Food and Agriculture Organization of the United Nations

Ethiopia

Availability and utilization of agroindustrial by-products as animal feed

2018

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Contents

Figures

Tables

Contributors

FAO Ethiopia, Addis Ababa: Alemu Yami, Lemma Gizachew

Ethiopian Institute of Agricultural Research: Adey Melesse

Wolega University, Nekempte: Dereje Duressa

Federal Urban Job Creation and Food Security Agency, Addis Ababa: Melaku W/Yohannes

Department of Animal, Rangeland and Wildlife Sciences, Mekelle University, Mekelle: Tetemke Kidane

Andassa Agricultural Research Center, Bahir Dar: Wondimeneh Mekonnen

FSiABD consulting and Plc. & First Consult Plc., Addis Ababa: Zewdu Ayele

Sustainable Bioeconomy, Vienna-Rome, Austria-Italy: Harinder Makkar

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Abbreviations

AIBPs	Agro-industrial by-products
CP	Crude protein
CSA	Central Statistics Agency
DM	Dry matter
EMDIDI	Ethiopia Meat and Dairy Industry Development Institute
ESAP	Ethiopian Society of Animal Science
FAO	Food and Agriculture Organization of the United Nations
FAO-ET	FAO Ethiopia Country Office
ME	Metabolizable energy
NA	Not applicable
SNNPR	Southern Nations Nationalities and Peoples Region
VDFACA	Veterinary Drug and Feed Administration and Control Authority

Executive summary

One of the major constraints for the very low production and productivity of livestock in Ethiopia is the poor quality and inadequate quantity of available feed. Agro-industrial by-products (AIBPs) can play an important role in meeting the widely prevalent feed shortage in the country. The AIBPs are usually less fibrous, rich in energy and/or protein contents. They have high digestibility and energy values compared with other classes of feed resources. The major AIBPs produced in Ethiopia include by-products from flour millings, sugar factories, edible oil processing factories, breweries, and abattoirs. These by-products play a vital role in the feeding of livestock mainly in urban and peri-urban livestock systems. The spatial and temporal availability of AIBPs in different parts of Ethiopia has not been quantified. Information on the utilization of such resources is also scanty. Data on availability of these resources is important for developing and using appropriate feeding strategies, improving livestock production and productivity, enhancing the efficiency of AIBPs utilization, decreasing burden on the environment and promoting technologies that further circular economy. This study is aimed at assessing the spatial and temporal availability of major AIBPs and their use as livestock feed. Information on storage and transport of these by-products has also been recorded with the aim to identify 'hotspots' at which the wastage takes place, and to suggest ways to reduce it.

A team of researchers took six directions to cover the country and gather information on availability and use of AIBPs. The information was generated through a survey, meetings with stakeholders, visits to farms, and various other secondary sources including a number of organizations. The data on availability of AIBPs presented in this report may be considered as an underestimate. The reasons for this are the difficulties encountered in obtaining complete data as a result of the prevailing unrest in different parts of the country during the data collection period and the unwillingness of many of the industries to provide the actual data due to the fear of higher taxation. The number of wheat milling industries in Ethiopia is around 300. Out of these, 140 are located in and around Addis Ababa. Total annual milling capacity of these factories is estimated to

be 3.7 million tonnes. The main oilseed cakes produced include noug, groundnut, sesame, cotton, and safflower. Some 202 134 tonnes of cake are produced annually. A substantial quantity of oilseeds is exported without value addition, which decreases the availability of by-products (oilseed cakes) for use in the animal industry. Most agro-industries are running below their capacities, which could be attributed to insufficient availability of raw materials (wheat, oilseeds etc.), water and/or power. Breweries across the country produce a number of by-products. Domestic brewing and distillation is also a common practice. The domestic and modern breweries produce a total of 635 343 tonnes of by-product. Some 515 097 tonnes of this are domestic brewing and distilling by-products from only Oromia and Tigray regions (contribution of other regions could not be taken into account). These by-products generally are relatively efficiently used as animal feed.

All available by-products of cereal, pulse and oilseed milling units, and brewery by-products are used as animal feed. On the other hand, fishery by-products are not at all used and slaughterhouse offal, bagasse, molasses, sugarcane tops and fruit peels are used as feed to the extent of 89, 50, 50, 63 and 31 percent respectively of their availability. Molasses is used for ethanol production, while the extent of use of the other by-products mentioned above can be enhanced as animal feed. The offal produced only in the Addis Ababa Abattoir is processed to meat meal and bone meal for use as poultry feed.

