Pulverised, Chopped and Milled:

A case study to appraise the services of small-scale feed processors in Kenya




East Africa Dairy Development

In partnership with

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Executive Summary

Feed processing is prevalent in project sites. With the seasonality of feed availability, processing can be used in conjunction with feed conservation strategies, such as silage making, to minimize wastage and to ensure that livestock have access to sufficient quantities of high quality feed all year round. In addition to enabling feed storage, processed feed is easier to transport. It can thus easily be used within the farm or even sold to other farmers. Processing feed increases intake by livestock and is also improves utilisation.

The processing machines used can be divided into pulverisers (ideal for crop residues), choppers (for green wet forages) and mills (for cereal and legume grains). The majority of operators purchase new machines from third party sources. However, machines purchased through EADD are cheaper than those purchased from non-EADD suppliers. The majority of feed operators are men. The women who process feed have fewer years of experience but are the same age as their male counterparts.

Access to technical and marketing services for feed processing entities is low. Whereas the majority of the operators are aware of the benefits of processing feed, few of them have the technical knowledge required to mix low cost feed rations.

Processing entities in EADD project sites are mainly engaged in business. The profitability of such businesses varies by the season, machine type, machine mobility (stationary versus mobile) and type of feed processed.

Mill businesses performed best, followed by pulveriser and chopper businesses. While mobile businesses performed better than stationary businesses, the latter earned higher net revenues.

The major constraints cited were poor transport infrastructure, escalating energy costs and lack of water. Processors also advocated for additional training on feed processing as well as awareness creation and the set up of demonstration farms.

Introduction

One of the main constraints facing small scale dairy farmers in smallholder mixed farming, pastoral and agro pastoral production systems in Kenya is the inability to provide sufficient quantity and quality feeds to their livestock on a consistent basis (Hall et al. 2008).

In the wet season, the quantity of crop residues declines, leaving fodder and grazing as the major feed source. In most farms, however, there is growing evidence that even during the rainy season the amount of fodder available for livestock is inadequate in both quality and quantity (Nyaata et al, 2000). Often, livestock underfeeding and loss of body condition continue to persist on smallholder systems.

Figure 1: An emaciated cow foraging on pasture in Daaba, Isiolo (Kenya). Source: *Business Daily Africa 2011*.

In the dry season, the quantity of fodder and grazing declines. This leaves cereal crop residues as the major feed resource. Elongated dry spells can result in severe feed shortage and lead to the tragic loss of livestock (Figure 1).

The commonly used feeds include planted fodders such as Napier grass or elephant grass (Pennisetum purpureum) fodder shrubs and herbaceous legumes. Other feeds are crop by-products such as sweet potato vines, banana leaves and pseudostems, stovers and straws, complemented with collection from and/or grazing of animals on communal land, forests, roadsides or fallow land (Staal et al, 1998).

One of the limitations to feeding crop residues and overgrown fodder on smallholder farms is that they are bulky to transport and store limiting efficient use (Methu et al., 1997). A key factor that leads to poor productive performance of livestock is low forage intake. Farmers usually unknowingly practice the self selection strategy where they offer whole crop residues especially maize stover or fodder such as Napier grass to cattle which, depending on the system of feeding, can result in high spoilage (Owen and Aboud 1998). This results in reduced feed intake so that underfeeding results.

Figure 2: An example of a pulveriser used by small scale farmers. Source: *EADD web site*

Physical treatment by reducing particle size is one of the key strategies of enhancing nutrient availability and intake of roughages. Pulverising at farm level is known to reduce wastage by 30- 60% (Smith et al, 1889), eases packaging, storage, transportation and feeding by farmers. It also aids in ensiling and on-farm mixing with other locally available feed resources. At the animal level it results in reduction in particle size which enhances feed intake by 30-60% depending on supplementation level (Chakeredza et al, 2008), enhances microbial attach in the rumen hence increased rate of digestion by 10-12% (Methu, 2001; Nicholson, 1984).

Figure 3; An example of the choppers used to process feed

Reduction in particle size can be achieved by using choppers (Figure 3), pulverisers (Figure 2), or grinding mills (Figure 4). Mills grind forage or grain finely (< 1 mm) while choppers reduce forages into course particle sizes of 2-3 mm length. Pulverisers shreds forages into more than 4 mm length particles. These machines have practical application whenever small scale farmers, store and stall-feed bulky dry forages (grass and legume hays, fibrous crop residues such as cereal stovers of maize, sorghum, millet, cereal straws of rice, teff, wheat, barley, oats, and haulms of beans).

Figure 4: An example of mills used by feed processors

The pulveriser technology is applicable to smallholder farmers producing milk and to service providers involved with the transport and trade of dry forages, and pulverising forages on farms. However, there is limited information about use and diffusion of the technology, cost and benefits of feed processing as well as operations and support of the service providers.

The purpose of this study is to appraise the use, operations and support of the small scale fed processing service providers in Kenya.

Methodology

Description of the study site

The survey was conducted in four EADD's hubs sites in Kenya, 3 of which are in Rift Valley province (namely, Kabiyet, Kipkelion and Longisa) and one site in Central province (Ol Kalou).

Ol Kalou is located in Nyandarua North district and lies between $0^0$50' South and $36^0$42'. The district is divided into 6 locations and covers an area of 592.2Km^2. The main food crops grown in the region include maize, wheat, beans, peas, cabbages, potatoes, carrots, onions and tomatoes. Livestock reared include cattle, goats, sheep and chicken.

Kabiyet is located in Nandi North district and lies between $34^0$44' South and $35^0$08' East. Kabiyet covers an area of 268.8 km^2 and has 6 locations. Average rainfall is about 1500mm per annum and the main crops grown include maize, beans, Irish potatoes, sorghum and millet. The major livestock kept include dairy cattle, sheep, goats and poultry.

Longisa is located in Bomet district which lies between $1^0$03' South and $0^0$35' East. Longisa covers an area of 257.4 km^2 and has 8 locations. Annual rainfall is between 1100mm to 1500mm. The main food crops grown include maize, beans, Irish and sweet potatoes. Livestock kept include dairy and beef cattle, sheep, goats, poultry rabbits and donkey.

Kipkelion is located in Kericho district which lies between 0.24^0 South and 35.02^0 East. Kericho has 7 divisions and covers an area of 315.9Km^2. Kipkelion is mainly dry and the main crops grown include maize, beans, Irish potatoes, finger millet and wheat. Main livestock kept include cattle, goats and sheep (Figure 5).

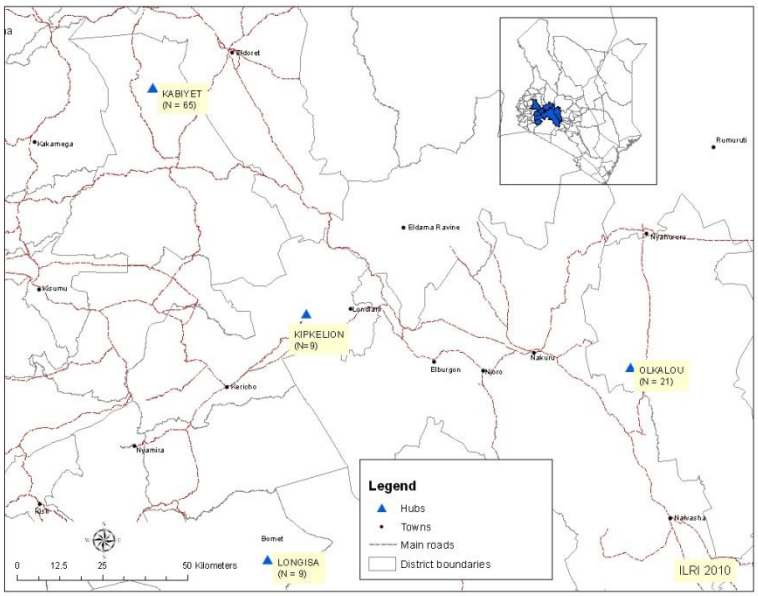

Figure 5: Map showing the sampled hubs in Kenya

Sampling procedure and data collection

A total of 104 feed operators were sampled from four EADD sites, namely Kabiyet (N=65), Longisa (N=9), Kipkelion (N=9) and Ol Kalou (N=21). Of these a total of 52 pulveriser operators were surveyed. The remaining sample constituted randomly selected chopper and mill operators.

