet potato silage based diets for pigs to overcome the dry season feed shortages. Sweet potato silage has been noted to offer potential business opportunities to SMEs. However, there is still an information gap as regards farmers demand and willingness-to-pay for the sweet potato silage based diet. This

study therefore aims at assessing the demand and farmer willingness to pay for sweet potato silage. The findings will help provide information that will be useful to stakeholders involved in promotion of smallholder pig value chains and use of sweet potato as pig feed.

METHODOLOGY

Theoretical and analytical framework

Contingent Valuation Methods (CVM), which was used in this study, involves asking consumers directly in a hypothetical survey, the maximum amount they are willing to pay (WTP), to have a good or service that has been offered (Louviere et al., 2000). CVM has been used by economists for approximately thirty years to value changes in natural resources and environment. In several other cases, CVM have been used to evaluate farmers' preferences for crop attributes and other technical innovations, particularly where revealed preference approaches are not feasible. For this reason, it is ideal when it comes to measuring the value of non-market goods (Yadav et al., 2012).

The underlying framework for WTP is based on utility maximisation. Let U (X), be an individual preference function where; $\mathrm{X} = x_{1,\ldots\ldots\ldots,}x_n$, is a vector of private goods available at parametric prices, $p = p_{1,\ldots\ldots\ldots,}p_n$,

The individual maximises utility subject to income constraint, *y* and the indirect utility function is given by:

$$V(p,y) = max\{u\,(x)\big|p.x \leq y\}, \quad (1)$$

The minimum expenditure function is dual to the indirect utility function and is given as:

$$\mathrm{m}(p,u) = min\{p.x\,\big|U(x) \geq u\} \quad (2)$$

An individual will therefore be WTP for a good if it maximises his utility function, subject to an income constraint.

In CVM, WTP can be estimated using questions that are open-ended, asking the respondents to declare the maximum amount they would be willing to pay, or close-ended, asking the respondents if they would be willing to pay a specific amount or not (dichotomous choice). The open-ended format can be problematic since the respondent might not have sufficient information and stimuli to thoroughly consider the values they would attach to such good if a market were to exist, and might not return realistic estimates (Arrow et al., 1993) Close-ended questions, on the other hand, are easier on the respondent and are more realistic since they correspond more to a real market situation, where the consumer is presented with a price for a product and faces a yes/no decision.

In the single-bounded method, the individual only responds to one bid. This approach is incentive-compatible in that it is in the respondent's strategic interest to say yes if her/his WTP is greater or equal to the price asked and no otherwise (Mitchell and Carson, 1989). Utility maximization implies that a person will then only answer yes to the offered bid if her maximum WTP is equal or greater than the bid. The single bound method however, requires a large sample size and is statistically not very efficient (Hanemann et al., 1991). Hanemann et al. (1991), show that efficiency can be improved by offering the respondent a second bid, higher or lower depending on the first response, in an approach known as the double-bounded CVM. This method incorporates more information about an individual's WTP and therefore provides more efficient estimates and tighter confidence intervals. This study applied the double-bounded CVM elicitation technique.

To examine the relationship between WTP and socio-economic variables, various studies have applied different econometric models. For instance, Chen and Chern (2002) and Kimenju and Hugo (2005), apply a binary logit model. The binary logistic model explaining consumers' WTP is specified as:

$$WTP = \propto + \rho\beta + \emptyset Z + \varepsilon \quad (3)$$

Where WTP is response to the WTP bid amount {1 if consumer is willing to pay and 0 otherwise}, β is the bid price, Z is a vector of explanatory, $\propto, \rho, \emptyset$ are vectors of unknown coefficient and ε is the error term assumed to be identically, and independently distributed with zero mean.