A total of 7.58 million tonnes (DM) of by-products with embedded crude protein (CP) and metabolizable energy (ME) of 762 846 tonnes and 73.34×10^9 MJ were recorded in this survey. Out of these, the use of the by-products as animal feed was 5.1 million tonnes containing 639 559 tonnes of CP and 52.15×10^9 MJ of ME. Slaughterhouse offal, brewery by-products, food industry by-product (mainly biscuit waste) and molasses could not be included in the feed inventory and feed balance conducted earlier for Ethiopia (FAO, 2018; http://www.fao.org/3/ca1718en/CA1718EN.pdf). These additional feed resources, captured through this survey, would add an additional 1 084 770 tonnes of DM, 213 389 tonnes of CP and 11.28×10^9 MJ of ME to the national feed inventory. Their contribution to the total actual feed DM, CP and ME availability in Ethiopia is only

1.08, 3.08 and 1.42 percent respectively. This would lead to a reduction in national feed balance of DM, CP and ME to -20.07, -45.06 and -50.26 percent respectively, from -21.6, -48.24 and -51.70 percent respectively recorded earlier (FAO, 2018). Currently, the contribution of these by-products to the total feed use is negligible.

Proper storage of the by-products at the production site and on farms, transport of the by-products to the users in a timely manner and in proper containers e.g. made of plastic or metal with a cover and without any leakages, proper loading and unloading of the by-products to and from vehicles, linking the industries that produce by-products with the feed industries, without intermediates, and introduction of drying technologies at the production site to increase shelf-life are likely to reduce the wastages. Equally important is enhancing awareness of the importance of the by-products as animal feed, and to build capacity to properly manage (storage, handling) them at the production sites and on-farm, and to inculcate the thinking that these are valuable resources and to avoid its wastage would enhance their utilization as animal feed. These by-products can contribute substantially to enhancing livestock production in mixed crop-livestock systems, agro-pastoral systems and peri-urban and urban livestock systems. In the raw form, their contribution to the pastoral system is little. They can, however, be used in pastoral systems after processing to multi-nutrient blocks especially during droughts.

Introduction

Livestock production and productivity are very low in Ethiopia. One of the major constraints being the poor quality and inadequate quantity of feed available. Given that grazing land is decreasing and production of cash crops is increasing, agro-industrial by-products (AIBPs) could become important inputs in feed rations for different classes of livestock. These feed resources are generally high in nutrient contents and can play an important role in mitigating the above-stated major constraints facing the livestock sector. The spatial and temporal availability of AIBPs in different parts of Ethiopia has not been quantified. Information on the utilization of such resources is also scanty. Agro-industrial by-products also have a number of alternative uses. It is presumed that there is substantial wastage to such an extent that these valuable resources can become a huge burden to the environment in some areas.

Knowledge of the availability of AIBPs is important for planning and implementing appropriate feeding strategies in different parts of the country, improving livestock production, enhancing the efficiency of their utilization and decreasing environment burden. The efficient use of AIBPs will help to decrease feeding cost, which generally constitutes about 70 percent of the total animal production cost (Demissie Negash, 2017).

The objective of this work, therefore, was to assess the availability, utilization as feed, other alternative uses and extent of wastage of AIBPs in different parts of Ethiopia; and thus, generate baseline information and data that can be used for livestock sector planning. In addition, the information generated would assist in the development of region- and country-wide AIBP utilization strategy. This report is based on the information generated through a survey, meetings with stakeholders, visits to farms, and various other secondary sources including a number of organizations.

Methodology used

Categories of agro-industrial by-products considered

Nine categories of agro-industrial by-products: (1) cereal milling by-products, (2) oil milling by-products, (3) pulse milling by-products, (4) brewery and malt factory by-products, (5) food industry by-products, (6) horticultural (fruits/vegetables) by-products, (7) sugar industry by-products, (8) slaughterhouse (abattoir), by-products, and (9) aquaculture/fisheries by-products were assessed.