The EADD field staff identified pulveriser operators in each of these sites. The snowballing approach where a respondent led the team to the next operator whom they know was used to identify additional pulveriser operators.

Information gathered included socio-economic characteristics of machine owners/operators, machines used, reasons for processing, feeds processed and economic performance measures such as number of customers, output, revenue and costs incurred in processing feed.

Results

Feed processing entities

About 9 out of 10 processing entities surveyed are owned by individuals (89%). The rest are owned by joint businesses (5%), farmer groups (3%), self help groups (2%) and registered companies (1%). In Ol Kalou, individuals own as many as 95% of the feed processing entities (Figure 1).

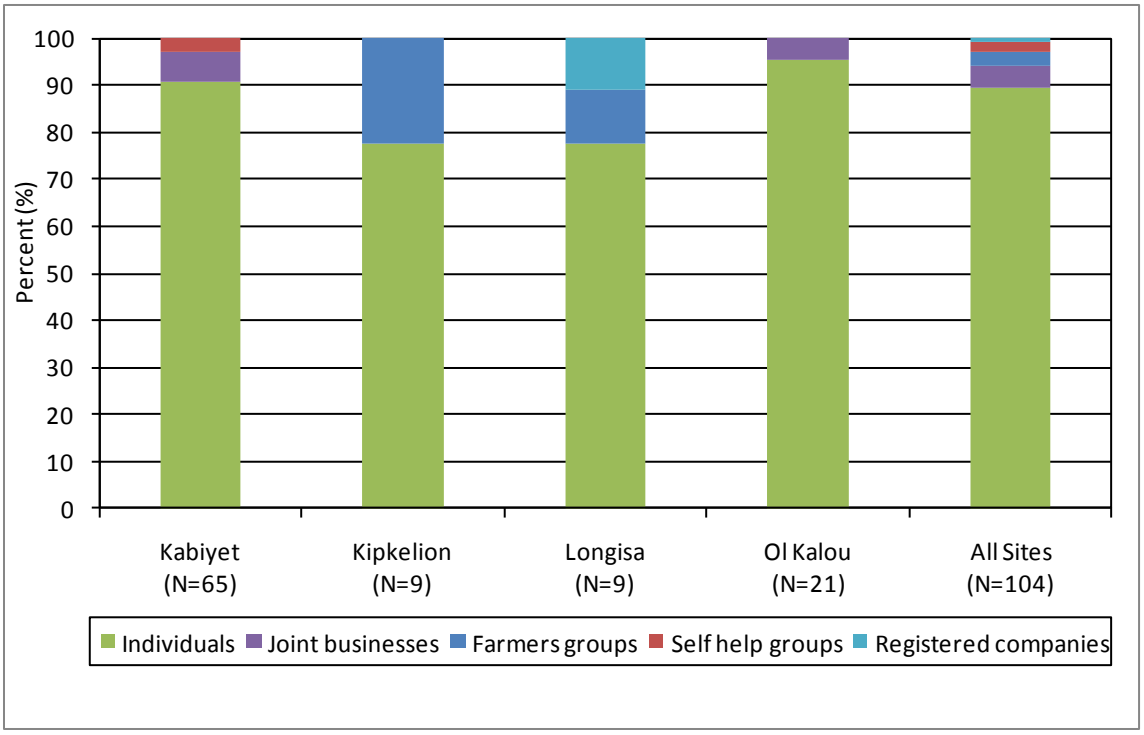

Figure 6: Percentage of feed processing entities that are owned by various stakeholders

About 64% of the entities surveyed are operated by managers (Figure 2), of which 53% are hired, 9% are family members and 2% are designated by the group. The fact that the majority of entities are operated by managers suggests that feed processing encourages job creation, especially in Kipkelion, where as many as 78% of the entities are operated by managers.

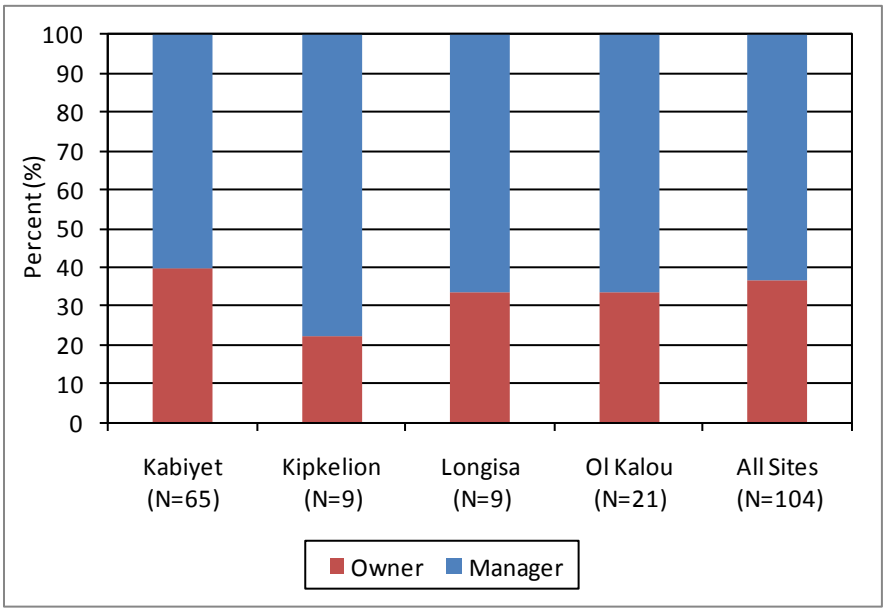

Figure 7: Percentage of feed processing entities whose operations are overseen by owners and managers

Both owners and managers of feed processing entities are engaged in other occupations, such as farming (63%), formal employment (26%), business (10%), retired (1%) probably because of the seasonal nature of feed processing.

Approximately 3 in 10 of feed operators surveyed are women across all sites (Table 1), and in all sites (except Ol Kalou) where there are significantly less women than men.

Women feed processors appear to be the same age as their male counterparts across all sites, although results by site vary. For example in Kipkelion, the women are significantly older than the men, while in Longisa, the men are significantly older than the women.

Women tend to have fewer years of feed processing experience, although this result is only significant for Ol Kalou.

Table 1: Gender of feed processor, age and years of feed processing experience

Site	Description	Men	Women	Tests
Kabiyet (N=65)	*Percentage of feed processors*	*70.8*	*29.2*	*11.22 ****
	Average age in years	39.8	40.7	-0.34
	Average years of feed processing experience	4.7	3.6	0.59
Kipkelion (N=9)	*Percentage of feed processors*	*77.8*	*22.2*	*2.78 **
	Average age in years	41.1	51.0	-2.16 **
	Average years of feed processing experience	1.4	2.0	-0.56
Longisa (N=9)	*Percentage of feed processors*	*77.8*	*22.2*	*2.78 **
	Average age in years	54.0	37.0	2.66 **
	Average years of feed processing experience	2.1	9.5	-0.86
Ol Kalou (N=21)	*Percentage of feed processors*	*66.7*	*33.3*	*2.33*
	Average age in years	42.9	44.0	-0.17
	Average years of feed processing experience	4.8	1.6	2.04 **
All sites (N=104)	*Percentage of feed processors*	*71.2*	*28.8*	*18.62 ****
	Average age in years	41.9	41.9	-0.03
	Average years of feed processing experience	4.2	3.4	0.57

Notes:

1. A chi-square goodness of fit test was performed to test if the gender of feed processors was
   equally distributed
2. T-tests were performed to investigate whether the age and years of feed processing was
   significantly different by gender. T-values and asterisks indicating levels of significance are shown.

*** significant at 1% ** significant at 5% * significant at 10%

Mode of operation

Overall, there are 3 major modes of operation, including processing feed for own use only (34%), processing feed for own use and business (14%) and processing feed for business only (52%) (Figure 3).