Other authors have used bivariate probit model, especially when estimating models based on the double bounded WTP elicitation format. The estimation of the coefficients using bivariate probit model includes two related models, which can be expressed as:

$$Y_{1=} \propto_1 + \beta_1 B_1 + \Sigma \beta_i X_i + \varepsilon_1$$

$$Y_{2=} \propto_2 + \beta_1 B_2 + \Sigma \beta_j X_j + \varepsilon_2 \quad (4)$$

Where *Y1* and *Y2* are the binary responses to the WTP questions; *B1* and *B2* are the bids in the first and second bid question; Xi represents socio-demographic variables and *α'*s and *ß*"s are the coefficients to be estimated. In this study, a binary logit regression and bivariate probit model using STATA 12 were fitted to assess the factors that influence farmers' willingness to pay (WTP) for sweet potato silage based diets.

Study sites and study design

The study was conducted in Masaka and Kamuli districts which are located in the Central and Eastern regions of Uganda respectively. The two districts were purposely selected because of their high levels of both pig and sweet potato production. Furthermore, several programmes aimed at boosting sweet potato and pig production have been implemented by the International Potato Center (CIP) and the International Livestock Research Institute (ILRI) in these districts under the framework of the CGIAR Research Program Livestock and Fish and EU-IFAD funded project "Expanding Utilisation of Roots, Tubers and Bananas and reducing their post-harvest losses" implemented by the CGIAR Research Program on Roots, Tubers and Bananas (RTB-ENDURE).

This study relied mainly on secondary data from the Uganda Bureau of Statistics to obtain percentage of pig rearing households in the study districts and primary data that were collected through an in-depth survey of pig farmers in Kamuli and Masaka districts. A semi-structured questionnaire was used to collect data through personal interviews with the respondents. A simple random sampling procedure was used to draw a total sample size of 256 respondents from 16 purposive clusters. These clusters were formed at a radius of 3 km around each of the 16 farmers piloting use of sweet potato silage as pig feed under the framework of the RTB-ENDURE project in both Kamuli and Masaka districts.

The data were collected from August to September 2016. The questionnaire constituted six sections. The first section involved collecting background information of the respondents, such as household head, marital status, level of education among others. The second section captured components related to pig production like number of pigs owned, housing and feeding systems, pig numbers sold among others. The third section dealt with the perception and acceptability of sweet potato silage as pig feed by respondents whilst the fourth section captured farmers' demand and willingness to pay data for the sweet potato silage.

For the WTP section, enumerators first described and presented pictorial illustrations of sweet potato silage based diet to the respondents before obtaining data on their WTP. This was done to create awareness since the product was new and not yet known by all respondents within the selected clusters. Six bids were then given to different respondents randomly. The six bids selected for use were: UGX 200, UGX350, UGX500, UGX650, UGX 800 and UGX 1000. The bid prices were chosen based on pretesting results where 30 respondents, were asked an open-ended question in regard to how much they were willing to pay per kilogram of sweet potato silage based diet. In the pretest, the lowest WTP given by the respondents was UGX 200 and the highest WTP was UGX 1000. Therefore, UGX 200 and UGX 1000 were chosen as the lowest and highest WTP respectively. The same method was used by Hall et al. (2002) to

determine bid values, based upon results from pre-testing. They used open-ended questions which gave them values from USD0 to USD260. They chose to place a bid from USD2 up to USD100. Depending on the response to the initial bid that was randomly offered, if the survey participant responded with a “Yes”, a follow up bid double the initial value was offered. Likewise if the survey participant responded with a “No” to the initial bid price randomly offered, a second follow up bid half the initial value was offered to that particular respondent (Table.1).

Table 1 Alternative bids for the sweet potato silage based diet

B	**B^d**	**B^u**
200	100	400
350	175	700
500	250	1000
650	325	1300
800	400	1600
1000	500	2000

Note: B is initial bid; B^d is second bid if response to first bid was "no." and B^u is second bid if response to first bid was "yes."

The fifth component of the questionnaire involved collecting information on socio-economic characteristics of the farmers. For example, farm size, group membership, income, extension visits, access to credit, distance to nearest feed market among others. The last section then captured other information such as farmer involvement in sweet potato growing, land area under sweet potato and vine and root yields obtained by the farmers per year.