General methods and procedures followed for data collection

Types of information/data collected

These were: companies producing the by-products (see Annex 1) and feed mass balance (fraction or percent of the raw material used as input to the by-product produced as output), current status of the by-product utilization, buyers and users of the by-products, competitive uses of the by-products, and the points in the production and utilization chain at which the wastage of by-products take place, and the means by which the wastage can be prevented.

Sources of data and information

Both quantitative and qualitative data were collected from primary and secondary sources. Primary data were gathered from sources that generate the AIBPs such as flour, brewery and sugar factories, oil mills, fishers' unions, and slaughter houses. Secondary data sources included the Ethiopian Food, Beverage and Pharmaceutical Industry Development Institute, Veterinary Drug and Feed Administration and Control Authority (VDFACA), Ethiopian Meat and Dairy Development Institute (EMDIDI), Federal Small and Medium Scale Manufacturing Industry Agency, Central Statistical Agency Ethiopia (CSA-Ethiopia), Ministry of Livestock and Fisheries, Regional Bureau of Trade and Industry, Research Centers, Regional, Zonal and Woreda Bureaus/Agencies of Livestock and Fisheries, and Cooperatives.

Data were collected using previously developed questionnaires and converted to dry matter using the factors (see Annex 2).

Selection and training of resource persons for accomplishing the work

The survey was conducted at the national scale by reaching to the most important areas of AIBP production.

A team of professionals identified by the Ethiopia Society of Animal Production (ESAP) conducted the survey. A focal person was recruited to oversee the accomplishment of the planned tasks by the team. The following tasks were accomplished:

- A detailed questionnaire for the survey/data collection in consultation with FAO was prepared and agreed upon.
- Detailed 'Terms of Reference' were prepared for six enumerators to conduct the survey process. The identified enumerators were trained on methodologies to be followed for the data collection.
- The enumerators then collected the data by travelling to the regions. They covered the entire country by travelling in six routes. The six routes followed were the following (Figure 1).

Route 1. Northern Oromia and Amhara Region. Start from Addis Ababa and then to Selale (North Shewa of Oromia), East Gojjam, Awi, West Gojjam, South Gondar, North Gondar, North Wollo, South Wollo, Kamise, North Shewa of Amhara Region, and back to Addis Ababa.

Route 2. Western Oromia and western SNNPR. Start from Addis Ababa and then to South West Shewa, Gurage zone (Wolkite), Jimma, Keffa, Bench Maji, Ilu-Aba Bora, Gambela, Assosa, Kelem Wollega, West Wollega, East Wollega, Horro Guduru Wollega, West Shewa, and back to Addis Ababa.

Route 3. Southern Nations Nationalities and Peoples' region (SNNPR) and South-East Oromia. Start from Addis Ababa and then move to Part of Gurage zone (Buta Jira, Bu'ii etc.), Silte, Kanbata, Hadiya, Wollayta, North Omo, Konso, Borana, Guji, Gedeo, Sidama, West Arsi, part of East Shewa (Batu, Meki, Mojo, Bishoftu), and back to Addis Ababa.

Route 4. South-eastern Oromia, Dire-Dawa, Harari, Somali and Afar. Start from Addis Ababa and then move to Adama, Arsi, Bale, East Hararge, West Hararge, Harari, Somali (JigJiga), Dire-Dewa, Afar, Methara, and back to Addis Ababa

Route 5. Tigray Region (All Zones). The whole Tigray region.

Route 6. Addis Ababa and Special Zone of Oromia surrounding Addis Ababa. Ten sub cities and 5 Special Woredas of Oromia (Burayou, Sebeta, Dukam , Lagatafo, and Sululta) surrounding Addis Ababa.