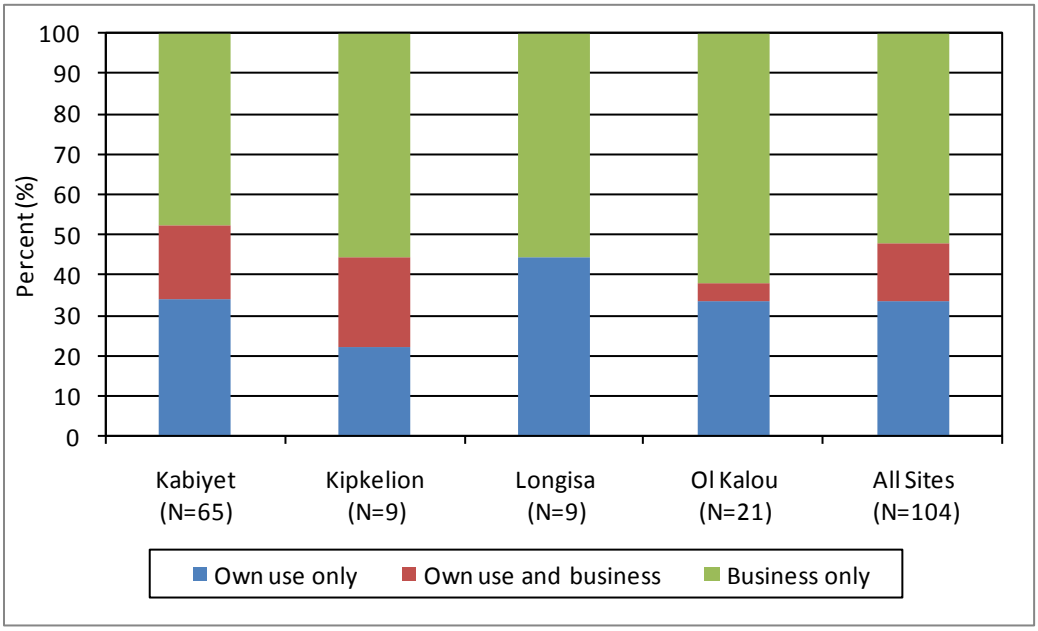

Figure 8: Percentage of feed processors running machines under various modes

Of the surveyed entities, feed processing for business only is the major mode of operation practised by more than 40% of respondents in all sites. While over 20% of respondents across all sites were processing feed for own use. In Longisa, none of the entities surveyed reported processing feed for own use and business.

Types of machines based on mobility

Feed processing machines used can be broken down into two categories, namely: stationary and mobile.

Stationary machines are fixed to a particular location (mainly in homesteads) and feed is brought to the site for processing. While with mobile machines, operators are able to ferry the machines to different locations.

Across all sites, the majority of pulverisers surveyed are mobile and used for business only (Table 2). Overall, the majority of choppers are stationary and kept for own use only, although there is some variation by site. For example, the majority of choppers in Kabiyet are stationary and kept for own use only , while in Ol Kalou they are mobile and kept for business only.

Figure 9: An example of a stationary mill

Figure 10: An example of a mobile mill

Table 2: Count of feed processing entities owning stationary or mobile machines by mode of operation

Machine type	Machine mobility	Reason for operation	Sites				
			Kabiyet	Kipkelion	Longisa	Ol Kalou	All Sites
Pulverisers	Stationary	Own use only	3	1	1	3	8
		Own use and business	2	1			3
		Business only	1	1			2
	Mobile	Own use only	1	1	2	2	6
		Own use and business	3	1		1	5
		Business only	16	4	2	6	28
Choppers	Stationary	Own use only	16		1	1	18
		Own use and business	4				4
		Business only	3			1	4
	Mobile	Own use only	2			2	4
		Own use and business	0			1	1
		Business only	2			9	11
Mills	Stationary	Own use only					
		Own use and business	2				2
		Business only	4		3		7
	Mobile	Own use only	1				1
		Own use and business	5				5
		Business only	6			1	7

The majority of mobile pulverisers are transported on foot. These machines are either carried on wheelbarrows or pushed manually from one location to another, whereas choppers and mills are transported by donkeys and tractors, respectively (Figure 4).

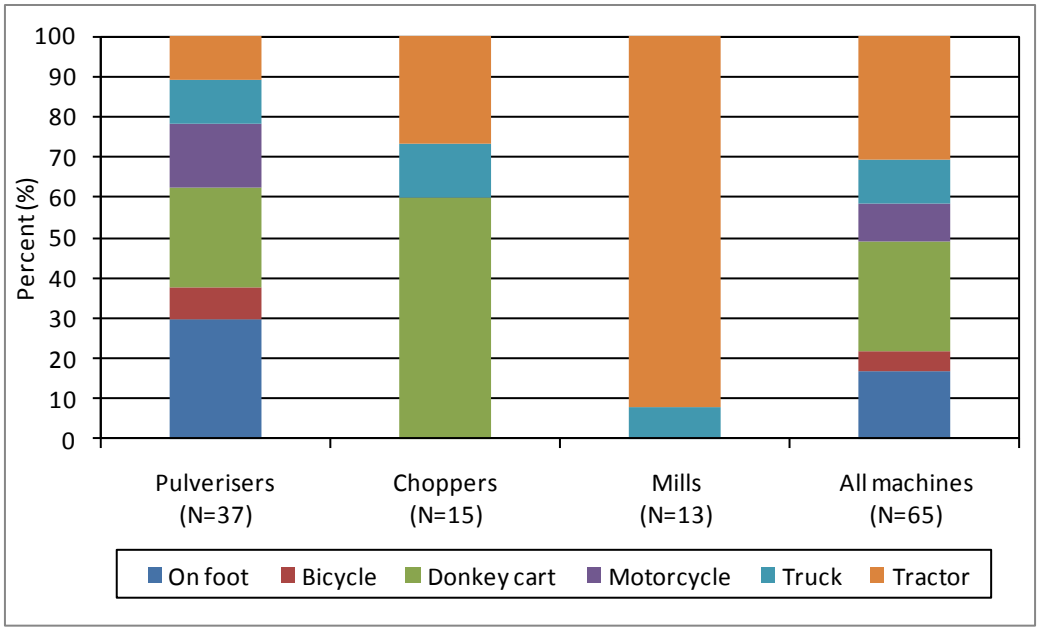

Figure 11: Percentage of mobile feed processing machines transported using various methods

Overall, mobile businesses spend roughly 19 minutes on average searching for customers and travel an average of 6.5 km to get to customers (Table 3). While mobile businesses in Longisa travel the greatest distance (9.5 km) to get to customers, mobile businesses in Kipkelion spend the most time (48 minutes) searching for customers. Some mobile businesses in Ol Kalou spend as much as 6 hours searching for customers. This may because of its expansive area with poor road network.

Mobile businesses that do not spend time searching for customers can be explained by the fact that these businesses respond to orders from customers, as opposed to spending time searching for business. This may also be due to the fact that hubs in Ol Kalou and Kabiyet are more developed than Kipkelion and Longisa. In devloped hubs clustering of input services through hubs have enhanced access to knowledge of feeds, markets and business development services (BDS); and farmer being able to obtain credit facilities against milk sales to invest improved feed production.

Table 3: Time spent by mobile businesses in searching for customers and distances covered

Site	N	Time spent searching for customers (minutes)					Distance covered in getting to customers (kilometres)				
		Min	Mean	Median	Max	Std	Min	Mean	Median	Max	Std
Kabiyet	31	0.0	7.7	0.0	120.0	30.0	0.5	6.6	5.0	55.0	9.6
Kipkelion	5	0.0	48.0	0.0	120.0	65.7	3.0	5.6	5.0	8.0	1.9
Longisa	2	0.0	0.0	0.0	0.0	0.0	3.0	9.5	9.5	16.0	9.2
Ol Kalou	13	0.0	36.9	0.0	360.0	99.6	2.0	6.3	5.0	14.0	3.1
All Sites	**51**	**0.0**	**18.8**	**0.0**	**360.0**	**59.4**	**0.5**	**6.5**	**5.0**	**55.0**	**7.8**

Overall, nearly all of the feed processing entities engaged in business largely rely on word of mouth and recommendations from current customers to advertise services to prospective clients. This may be due to lack of adequate information on use, efficiency and value of using the pulveriser technology.

Acquisition of feed processing machines

Feed processing operators acquire machines either through business development services offered by EADD or independently from other suppliers (non EADD). Overall, most of the machines were purchased new and non EADD related (Table 4). All of the machines that were EADD related were purchased new. Roughly 43% of the pulverisers are EADD related, while none of the operators that were surveyed purchased EADD related mills.