STATA 12 was used to estimate farmers’ WTP for sweet potato silage based diet. A binary logit regression and Bivariate probit model were fitted to assess the factors that influence farmers’ willingness to pay (WTP) for sweet potato silage based diets. Following Chen and Chern, (2002) and Kimenju and Hugo (2005), a logit model is specified to examine the relationship between

WTP and socio-economic variables, price as well as perceptions about the product. Formally, the binary logistic model explaining consumers' WTP is specified as:

$WTP = \propto + \rho\beta + \emptyset Z + \varepsilon$

Where WTP is willingness to pay {1 if consumer is willing to pay and 0 otherwise}, β is the bid price, Z is a vector of explanatory, $\propto, \rho, \emptyset$ are vectors of unknown co efficient and ε is the identically, independently distributed variable with zero mean.

For bivariate probit model, the estimation of mean and median WTP was done by using the estimated coefficients as given by Cameron and Quiggin (1994). The estimation of the coefficients using bivariate probit model includes two related models, which can be expressed as:

$Y_{1=} \propto_1 + \beta_1 B_1 + \Sigma \beta_i X_i + \varepsilon_1$

$Y_{2=} \propto_2 + \beta_1 B_2 + \Sigma \beta_j X_j + \varepsilon_2$

Where *Y1* and *Y2* are the binary responses to the WTP questions; *B1* and *B2* are the bids in the first and second bid question; Xi represents socio-demographic variables and *α's* and *ß*"s are the coefficients to be estimated.

Data for econometric estimations

The variables used in the binary logit and bivariate probit model are presented in Table 2. Factors considered included: - bid price, whether the respondent has ever heard of or seen sweet potato silage, Keeps other livestock apart from pigs, Pig housing type, Farmer involvement in sweet potato growing, Distance to nearest feed market, Membership to pig producer group, Farmer sex, Pig units owned, Pig breed kept, Access to credit, Visitation by extension worker in relation to pig production in the last one year, Pig income, Farm size and Farmer years of schooling.

Table 2: Socio-economic and demographic attributes of pig farmers in Masaka and Kamuli

Farmer characteristic	Pooled sample (256)
Farmer age (years)	46.14 (14.09)
Household number (persons)	5.33 (2.40)
Male farmers (%)	41.77
Female farmers (%)	58.23
Farmer years of schooling	8.19 (3.58)
Pig units owned	3.60 (4.79)
Local pig breeds (%)	40.63
Pigs under tethered housing type (%)	35.94
Access to credit (%)	92.58
Visitation by extension agent (visit/year %)	41.41
Membership to pig producer group (%)	27.73
Distance to the nearest feed market (km)	2.46 (2.22)
Heard of or seen sweet potato silage (%)	64.43
Involvement in sweet potato growing (%)	94.53
Farm size (acres)	3.33 (2.88)
Pig income (UGX)	474953.00 (967612.00)

Note: figures in brackets are standard deviations, Source: survey data 2016

The bid response to the various WTP values was further analyzed to estimate the proportion of farmers willing to pay at different prices (Figure 1). Results show that the proportion of farmers willing to pay for sweet potato silage based diet declined with increase in prices of the feed stuff. This finding is consistent with the law of demand which indicates that price is inversely related to the demanded of a particular commodity.