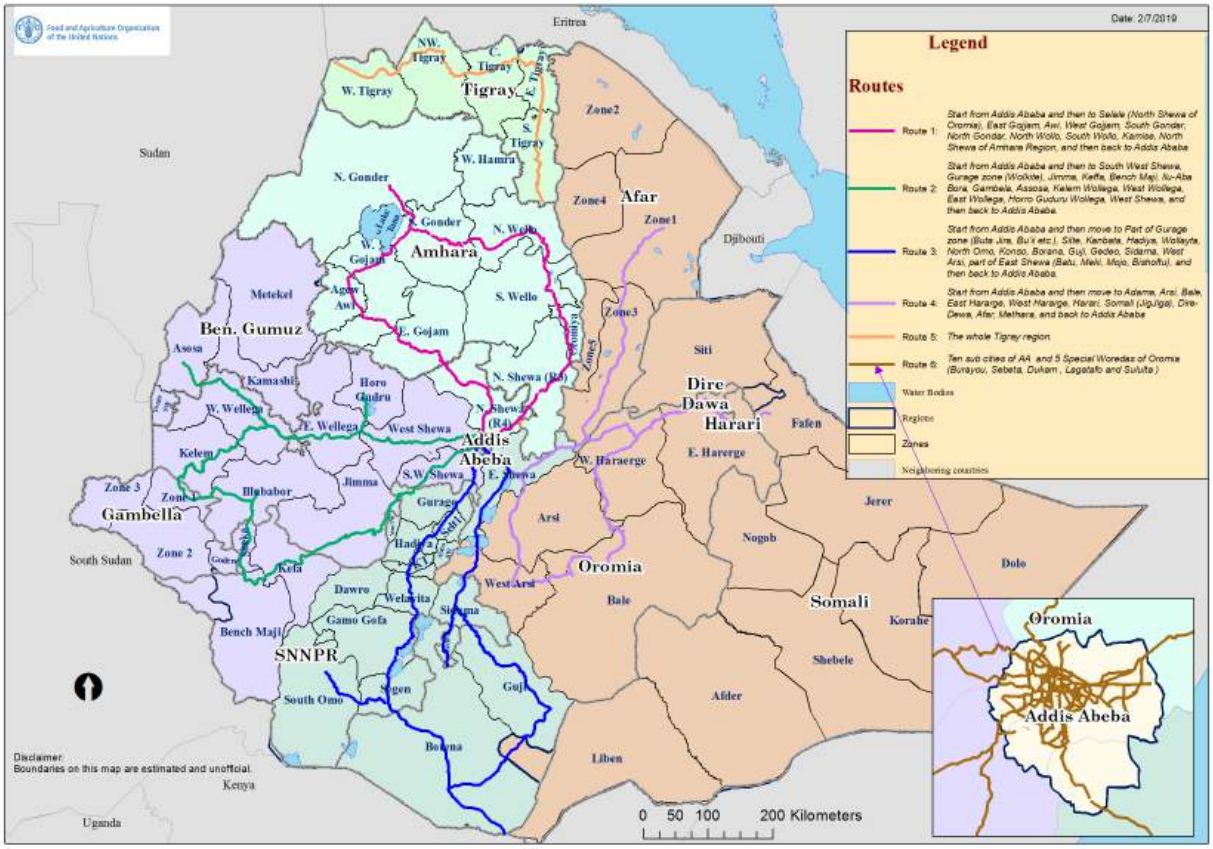

Figure 1. Map showing the six routes (Credit:Tefera Muhie)

- The data collected were then collated and a draft report was prepared by each enumerator on his/her respective geographic area of coverage; and
- The information was compiled at the national level by region and by category of AIBPs.

Results

Categories, production process and quantity of agro-industrial by-products produced by region

Agro-industrial by-products widely used include those resulting from flour factories, modern and traditional oilseed processing units, breweries, sugar factories, among others. The availability of these by-products varies from region to region and season to season, which is attributable to the location of the industries and seasonal availability of raw materials. The categories, production process and amounts available of by-products are given in Tables 1 to 7.

Cereal milling by-products

Wheat is the major cereal crop utilized as raw material for flour milling. Small quantities of rice and maize milling by-products are produced in the Southern Nations, Nationalities and Peoples' Region (SNNPR) and Tigray regions. There are two sources of the wheat for these milling units: a) produced locally (65–75 percent) and imported (25–35 percent). In 2017, Ethiopia imported about 850 000 tonnes of Durum wheat (Schroeder, 2017). The number of wheat milling factories in Ethiopia are around 300; out of which 140 are located in and around Addis Ababa (CSA, 2017). The annual total milling capacity of these factories is estimated to be 3.7 million tonnes.

By-products are produced before milling and during the actual grinding process.

Before milling: A cleaning and conditioning process is employed that removes grain impurities and separates the husk from the grain. The husk, broken wheat grains and unwanted grains (Figure 2) are separated at this stage. The extent of wheat reduction at this stage i.e. before the milling varies from 5 to 13 percent.