Table 4: Count of feed processing entities buying new and machines from various sources

Site	Source	N	Pulverisers		Choppers		Mills	
			Used	New	Used	New	Used	New
Kabiyet (N=64)	Non EADD	49	1	8	2	20	5	13
	EADD	15		14		1		
Kipkelion (N=9)	Non EADD	5		5				
	EADD	4		4				
Longisa (N=9)	Non EADD	6		2		1	1	2
	EADD	3		3				
Ol Kalou (N=21)	Non EADD	20	2	11		7		
	EADD	1		1				
All Sites (N=103)	Non EADD	80	3	26	2	28	6	15
	EADD	23		22		1		

Machines that were sourced from non EADD related suppliers are older than those sourced through EADD. This is not surprising, given the fact that EADD began to promote feed processing machines in 2009.

Overall, non EADD related mills are the oldest (10 years) followed by choppers (6 years) and pulverisers (3 years) (Table 5).

Table 5: Average age (years) of new and old machines purchased from non EADD and EADD related suppliers

Site	Source	N	Pulverisers		Choppers		Mills	
			Used	New	Used	New	Used	New
Kabiyet (N=64)	Non EADD	49	1.0	1.8	4.5	7.5	2.0	9.7
	EADD	15		1.1		0.0		
Kipkelion (N=9)	Non EADD	5		1.2				
	EADD	4		1.8				
Longisa (N=9)	Non EADD	6		2.0		3.0	1.0	11.5
	EADD	3		0.3				
Ol Kalou (N=21)	Non EADD	20	2.0	4.1		3.7		
	EADD	1		2.0				
All Sites (N=103)	Non EADD	80	1.7	2.7	4.5	6.4	1.8	9.9
	EADD	23		1.1		0.0		

Mills are the most expensive to purchase, followed by choppers and pulverisers across all sites (Table 6). The machines sourced from EADD suppliers are cheaper than those sourced from non EADD suppliers. This can be explained by the fact that EADD sourced machines in bulk and are able to negotiate for lower prices. As would be expected, used machines are cheaper than new ones.

Table 6: Cost of feed processing machines purchased in 2009-2010 in Kenya Shillings (KES)

Site	Source	N	Pulverisers		Choppers	Mills	
			Used	New	New	Used	New
Kabiyet	Non EADD	16	35,000	39,000	33,600	55,000	85,000
	EADD	13		38,000	55,000		
Kipkelion	Non EADD	3		39,667			
	EADD	1		32,000			
Longisa	Non EADD	2		40,000		9,000	
	EADD	2		32,000			
Ol Kalou	Non EADD	5		37,500	60,000		
All Sites	Non EADD	26	35,000	38,769	38,000	39,667	85,000
	EADD	16		36,800	55,000		

Overall, the majority of the machines were bought using cash (Table 7). The check off system through hubs against milk supplied was used to purchase pulverisers in Kabiyet only. Only 1 feed processor in Longisa reported owning a mill made by a local artisan.

Table 7: Count of machines acquired through different means

Machine type	Different methods of acquisition	Site									
		Kabiyet (N=64)		Kipkelion (N=9)		Longisa (N=9)		Ol Kalou (N=21)		All Sites (N=103)	
		Non EADD	EADD	Non EADD	EADD	Non EADD	EADD	Non EADD	EADD	Non EADD	EADD
		49	15	5	4	6	3	20	1	80	23
Pulveriser	Bought using cash	9	4	5	4	2	2	12		28	10
	Hire purchase		3								3
	Loan from bank						1				1
	Loan from other source							1	1	1	1
	Check off system		5								5
	Gift		2								2
Chopper	Bought using cash	22	1			1		5		28	1
	Loan from bank							1		1	
	Loan from other source							1		1	
Mill	Bought using cash	16				2				18	
	Hire purchase	2								2	
	Made by self					1				1	

Types of feeds processed

The various types of feeds processed included crop residues, forages and grain by 93%, 79% and 40% of feed operators, respectively (Table 8). Processed grain is for both human and livestock use however it should be noted that grain for livestock use is usually spoilt/reject cereals.

Amongst roughages, Napier grass was the most common forage processed, by 58% of operators across all the sites. In Kipkelion and Ol Kalou, Napier grass was the most common forage processed, by 67% and 43% of feed operators respectively while Rhodes grass is the most commonly processed forage processed in Kabiyet, by 68% of operators.

Overall, maize stover is by far the most popular crop residue processed, followed by bean haulms and sorghum, millet and oat straw. This may be because maize is the most important food crop in all study sites. Maize cobs and grain are other cereal by products processed and feed to livestock across all the sites.

Table 8: Percentage of feed processing entities utilizing various feeds

Feed type	Feed name	Kabiyet (N=65)	Kipkelion (N=9)	Longisa (N=9)	Ol Kalou (N=21)	All sites (N=104)
Crop residues	Bean haulms	51	11	22		35
	Cabbages and kales				5	1
	Maize stover dry	82	100	89	86	85
	Maize stover green	35	11	22	57	37
	Oat straw				24	5
	Sorghum and millet straw	5		11	5	5
	Overall	91	100	89	100	93
Forages	Boma Rhodes	68		33		45
	Napier grass	65	67	33	43	58
	Natural grasses	11	11	11	5	10
	Overall	91	78	56	52	79
Grains	Maize cobs	20	56	56	19	26
	Maize grain	32	56	56		30
	Overall	40	67	67	19	40

Feed processing as a business

Types of machines used

Across all sites, 66% of the surveyed entities are engaged in feed processing as a business; either exclusively for customers (52%) or both for customers and own use (14%). Whereas such entities can process feed using several machines, Figure 5 below shows that they are specialized, tending to use just one machine type as opposed to several types.

Overall, those using pulverisers only are the majority, followed by those using mills and choppers only. Kabiyet and Ol Kalou show the most variety in the types of machines used amongst the surveyed feed processing businesses. In Kipkelion, all of the surveyed feed processing businesses use pulverisers only, while in Longisa, the majority of the surveyed feed processing businesses use mills only.

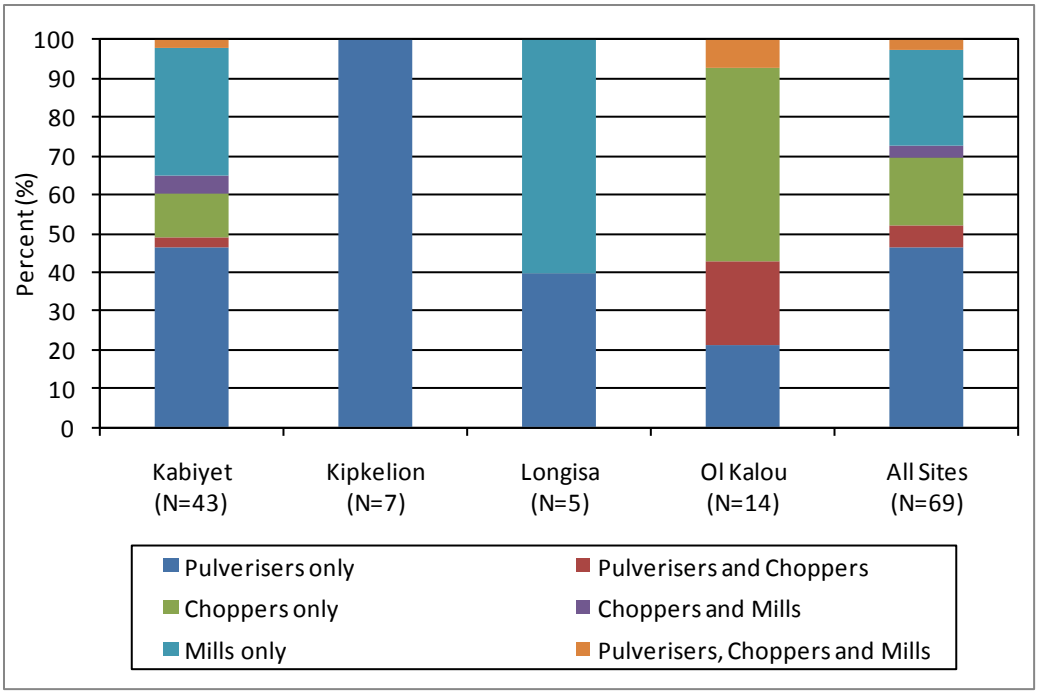

Figure 12: Percent of feed processing entities using one or more machine types

The type of machine used largely influences the number of customers that feed processing businesses can service. Mills, for example, have the highest throughput when compared to pulverisers and choppers and as a result can service more customers. The high throughput of mills could be due to the fact that they process grains for both human and livestock use throughout dry and wet seasons.