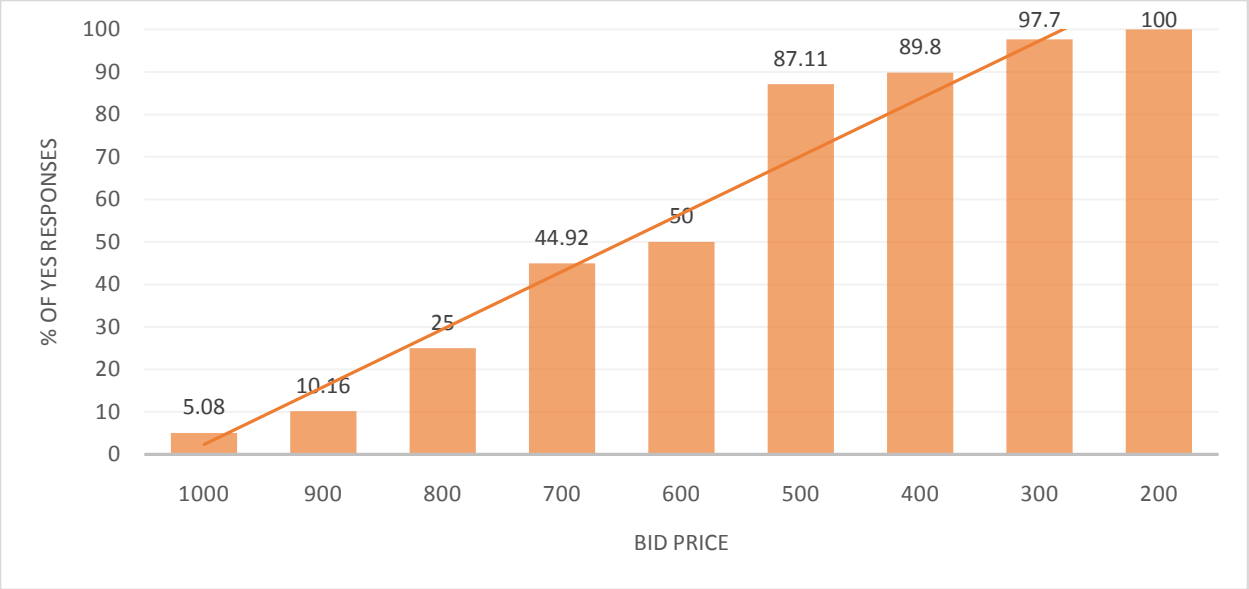

Figure: 1 Proportion of farmers willing to pay at different bid prices

RESULTS AND DISCUSSIONS

Results from the econometric estimations is presented in Table 3.

Table: 3 Logit and Bivariate Probit model estimates for factors influencing famer's willingness to pay for sweetpotato silage as pig feed.

Variables	Logit Model	Bivariate Probit	
	Initial bid	WTP[1]	WTP[2]
Constant	6.6506	3.8759	3.5873
	(1.3054)***	(0.7124)***	(0.6677)***
Initial bid price	-0.0091	-0.0052	
	(0.0011)***	(0.0006)***	
Bid price2			-0.0048
			(0.0006)***
Heard of or seen sweet potato silage	-1.4580	-0.8324	0.0819
	(0.4953)***	(0.2696)***	(0.2885)
Keep other livestock apart from pigs	-0.6866	-0.4106	0.2681
	(0.4989)	(0.2788)	(0.2798)
Pig housing type	-1.0165	-0.4926	-0.1506
	(0.5394)*	(0.2952)*	(0.3131)
Farmer growing sweet potato	1.1116	0.7022	0.1705
	(0.9515)	(0.5476)	(0.4923)
Distance to nearest feed market	-0.0744	-0.0349	-0.1792
	(0.0908)	(0.0528)	(0.0591)***
Membership to pig producer group	0.2224	0.0559	-0.1277
	(0.4802)	(0.2615)	(0.2763)
Farmer sex	0.3703	0.1340	0.2450
	(0.4129)	(0.2326)	(0.2325)
Pig units owned	0.3547	0.1613	-0.3236
	(0.5628)	(0.3127)	(0.3214)
Pig breed kept	1.1711	0.5324	0.2173
	(0.5185)**	(0.2718)*	(0.2970)
Access to credit	0.4040	0.2523	0.4329
	(0.8195)	(0.4652)	(0.4113)
Visitation by extension worker	-0.0122	0.0062	-0.2330
	(0.4361)	(0.2507)	(0.2441)
Pig income	0.0559	0.0293	0.0597
	(0.0802)	(0.0453)	(0.0476)
Farm size	0.5454	0.2540	-0.3313
	(0.4329)	(0.2380)	(0.2492)
Farmer years of schooling	-0.0908	-0.0554	-0.0316
	(0.0547)*	(0.0304)*	(0.0336)
Log likelihood	-91.0427	-176.2378	