Figure 2. Brockenwheat grains (left), husk (middle) and impurities (right) (Credit: Adey Melesse)

During the milling process: The grains are then tempered and subjected to a series of screening and grinding operations that produce the flour and by-products such as wheat bran, wheat middlings and aspiration dust. The soil particles and other inedible particles are removed as waste. Depending on type of the final product, whether required for bread or pasta, the extraction rate ranges from 70 to 81 percent, resulting in the production of 20–30 percent by-products. Out of the total by-products produced, about 50–60 percent is wheat bran (furushca) and about 30 percent is wheat shorts/middlings (furiskello), and the rest goes as fine flour like material (finno) and aspiration dust that can not readily be used as feed. Wheat bran and wheat shorts (mixed with middlings) are the major ingredients (Figure 3) currently used in the concentrate feeds produced and marketed in Ethiopia.

Figure 3. Wheat middlings (left), wheat bran (middle) and aspiration dust (right) (Credit: Adey Melesse)

The different categories, production process and amount of wheat milling by-products produced are outlined in Table 1.

Oilseed milling by-products

Oilseed cakes are the residues produced as by-products during extraction of oil from oilseeds. The main ones are noug cake, cottonseed cake, groundnut cake, sesame cake, and sunflower cake. A substantial quantity of oilseed is exported while the mills are generally operating below their capacity. The exported oilseed could be channelized to these factories, resulting in value addition as additional oil and by-products, increasing food and feed security in the country.

Table 1. Categories, production process and quantity (tonnes DM)of cereal milling by-products produced

Region		Categories of cereal milling by-products produced (tonnes DM)					Total (tonnes DM)	Process followed for obtaining by-product
	Wheat bran	Wheat shorts /middlings	Wheat grain screening	Maize bran	Rice bran	Oat bran		Threshing washing drying, milling Screening and crushing for rice bran
Addis Ababa and surroundings	1 464 182	732 091	--	--	--	--	1 566 291	
Tigray	19 554	1 714	3 027	499			24 794	
Amhara	47 394				3 714	1 482	52 590	
Afar	--	--	--	--	--	--	0	
Oromia	166 436	19 005	184	45 377	323		231 325	
SNNPR	123 099	18 666	--	5283	2 062		149 110	
Benishangul-Gumuz	--	--	--	--	--	--	0	
Somali	7 836	--	--	1 480			9 316	
Gambela	171	38	8				217	
Harari	1 7718	202	2	375	--	--	18 297	
Diredawa	25 978	2 954	29	2 120	--	--	31 081	
Total	1 872 368	144 688	714	57 670	6 099	1 482	2 083 021	

SNNPR, Southern Nations, Nationalities and Peoples' Region

Almost all the oilseed mills use the expeller method for oil extraction. The by-products produced are, thus, cakes because these have been produced using only extrusion and contain a substantial amount of unextracted oil. A summary of the oil cakes produced is presented in Table 2.

Table 2. Categories, production process and quantity (tonnes DM) of oil milling by-products produced

Region	Categories of oil milling by-products produced (tonnes DM)					Total (tonnes DM)	Process followed for obtaining by-product
	Noug seed cake	Sunflower seed cake	Sesame seed cake	Groundnut seed cake	Cotton seed cake		
Addis Ababa and surroundings	--	--	--	--	--	6 912*	
Tigray	115		4 130	84	16 136	20 465	Screening, soaking and mechanical pressing
Amhara	--		--	--	--	51 649*	
Afar	--	--	--	--	--	--	
Oromia	--	--	--	--	--	110 849*	
SNNPR	1 661	0.88				1 662	
Benishangul-Gumuz	--	--	--	--	--	1 296*	
Somali	--	--	--	--	--	1 350*	
Gambela	--	--	--	--	--	--	
Harari	--	--	--	6 856	--	6 856	
Diredawa	--	--	--	--	--	1 095*	
Total						202 134	

**Disaggregated valiues were not available*

Pulse milling by-products

The main pulse crops in the country include different types of beans, peas and lentils. The main pulse processing by-products are found in the Northern Special Oromia Zone (stretches from Sendafa to Kemisse). Table 3 summarizes the production of different pulse milling by-products.