Number of customers served

Table 9 shows the average number of customers served by day by machine type and season. Where present, businesses where the only machines used are mills serve the most customers per day, followed by those with pulverisers only. The exception is in Ol Kalou, where businesses with choppers only serve more customers than those with pulverisers only. This may be because farmers in Ol Kalou tend to process green forages which is most abundant in the wet season.

Whereas it is expected that businesses using more than one machine type would service more customers, this isn't always the case. For example, in Kabiyet, businesses with two or more machines serve the least number of customers, while in Ol Kalou, such businesses serve the most number of customers. In Ol Kalou, the number of customers served by machine type is only significant in the wet season.

Overall, more customers are serviced in the dry season, as compared to the wet, with the exception of businesses with two or more machines. This can be explained by the fact that the feed types that are commonly processed are abundant in the dry season, immediately following the harvest season in most sites.

Finally, businesses in Kabiyet serve the most number of customers per day, across all machine types.

Table 9: Average number of customers per day served by machine type and season

Site	Machine type	N	Season			T-tests
			Dry	Wet	Overall	
Kabiyet (N=43)	Pulverisers only	20	3.1	1.1	4.1	4.02 ***
	Choppers only	5	2.2	1.0	3.1	2.16 **
	Mills only	14	8.6	3.4	11.9	3.68 ***
	2 or more machines	4	1.0	0.4	1.4	2.12 *
	All machines	43	4.6	1.7	6.3	4.96 ***
	ANOVA		*0.0213*	*0.1711*	*0.0375*	
Kipkelion (N=7)	Pulverisers only	7	1.9	0.2	2.1	2.56 **
	All machines	7	1.9	0.2	2.1	
Longisa (N=5)	Pulverisers only	2	0.6	0.5	1.1	0.33
	Mills only	3	1.5	0.8	2.3	0.62
	All machines	5	1.2	0.7	1.8	0.71
	ANOVA		*0.4069*	*0.7302*	*0.2487*	
Ol Kalou (N=14)	Pulverisers only	3	1.1	0.0	1.2	1.90 *
	Choppers only	7	1.3	0.2	1.5	5.75 ***
	2 or more machines	4	2.2	2.1	4.3	0.12
	All machines	14	1.5	0.7	2.2	2.99 ***
	ANOVA		*0.1729*	*0.0355*	*0.0410*	
All Sites (N=69)	Pulverisers only	32	2.5	0.7	3.2	4.92 ***
	Choppers only	12	1.6	0.5	2.2	4.55 ***
	Mills only	17	7.3	2.9	10.2	3.55 ***
	2 or more machines	8	1.6	1.2	2.8	0.98
	All machines	69	3.4	1.3	4.7	5.55 ***
	ANOVA		*0.0024*	*0.0446*	*0.0052*	

Notes:
1. Only levels of significance of ANOVA tests are shown.
2. T-values and asterisks indicating levels of significance are shown *** significant at 1% ** significant at 5% * significant at 10%

Table 10 suggests that mobile businesses service more customers than stationary ones, although, this result is only significant in the dry season in Ol Kalou. As expected, both mobile and stationary businesses tend to service more customers in the dry season as compared to the wet in all sites.

Table 10: Average number of customers per day by machine mobility and season

Site	Machine mobility	N	Season			T-tests
			Dry	Wet	Overall	
Kabiyet (N=43)	Mobile only	29	5.5	2.1	7.5	4.40 ***
	Stationary only	12	3.1	1.2	4.2	2.36 **
	Stationary and mobile	2	0.8	0.1	0.9	1.92
	All machines	43	4.6	1.7	6.3	4.96 ***
	ANOVA		*0.3641*	*0.5842*	*0.4116*	
Kipkelion (N=7)	Mobile only	5	2.6	0.3	2.9	2.88 **
	Stationary only	2	0.3	0.0	0.3	1.67
	All machines	7	1.9	0.2	2.1	2.56 **
	ANOVA		*0.1489*	*0.3881*	*0.1342*	
Longisa (N=5)	Mobile only	2	0.6	0.5	1.1	0.33
	Stationary only	3	1.5	0.8	2.3	0.62
	All machines	5	1.2	0.7	1.8	0.71
	ANOVA		*0.4069*	*0.7302*	*0.2487*	
Ol Kalou (N=14)	Mobile only	13	1.6	0.8	2.4	3.02 ***
	Stationary only	1	0.1	0.0	0.1	
	All machines	14	1.5	0.7	2.2	2.99 ***
	ANOVA		*0.0966*	*0.5980*	*0.3010*	
All Sites (N=69)	Mobile only	49	3.9	1.5	5.4	4.98 ***
	Stationary only	18	2.3	0.9	3.2	2.45 **
	Stationary and mobile	2	0.8	0.1	0.9	1.92
	All machines	69	3.4	1.3	4.7	5.55 ***
	ANOVA		*0.4006*	*0.6300*	*0.4504*	

Notes:
1. Only levels of significance of ANOVA tests are shown.
2. T-values and asterisks indicating levels of significance are shown. *** significant at 1% ** significant at 5% * significant at 10%

Output produced

Overall, businesses process more feed in the dry season as compared to the wet (Table 11). This is especially true for businesses with pulverisers. This can be explained by the fact that pulverisers are most suited to process dry crop residues that are abundant during the dry season. In Kabiyet, businesses with choppers process more feed in the wet season as compared to the dry. This is because choppers are suited to process wet forages for feeding directly to livestock or making silage. A general trend is that feed processors with more than one machine have a higher throughput as compared to those with only one machine.

Table 11: Average output per day and per customer by machine type and season (kilograms)

Site	Machine type	N	Season			T-tests
			Dry	Wet	Overall	
Kabiyet (N=43)	Pulverisers only	20	553	424	977	1.94 **
	Choppers only	5	361	552	913	-1.95 *
	Mills only	14	423	329	752	0.84
	2 or more machines	4	1,284	1,294	2,578	-0.35
	All machines	43	556	489	1,045	1.34 *
	ANOVA		*0.0001*	*0.0001*	*0.0000*	
Kipkelion (N=7)	Pulverisers only	7	675	279	954	2.54 **
	All machines	7	675	279	954	
Longisa (N=5)	Pulverisers only	2	719	360	1,079	0.99
	Mills only	3	305	106	411	0.76
	All machines	5	471	208	678	1.41
	ANOVA		*0.2239*	*0.4328*	*0.1485*	
Ol Kalou (N=14)	Pulverisers only	3	720	237	956	2.04 *
	Choppers only	7	578	418	996	0.9
	2 or more machines	4	1,133	1,148	2,281	-0.07
	All machines	14	767	587	1,355	1.51 *
	ANOVA		*0.0114*	*0.0078*	*0.0006*	
All Sites (N=69)	Pulverisers only	32	606	371	977	3.74 ***
	Choppers only	12	488	474	962	0.12
	Mills only	17	402	290	692	1.12
	2 or more machines	8	1,209	1,221	2,430	-0.13
	All machines	69	605	467	1,072	3.04 ***
	ANOVA		*0.0000*	*0.0000*	*0.0000*	

Notes:
1. Only levels of significance of ANOVA tests are shown.
2. T-values and asterisks indicating levels of significance are shown.
*** significant at 1% ** significant at 5% * significant at 10%

Overall, businesses with mobile machines are able to process more feed than those with stationary machines (Table 12). In Kabiyet, businesses with both mobile and stationary machines are able to process more feed than those businesses with either stationary or mobile machines.