*Note: Standard errors in parentheses ** denote significance at 5% level *** denote significance at 1% level * denote significance at 10% level*

The results revealed that the coefficients for bid offered are negatively correlated with the probability of acceptance as expected. The negative and statistically significant coefficients on bid suggested that the higher the amount respondents were asked to pay, the less likely they would be willing to pay for sweet potato silage based diet. This result is consistent with the theory of demand where an increase in price reduces the demand for a particular commodity by the consumer. Having heard of or seen silage on the other hand had a negative and statistically significant influence on farmers' willingness to pay for silage based diet. It was observed that farmers who have seen or heard of the silage thought it was less constraining to make personal silage. Furthermore, the proximity of raw materials like vines and non-marketable roots to farmers gave them a motivation to start making their own silage instead of buying from an outside source. Similar findings were reported by Abdullah et al. (2015), who indicated that respondents who had knowledge or knew Forest Research Institute Malaysia (FRIM) had less probability of accepting the bid offered. But sharply contrasts with the findings of Asrat, *et al.* (2004), who found that farmers who were aware of the available options for agricultural technology were more receptive to paying for these technologies. The coefficient for farmers who keep other livestock other than pigs though negative was not correlated with the probability of farmers' willingness to pay decision.

On the contrary, the coefficient for pig housing type was however negatively correlated with the farmers' willingness to pay decision for sweet potato silage based diet. Farmers who tethered pigs under tree shades had less likelihood of willingness to pay for the silage as compared to those whose pigs were confined in slatted houses or house constructed on ground. This could be attributed to the fact that most farmers tethering pigs were characterized by extensive and semi-intensive pattern of feeding, where pigs were quite often left to fend for themselves and therefore are less concerned about purchase of feeds for the pigs.

Farmer involvement in sweet potato production though positive, had insignificant influence on farmers' willingness to pay decision for sweet potato silage based diet. Ideally one would expect farmers involved in sweet potato production to be highly willing to pay for sweet potato silage based diet. This is attributed to the fact that they use sweet potato components to feed pigs quite often and are very much aware of the benefits associated with feeding sweet potato components to pigs as compared to other feeds. Distance to the nearest feed market had no significant influence on farmers' willingness to pay, considering results from the logistic and initial decision for the bivariate probit model, however, when the subsequent decision for the bivariate probit model was considered, distance to the nearest feed market negatively and significantly influenced the likelihood of farmers to pay for sweet potato silage based diet. Farmers with better access to produce markets were more willing to pay compared to their counterparts far away from the markets. Because the proximity to markets reduced transaction costs.

Unlike the findings of Abdullah et al. (2015), who reported a statistically significant positive relationship for the involvement of respondent as a member of a group, citing that they were familiar with the issues related to the environment and would be willing to pay more. For this particular study, Membership to pig producer group or association had a positive but statistically insignificant influence on farmers' willingness to pay for sweet potato silage based diet. A finding that also does not concur with that of Uaiene (2011), who reported a positive and significant influence for membership, to an association in his study.

Sex of the household head though positive, did not have any statistically significant influence over farmers' willingness to pay decision for sweet potato silage based diet. This finding concurs with those of Kimenju and De Groote (2015) who indicated that gender did not have significant influence on willingness to pay decision of respondents in their study. Sebstad and Manfre (2011), however contradicted with this finding by reporting that men are harder to convince to

use new products because they will always challenge the input and need to see the outcome first, resulting into negativity in their willingness to pay. Meanwhile Mwaura et al. (2010) found out that male headed households had an increased probability of willingness to pay as opposed to female headed households.