Table 12: Average output per day and per customer by machine type and season (kilograms)

Site	Machine type	N	Season			T-tests
			Dry	Wet	Overall	
Kabiyet (N=43)	Mobile only	29	568	443	1,012	1.96 **
	Stationary only	12	321	381	702	-0.71
	Stationary and mobile	2	1,800	1,795	3,595	0.82
	All machines	43	556	489	1,045	1.34 *
	ANOVA		*0.0000*	*0.0000*	*0.0000*	
Kipkelion (N=7)	Mobile only	5	661	391	1,052	1.40
	Stationary only	2	709		709	81.00 ***
	All machines	7	675	279	954	2.54 **
	ANOVA		*0.6118*	*0.2137*	*0.2236*	
Longisa (N=5)	Mobile only	2	719	360	1,079	0.99
	Stationary only	3	305	106	411	0.76
	All machines	5	471	208	678	1.41
	ANOVA		*0.2239*	*0.4328*	*0.1485*	
Ol Kalou (N=14)	Mobile only	13	772	633	1,404	1.15
	Stationary only	1	708		708	
	All machines	14	767	587	1,355	1.51 *
	ANOVA		*0.8614*	*0.2268*	*0.3643*	
All Sites (N=69)	Mobile only	49	638	485	1,123	2.85 ***
	Stationary only	18	383	272	655	1.15
	Stationary and mobile	2	1,800	1,795	3,595	0.82
	All machines	69	605	467	1,072	3.04 ***
	ANOVA		*0.0000*	*0.0000*	*0.0000*	

Notes:
1. Only levels of significance of ANOVA tests are shown.
2. T-values and asterisks indicating levels of significance are shown.
*** significant at 1% ** significant at 5% * significant at 10%

Revenue earned

Overall, businesses utilizing two or more machines earn the most from feed processing activities (Table 13). Additionally, more revenue is earned in the dry season as compared to the wet.

Table 13: Average revenue per day and per customer by machine type and season (KES)

Site	Machine type	N	Season			T-tests
			Dry	Wet	Overall	
Kabiyet (N=43)	Pulverisers only	20	1,569	976	2,544	2.54 **
	Choppers only	5	410	769	1,179	-1.41
	Mills only	14	1,131	597	1,728	1.58 *
	2 or more machines	4	2,512	3,119	5,631	-1.00
	All machines	43	1,379	1,028	2,407	2.01 **
	ANOVA		*0.0161*	*0.0000*	*0.0001*	
Kipkelion (N=7)	Pulverisers only	7	984	341	1,326	1.64 *
	All machines	7	984	341	1,326	
Longisa (N=5)	Pulverisers only	2	795	62	858	6.53 **
	Mills only	3	703	313	1,015	0.64
	All machines	5	740	213	952	1.53 *
	ANOVA		*0.8844*	*0.3161*	*0.7104*	
Ol Kalou (N=14)	Pulverisers only	3	800	263	1,062	2.04 *
	Choppers only	7	678	493	1,171	0.90
	2 or more machines	4	1,493	1,218	2,711	1.41
	All machines	14	937	651	1,588	2.26 **
	ANOVA		*0.0539*	*0.0347*	*0.0206*	
All Sites (N=69)	Pulverisers only	32	1,320	713	2,033	3.63 ***
	Choppers only	12	567	608	1,174	-0.24
	Mills only	17	1,055	547	1,602	1.75 **
	2 or more machines	8	2,003	2,168	4,171	-0.49
	All machines	69	1,203	823	2,026	3.17 ***
	ANOVA		*0.0064*	*0.0001*	*0.0001*	

Notes:
1. Only levels of significance of ANOVA tests are shown.
2. T-values and asterisks indicating levels of significance are shown.
*** significant at 1% ** significant at 5% * significant at 10%

Overall, businesses with both mobile and stationary machines earn more than those with just one machine, and mobile businesses earn more than stationary businesses (Table 14).

Table 14: Average revenue per day and per customer by machine mobility and season (KES)

Site	Machine mobility	N	Season			T-tests
			Dry	Wet	Overall	
Kabiyet (N=43)	Mobile only	29	1,576	991	2,567	2.72 ***
	Stationary only	12	573	580	1,153	-0.03
	Stationary and mobile	2	3,362	4,243	7,605	-0.68
	All machines	43	1,379	1,028	2,407	2.01 **
	ANOVA		*0.0003*	*0.0000*	*0.0000*	
Kipkelion (N=7)	Mobile only	5	559	478	1,037	0.48
	Stationary only	2	2,047		2,047	4.52 *
	All machines	7	984	341	1,326	1.64 *
	ANOVA		*0.0083*	*0.3402*	*0.2217*	
Longisa (N=5)	Mobile only	2	795	62	858	6.53 **
	Stationary only	3	703	313	1,015	0.64
	All machines	5	740	213	952	1.53 *
	ANOVA		*0.8844*	*0.3161*	*0.7104*	
Ol Kalou (N=14)	Mobile only	13	960	701	1,661	1.94 **
	Stationary only	1	637		637	
	All machines	14	937	651	1,588	2.26 **
	ANOVA		*0.6076*	*0.2491*	*0.3625*	
All Sites (N=69)	Mobile only	49	1,277	824	2,101	3.36 ***
	Stationary only	18	762	439	1,201	1.36 *
	Stationary and mobile	2	3,362	4,243	7,605	-0.61
	All machines	69	1,203	823	2,026	3.17 ***
	ANOVA		*0.0005*	*0.0000*	*0.0000*	

Notes:
1. Only levels of significance of ANOVA tests are shown.
2. T-values and asterisks indicating levels of significance are shown.
*** significant at 1% ** significant at 5% * significant at 10%

The main method of making payments for processing services is by cash. Of all surveyed feed processing businesses, only those in Kabiyet (35%) and Ol Kalou 29%, offer credit to their customers.

The majority of the surveyed feed processing businesses in Kabiyet and Kipkelion rank income from their business in second place, as compared to total income (Figure 6). This is higher than in Longisa and Ol Kalou, where the majority of feed processors rank income from their business in third and fourth position, respectively. Less than 10% across all sites rank feed processing income in first place.

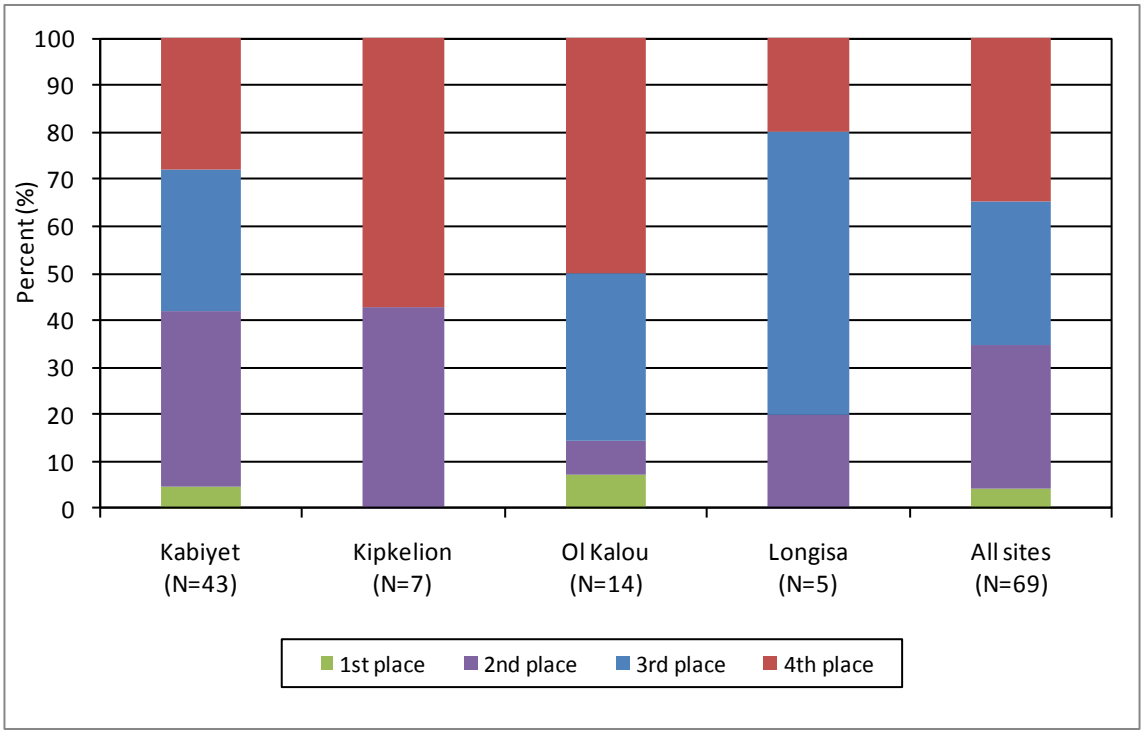

Figure 13: Percentage of feed businesses ranking processing income as compared to total income

Costs incurred

Overall, businesses with more than one machine types incur more costs than those with only one machine. Choppers are the cheapest to run, followed by pulverisers and then mills.

About 40% of the total cost incurred in running machines is due to fuel costs followed by hired labor at 31%. In Kabiyet, fuel costs contribute to 51% of the total cost to operate pulveriser businesses. Hired labor contributes 56% of the total cost to operate chopper businesses. Electricity cost contributes to less than 1% of the total cost to operate machines due to the fact that the majority of motorized machines are fuel powered. In addition, operators cited challenges in attributing the proportion of electricity consumed by machines, from total electricity consumption.

Other costs incurred in running feed businesses include costs of meals, licensing fees, transport charges, security levies, etc.

Table 15: Average costs per day and percent contribution to various expenditures by machine type (KES)

Site	Machine type	N	Average cost	Percentage contribution of various expenditures on average cost					
				Hired labor	Maintenance	Energy: Fuel	Energy: Electricity	Energy: Tractor PTO	Other
Kabiyet (N=43)	Pulverisers only	20	721	39.2	5.5	50.5	0.3		4.6
	Choppers only	5	171	55.6	12.3	31.0	1.2		
	Mills only	14	1,493	33.0	4.3	23.8	1.6	27.9	9.4
	2 or more machines	4	1,256	24.9	3.9	29.9		15.9	25.4
	All machines	43	958	34.7	4.8	34.0	0.9	16.1	9.5
	ANOVA		*0.0259*	*0.2532*	*0.4379*	*0.5355*	*0.3360*	*0.0555*	*0.0216*
Kipkelion (N=7)	Pulverisers only	7	601	36.9	7.6	47.4			8.2
	All machines	7	601	36.9	7.6	47.4			8.2
Longisa (N=5)	Pulverisers only	2	393	31.8	4.5	63.7			
	Mills only	3	382	26.2	9.7	43.6	10.9		9.6
	All machines	5	386	28.5	7.6	51.8	6.5		5.7
	ANOVA		*0.9695*	*0.8396*	*0.5818*	*0.7538*	*0.4950*		*0.4950*
Ol Kalou (N=14)	Pulverisers only	3	416	28.0	4.7	65.3			2.0
	Choppers only	7	675	35.2	9.8	43.7		0.7	10.5
	2 or more machines	4	1,833	15.7	11.3	71.2			1.8
	All machines	14	950	23.2	10.2	61.7		0.2	4.7
	ANOVA		*0.0187*	*0.4312*	*0.1448*	*0.0104*		*0.6439*	*0.7887*
All Sites (N=69)	Pulverisers only	32	646	37.8	5.8	51.2	0.2		5.0
	Choppers only	12	465	38.7	10.3	41.5	0.2	0.6	8.7
	Mills only	17	1,297	32.6	4.6	24.9	2.0	26.5	9.4
	2 or more machines	8	1,544	19.4	8.3	54.4		6.5	11.4
	All machines	69	879	32.2	6.2	41.4	0.8	11.1	8.2
	ANOVA		*0.0029*	*0.1872*	*0.0321*	*0.0126*	*0.0366*	*0.0121*	*0.0680*

Notes:
1. Only levels of significance of ANOVA tests are shown.

Overall, mobile machines cost more to operate as compared to stationary ones. This can be explained by the fact that the largest contributor to total costs for mobile machines is fuel, as opposed to hired labor for stationary machines.

Table 16: Average costs per day and percent contribution to various expenditures by machine mobility (KES)

Site	Machine mobility	N	Average Cost	Percentage contribution of various expenditures on average cost					
				Hired labor	Maintenance	Energy: Fuel	Energy: Electricity	Energy: Tractor PTO	Other
Kabiyet (N=43)	Mobile only	29	1,151	33.7	4.4	37.1	0.1	17.0	7.8
	Stationary only	12	328	51.9	10.9	21.6	8.8	4.1	2.8
	Stationary and mobile	2	1,950	25.6	2.6	20.5		20.5	30.8
	All machines	43	958	34.6	4.8	34.0	0.9	16.1	9.5
	ANOVA		*0.0146*	*0.2579*	*0.7572*	*0.0514*	*0.0685*	*0.3938*	*0.0001*
Kipkelion (N=7)	Mobile only	5	795	35.2	7.5	49.2			8.1
	Stationary only	2	115	65.0	7.6	16.5			10.8
	All machines	7	601	36.9	7.5	47.4			8.2
	ANOVA		*0.0919*	*0.1735*	*0.2438*	*0.2542*			*0.6257*
Longisa (N=5)	Mobile only	2	393	31.8	4.5	63.7			0.0
	Stationary only	3	382	26.2	9.7	43.7	10.9		9.6
	All machines	5	386	28.5	7.6	51.8	6.5		5.7
	ANOVA		*0.9695*	*0.8396*	*0.5818*	*0.7538*	*0.4950*		*0.4950*
Ol Kalou (N=14)	Mobile only	13	1,020	22.2	9.7	59.1			4.5
	Stationary only	1	39	12.8	10.6			76.6	0.0
	All machines	14	950	22.2	9.7	58.9		0.2	4.5
	ANOVA		*0.2647*	*0.2068*	*0.5379*	*0.3934*			*0.7034*
All Sites (N=69)	Mobile only	49	1,049	30.8	6.0	44.1	0.1	11.0	6.8
	Stationary only	18	297	46.6	10.5	25.9	8.8	3.6	4.6
	Stationary and mobile	2	1,950	25.6	2.6	20.5		20.5	30.8
	All machines	69	879	31.9	6.2	41.0	0.8	11.0	8.2
	ANOVA		*0.0013*	*0.0950*	*0.3604*	*0.0104*	*0.0115*	*0.3001*	*0.0000*

Notes:
1. Only levels of significance of ANOVA tests are shown.

Net revenue

Net revenues are defined as revenue earned from processing feeds minus all costs. Overall, businesses with more than one machine types earn the highest net revenue per customer and per day as compared to other businesses. In Longisa, businesses with mills earn more than those with pulverisers.

Table 17: Average net revenue calculations in KES by machine type

Site	Machine type	N	Net revenue calculations		
			Per day	Per day and customer	Per KG
Kabiyet (N=43)	Pulverisers only	20	4,447	1,257	2.18
	Choppers only	5	1,452	398	0.84
	Mills only	14	6,217	630	1.69
	2 or more machines	4	1,919	1,409	1.08
	All machines	43	4,440	967	1.76
	ANOVA		*0.3800*	*0.0328*	*0.1115*
Kipkelion (N=7)	Pulverisers only	7	809	499	0.77
	All machines	7	809	499	0.77
Longisa (N=5)	Pulverisers only	2	132	114	0.22
	Mills only	3	1,701	656	2.16
	All machines	5	1,074	439	1.39
	ANOVA		*0.3973*	*0.3437*	*0.0022*
Ol Kalou (N=14)	Pulverisers only	3	516	277	0.39
	Choppers only	7	316	248	0.39
	2 or more machines	4	3,564	924	0.75
	All machines	14	1,287	447	0.49
	ANOVA		*0.0095*	*0.0361*	*0.2468*
All Sites (N=69)	Pulverisers only	32	3,013	928	1.58
	Choppers only	12	790	311	0.58
	Mills only	17	5,420	635	1.77
	2 or more machines	8	2,741	1,166	0.91
	All machines	69	3,188	776	1.38
	ANOVA		*0.1104*	*0.0299*	*0.0225*

Notes:
1. Only levels of significance of ANOVA tests are shown.

Overall, stationary and mobile businesses earn more net revenue per day than those with only one machine type. In Kipkelion and Longisa, stationary businesses earn more than mobile ones (Table 18).