The variable for pig units owned had a positive coefficient that was statistically insignificant in terms of influencing farmers' likelihood to pay for sweet potato silage based diet. It is observed that famers with large number of pigs have a challenge purchasing enough of the expensive commercial feeds to meet the daily needs of the pigs. Therefore, offering an alternative like sweet potato silage based diet that is slightly of low cost compared to the commercial feed would motivate them to be willing to pay.

The variable for breed of pigs kept by the farmer had a positive and statistically significant influence on farmers' willingness to pay for sweet potato silage based diet. Ownership of local pig breed increased the likelihood that a farmer would purchase sweet potato silage based diet. Most of the farmers keeping local pigs are those constrained by income. This justifies why they are increasingly unable to upgrade to cross breeds or exotic pigs that are quiet expensive to purchase and maintain in terms of feeding and veterinary treatment. Therefore, the emergency of a cheaper feed alternative that is within their financial reach such as the sweet potato silage based diet will definitely boost their probability of willingness to pay decision.

Access to credit positively influenced willingness to pay for sweetpotato silage though this was not statistically significant as reported by Mugisha et al (2012) and Uaiene (2011), who indicated that credit had a positive and significant influence on the rate of adoption of new technologies.

The variable for Visitation of pig farmers by extension workers in the last one year had a negative coefficient but did not have any statistically significant impact on farmers willingness to pay as is with the case of Ulimwenu and Sanyal (2011), who reported that prior access to

Agricultural services tends to reduce farmers' willingness to pay. Ideally, one would expect that prior access to extension services would increase farmers' willingness to pay for sweet potato silage based diet. But this was not the case. Implying that farmers who have prior access to extension services probably opt to put their idea and experiences into practice. As such they are motivated to make their own silage using on-farm vines other than purchasing. As expected, income from pig sales had a positive relationship with willingness to pay for sweet potato silage based diet though the impact was not statistically significant. Implying that an increase in the level of income a farmer gains from selling pigs increases their likelihood of paying for the sweet potato silage based diet. Similarly, Farm size had a positive but statistically insignificant influence on farmers' willingness to pay for silage- based diet as pig feed. This partly shows that a big farm has the potential to generate extra income that can be used to purchase other agricultural inputs unlike the small ones where every component is virtually for subsistence purpose. This finding is consistent with those of Abudallah *et al.* (2014), who reported that farmers with large farm sizes have a higher chance of willingness to pay for insurance compared to farmers with small farm sizes.

Lastly farmer years of schooling had a negative and statistically significant influence on willingness to pay for both the logistics model and the initial response for the bivariate probit model. This was attributed to the fact that increase in an individual's level of education is normally associated with complexity in the degree with which they perceive ideas. Possibly, the highly-educated farmer looked at silage as a dirty and low quality feed thus opting for commercial concentrates. Uaiene (2011), earlier on in his study also indicated that high level of education comes with a higher propensity to adopt new technology. Implying that an increase in a farmers' level of education would likely motivate him/her to make own silage other than buy thus reducing the likelihood that they will be willing to pay. However, this finding contradicts with those of Owusu and Anifori (2013) and Muara (2010), who reported that years of schooling has

a positive and significant influence on WTP. Likewise Mamat et al. (2013) showed that years in education had a statistically significant positive impact on both the respondents' initial and subsequent decision on their contribution towards willingness to pay for preservation of the Palau Redang Marine Park (PRMP). Unlike, Pascucci et al (2011), whose study found no significant, impact of education on willingness to pay.

Farmer willingness to pay and market potential for sweet potato silage based diet.

Farmers' willingness to pay for sweet potato silage based diet

Two approaches were used to estimate the mean price for a kilogram of sweet potato silage based diet, namely logistic and bivariate probit analysis. For the logistic model, the mean WTP was UGX 679 (Table 4). This is approximately US$ 0.20, considering an exchange rate of US$ 1 = UGX 3340, at the time the survey was conducted. While from the bivariate probit model, the mean WTP price ranged from UGX 681 – UGX 697, an equivalent of US$ 0.20 and US$ 0.21 respectively, which was slightly higher than the mean obtained from the logistic model. Deriving from the results, there was clear indications that mean WTP price for a kilogram of sweet potato silage based diet was higher than the cost of production which was about UGX 545. This portrays that entrepreneurs of sweet potato silage based diet would make profit margins in the range of UGX 134, UGX 136 and UGX 152, if they sold off a kilogram of their sweet potato silage based diet at the respective mean prices. The results further showed that about 43% and 47% of the households in Masaka and Kamuli district respectively were willing to pay an amount from the respective mean prices and above.

Table: 4 Mean WTP estimates for the sample

Model	Bid	Mean WTP (UGX)
Logistic model	Initial bid	678.92
Bivariate probit	Initial bid	680.51
	Follow up bid	697.04

Estimated Market Potential for sweet potato silage based diets

We further made use of the WTP estimate to assess the market potential for sweet potato silage based diet. This was obtained basing on the population estimates for Masaka and Kamuli districts for the year 2014. The National Population and Housing Census conducted by UBOS in 2014, estimated 75,306 and 93,789 households in Masaka and Kamuli respectively, giving a total of 169,195 households for the two districts combined. According to the national livestock census report (UBOS, 2009), 42.3 and 15.5% of the households in Masaka and Kamuli respectively are involved in pig rearing. This results into a total of 31,854 and 14,537 pig rearing households in the two districts respectively. Further analysis done on the primary data collected indicated that 43% of the pig rearing households in Masaka and 47% in Kamuli expressed willingness to pay above the mean prices of UGX 679, UGX 681 and UGX 697 per kg of silage based diet respectively. This therefore gave a potential buying population of 13,697 and 6833 pig rearing households for Masaka and Kamuli respectively. Considering the fact that the average annual demand for sweet potato silage based diet was 0.955 and 0.673 tons per household in Masaka and Kamuli respectively, the market potential for both Masaka and Kamuli were then computed using the formula below as derived by (Wolfe, 2006).

$MP = N \times P \times A$

Where: MP = is the market potential, N= Number of possible buyers at price P, P= Mean Willingness to pay or average selling price and A= Average annual consumption

Market potential was estimated in terms of maximum annual total sales revenue from sweet potato silage based diets in Masaka and Kamuli districts. This was about UGX 12.00, UGX 12.40 and UGX 12.32 billion per year respectively at the three different mean WTP prices of UGX 679, UGX 681 and UGX 697 per kilogram of sweet potato silage based diet respectively. With the exchange rate standing at UGX 3340 = US$ 1 at the time of data collection way back in 2016, the estimated market potential was therefore equivalent to US$ 3.59, US$ 3.60 and US$ 3.69 million per year for the two districts at the respective mean prices. The required quantity of sweet potato silage based diet for the two districts stood at 17,679.32 tons annually. Annual demand for silage based diet for Masaka district was almost three times that of Kamuli district. This difference in demand was attributed to the fact that farmers in Masaka owned larger pig units compared to their counterparts in Kamuli district. Furthermore, Masaka district was heavily populated with farmers owning small farmlands from which they obtain feeds for pigs thus resorting to buying whereas in Kamuli there are large farmlands with a lot of local feeds for the pigs.

Table: 5 Market potential estimate for sweet potato silage based diet in Masaka and Kamuli districts

PARAMETERS	DISTRICTS		
	MASAKA	KAMULI	TOTAL
Household number	75,306	93,789	169,195
Percentage of households keeping pigs	42.3	15.5	
Number of households keeping pigs	31,854	14,537	46,391
Percentage of households WTP at mean price and above	43	47	
Number of households WTP at mean price and above	13,697	6,833	20,530
Annual demand per household (tons)	0.96	0.67	
Annual demand by district (tons)	13, 081.03	4, 598.29	17,679.32
Market potential by district (Billion UGX)			
Market potential at UGX 679 mean WTP price/kg	8.88	3.12	12.00
Market potential at UGX 681 mean WTP price/kg	8.91	3.13	12.04
Market potential at UGX 697 mean WTP price/kg	9.12	3.21	12.32