Table 18: Net revenue calculations by machine mobility

Site	Machine mobility	N	Net revenue calculations		
			Per day	Per day and customer	Per KG
Kabiyet (N=43)	Mobile only	29	5,755	1,170	1.99
	Stationary only	12	1,762	411	1.33
	Stationary and mobile	2	1,438	1,370	0.95
	All machines	43	4,440	967	1.76
	ANOVA		*0.1185*	*0.0174*	*0.2126*
Kipkelion (N=7)	Mobile only	5	1,002	272	0.48
	Stationary only	2	329	1,065	1.50
	All machines	7	809	499	0.77
	ANOVA		*0.5980*	*0.0545*	*0.1211*
Longisa (N=5)	Mobile only	2	132	114	0.22
	Stationary only	3	1,701	656	2.16
	All machines	5	1,074	439	1.39
	ANOVA		*0.3973*	*0.3437*	*0.0022*
Ol Kalou (N=14)	Mobile only	13	1,385	469	0.51
	Stationary only	1	14	167	0.24
	All machines	14	1,287	447	0.49
	ANOVA		*0.5266*	*0.5533*	*0.4881*
All Sites (N=69)	Mobile only	49	3,881	849	1.37
	Stationary only	18	1,496	511	1.43
	Stationary and mobile	2	1,438	1,370	0.95
	All machines	69	3,188	776	1.38
	ANOVA		*0.2139*	*0.1378*	*0.8717*

Notes:
1. Only levels of significance of ANOVA tests are shown.

Technical innovations and knowledge services

Technical advisory services include information on how to operate, maintain and repair feed machines. The major providers of such services are ongoing projects such as EADD, BDS providers and machine dealers (including mechanics and artisans).

Only 9% of feed processors have access to reliable advisory services in general, in spite of the fact that 24% of feed processors have access to reliable technical advisory services and 10% have access to reliable marketing advisory services (Table 19).

Marketing advisory services are largely provided by ongoing projects, BDS providers and the media.

Whereas 50% of feed processing entities believe that advisory services can be improved, only 3.8% believe so having accessed the service. This suggests that those

accessing the various services are satisfied, however, the perception is that the services are lacking.

In spite of the fact that 98% of feed processing entities are aware of the documented benefits of processing feeds, only 19% have the technical knowledge and also mix developing cost effective livestock feed and rations. Only 2% of the feed processing entities are not aware of the documented benefits of processing feeds, but this does not prohibit them from mixing cost effective livestock feeds and rations. This can be explained by the fact that these businesses are operated by the manager, as opposed to the owner.

Overall, technical knowledge on how to develop cost effective feeds is low. Perhaps EADD can address this knowledge gap so as to improve the quality of processed feeds in project sites.

Table 19: Percentage of feed processing entities citing various aspects related to technical innovations and knowledge services

Description	Sites				
	Kabiyet (N=65)	Kipkelion (N=9)	Ol Kalou (N=21)	Longisa (N=9)	All sites (N=104)
Have access to reliable technical advisory services	23.1	11.1	38.1	11.1	24.0
Have access to reliable marketing advisory services	7.7	11.1	14.3	11.1	9.6
Have access to both reliable technical and marketing advisory services	7.7	11.1	14.3	0.0	8.7
Generally believe that the advisory services can be improved	52.3	44.4	42.9	55.6	50.0
Aware of the documented benefits of processing feeds, AND	98.5	100.0	95.2	100.0	98.1
• Have technical knowledge for developing cost effective rations	16.9	22.2	33.3	33.3	22.1
• Mix cost effective livestock feeds and rations	66.2	44.4	47.6	66.7	60.6
• Have technical knowledge and mix cost effective livestock feeds	15.4	11.1	28.6	33.3	19.2
• Have technical knowledge for developing cost effective rations	0.0	0.0	0.0	0.0	0.0
• Mix cost effective livestock feeds and rations	1.5	0.0	4.8	0.0	1.9
• Have technical knowledge and mix cost effective livestock feeds	0.0	0.0	0.0	0.0	0.0

Future outlook

The future of feed processing is promising, as over 67% of the feed processing entities surveyed believe that feed processing is on the increase (Figure 8). This finding is grounded by the fact these processors know others who have purchased feed machines in the recent past. In Ol Kalou, 95% of the feed processors believe that the practice is on the increase.

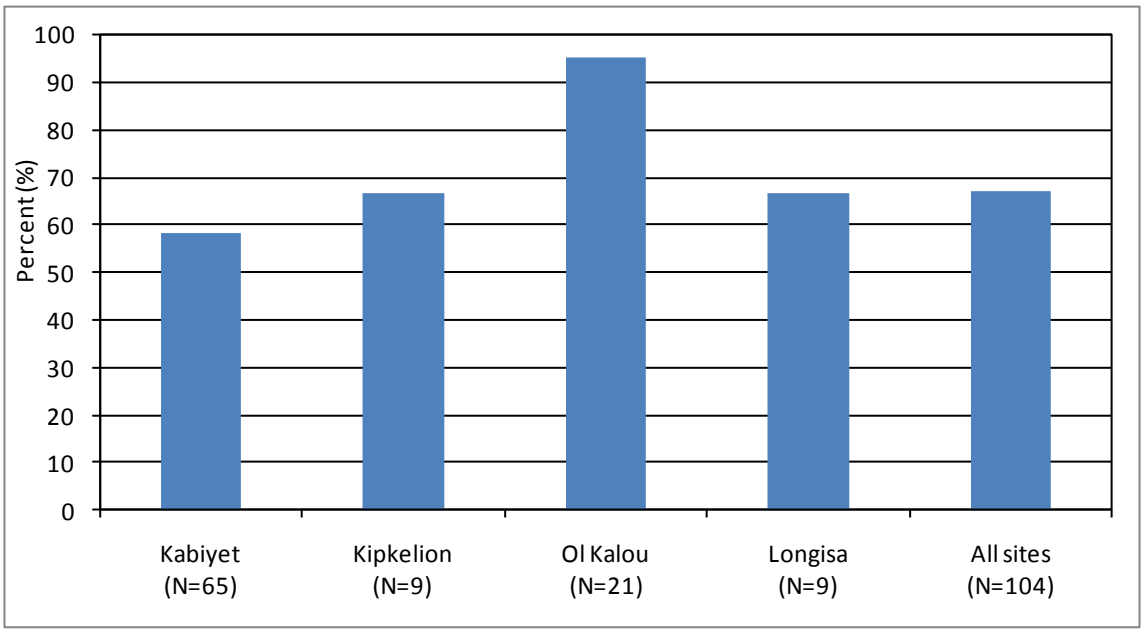

Figure 14: Percentage of feed processors who believe that the practice is on the increase

In addition, 74% of feed processors plan on expanding their operations by planting more fodder, purchasing additional fuel efficient machines, searching for new markets and by venturing into feed mixing based on locally available ingredients as a business. Roughly only 7% plan on focusing their feed processing efforts to cater exclusively to providing feed for their own livestock (as opposed to operating the processing entity as a business).

In spite of the fact that feed processing is on the increase and the majority are planning to expand, processing entities face constraints that limit their operations, or even cause them to scale back. Currently, 3% of the processors (which is 14% in Ol Kalou) plan on scaling back operations, due to increased costs and intensified competition. However, more processors can be expected to do the same if the constraints persist.

Poor transport infrastructure is the major constraint reported by 51% of the processors. The dilapidated road system causes delays, inefficiencies in service delivery and high production costs. Processors believe that the government can intervene by improving the roads.

The high cost of energy is another constraint cited by 43% of the feed processors. Escalating petroleum and diesel prices increases production costs for processors relying

on fuel driven machines. Providing fuel efficient machines, controlling fuel prices, providing machines that can run on alternate energy sources (such as solar, biogas, etc) and providing are cited as possible solutions to the problem.

Finally, lack of water was cited by 15% of the feed processors, which can be explained by the fact that forage production is mainly rain-fed. Extended dry spells results in reduced feed, which in turn diminishes output and revenue. Possible interventions include improving piped water supply, provision of water reservoirs (such as dams) and encouraging rain water harvesting.

Although not cited as a constraint, 25% of the feed processors advocated for training on feed processing and rations to be offered to traders as well as farmers, as well as increasing awareness on benefits of feed processing and the establishment of demonstration farms.

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