With price of a commodity being a key driver of demand and supply in the market, analysis was done to explore the effect of either increasing or decreasing the mean price of sweet potato silage based diet on its demand and supply. The result showed that increasing the price of sweet potato silage based diet by 7% from the initial price of UGX 700, resulted into a decrease in the number of potential buyers and an increase in the market potential by UGX 0.13 billion. This increase in market potential is attributed to the fact that the increase in price outweighed the decrease in the number of potential buyers. Further increase in price of sweet potato silage based-diet by 14%, 21% and 29% respectively however, resulted into decreased market potential. This was as a result of the decrease in the number of potential buyers outweighing the resultant price increased. The implication of this finding to the entrepreneur is that they can

freely increase the price of sweet potato silage based diet by 7% and still enjoy increased market potential with an increased positive profit margin resulting from the price increase.

Contrary to the price increase scenario, decreasing the price of sweet potato silage based diet by 7%, 14%, 21% and 29% respectively, resulted into gradual increase in the number of potential buyers in both Masaka and Kamuli districts. This finding is in line with the law of demand which indicates that price is inversely related to the quantity demanded. At 7%, 14% and 21% price decrease, the market potential kept on decreasing. This was because the decrease in price of the sweet potato silage based diet outweighed the increase in the number of potential buyers. However, at 29% price decrease, the market potential shot up. This occurred as a result of the decrease in price being outweighed by the increase in the number of potential buyers. To the entrepreneur, its however, not economical to take advantage of the market potential resulting from the 29% decrease in price of sweet potato silage based diet. As at these prices, the cost of production to meet the market demand exceeds the maximum revenue that can be achieved, resulting into negative profit margins for the entrepreneur.

Table: 6 Effect of price change on market potential of sweet potato silage based diet.

Change in price (%)	Resulting price (UGX)	Number of potential buyers in Masaka district (households)	Number of potential buyers in Kamuli district (households)	Quantity of silage based-diet demanded annually for the two districts (tons)	Percentage change in annual demand for silage	Estimated market potential in billion (UGX)
0.00	700	13,697	6,833	17,679	0	12.38
7.14	750	13,060	6,251	16,680	-6	12.51
14.28	800	8,919	2,907	10,475	-41	8.38
21.42	850	5,415	2,326	6,737	-62	5.73
28.56	900	4,141	727	4,444	-75	4.00
-7.14	650	14,334	7,414	18,679	6	12.14
-14.28	600	15,290	7,559	19,690	11	11.81
-21.42	550	15,290	8,141	20,081	14	11.04
-28.56	500	25,165	13,810	33,327	89	16.66

From the analysis (table 4.13 and 4.14), it is evident that at the mean prices obtained from the logistic and Bivariate models, for every kilogram of sweet potato silage based diet, there exists a great market potential for entrepreneurs to exploit. However, the entrepreneurs would achieve much more profits if they strategically increased their price to UGX 750. At this price, the quantity of sweet potato silage based diet to be supplied would decrease due to the decrease in the number of potential buyers. But the decrease in number of potential buyers would not be huge enough to offset the price increase. As such, higher revenue than would be if a kilogram of sweet potato silage based diet was sold at the mean prices will be realized.

Conclusions and recommendations

Farmers are willing to pay a mean price ranging from Uganda shillings 679 to 697 (US$ 0.2), per kilogram of sweet potato silage based diet. At this price range, SMEs capable of venturing into silage business could generate annual revenue in the range of 12 to 12.32 billion UGX from the two districts respectively given the existing total annual demand of 17,679 tons of sweet potato silage based diet in these districts. However, since the sweet potato silage based diet was only tested with pigs, there is need to further test it out with other livestock such as goats, cows, rabbits and sheep. This might eventually help to expand the demand and market potential thus widening the overall expected revenue.

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