Table 3. Categories, production process and quantity (tonnes DM) of pulse milling by-products produced

Region	Categories of pulse milling by-products produced (tonnes DM)				Total (tonnes DM)	Process followed for obtaining by-product
	Field pea waste	Grass pea waste	Lentil waste	Haricot bean		
Addis Ababa and surroundings	6 359	--	5 103	--	11 462	Screening, crushing and blowing
Tigray	--	--	--	--	0	
Amhara	1 612	864	1 612		4 088	
Afar	--	--	--	--	0	
Oromia	--	--	--	--	248*	
SNNPR					1 894*	
Benishangul-Gumuz	--	--	--	--	0	
Somali	--	--	--	--	0	
Gambela	--	--	--	--	0	
Harari	--	--	--	--	0	
Diredawa				9 300	9 300*	
Total	7 971	864	6 715	9 300	26 992	

**Disaggregated values were not available*

Brewery and malt factory and food industry by-products

Breweries located in different parts of the country are producing substantial amounts of brewery by-products. Some of these are currently used as animal feed.

Brewery and malt industries. There are a number of modern breweries in Ethiopia that produce beer from barley. Among the by-products from these operations, brewers grains or spent grains are highly valued as feed especially for dairy cattle and fattening animals. Some breweries use malt produced by other companies for the production of beer. The malt production factories produce a mix of by-products that include 3rd grade grain residues, dusts, germs, and floaters, which can be used as animal feed. Production of domestically brewed beverages (e.g. Tella and Areki) from sorghum and other grains is also a common practice in many parts of Ethiopia. Atella, a by-product is produced from the domestically brewed beverage production. It is also used as animal feed. An attempt was made to collect information on this by-product from Oromia and Tigray regions, which

are the main regions for the production of local liquor. Further efforts are required to quantify the production of Atella from other regions, especially from Amhara where the practice is also wide spread.

Spent grains from large breweries are collected by animal feed producers for use as a base material for the production of animal feed. These are not delivered directly to farms. Dead yeast (brewers yeast) is produced as a part of the spent grain in all breweries contacted, and is thus not accessible separately. The production of brewers yeast as a by-product should be sought because it is a high valued ingredient (high in protein and vitamins) especially for poultry rations. Table 4 shows a summary of the production of brewery by-products. The availability of the by-product from domestic brewery production is much higher than that produced in the organized sector. The consumption and awareness of the quality of beer is growing in Ethiopia, and as a result the availability of the by-products (brewers grains) from breweries would increase in the future.

Food Industry. A number of food industries exist. However, due attention is not given to handling and utilization of their by-products, which could be potential feed resources (Makkar, 2017; Thieme and Makkar, 2017). Disaggregated data of the by-products of the food industry could not be obtained.

Table 4. Categories, production process and amount of brewery, malt factory and food industry by-products produced

Region	Categories of brewery, malt factory and food industry by-products production (tonnes DM)					Process followed for obtaining the by-product
	Spent Grain	Local/domestic brewing/distilling by-products (Atella)	Miscellaneous brewery by-products*	Food industry by-products**	Total	
Addis Ababa and surroundings	56 746			73.3	56 819	Soaking, fermentation, distillation, screening; Soaking, malting, screening
Tigray	343	18 972			19 315	
Amhara	31 450		17 224		48 674	
Afar	--	--	--	--	0	
Oromia	3 277	496 125	7 979	2 579	509 960	
SNNPR	7 910				7 910	
Benishangul-Gumuz	--	--	--	--	0	
Somali	--	--	--	32.31	32	
Gambela	--	--	--	--	0	
Harari	2 593			5.85	2 599	
Diredawa	--	--	--	33.7	34	
Total	102 319	515 097	25 203	2 724	635 343	

** A mixture of 3rd grade grain residues, germ dust and offal*
*** Mainly biscuit wastes and by-products*

Horticultural/fruit and vegetable by-products

Substantial quantities of fruit and vegetable wstes/by-products are produced at production marketing and consumption points. These can play a crucial role in livestock feeding (Wadhwa and Bakshi, 2013). These are, however, not dully valued as important livestock feed resource in Ethiopia and thus not given due attention in terms of proper collection and utilization. Vegaetable and fruit wastes are generally dumped. Table 5 summarizes the amount of fruit by-products. Data on vegetable by-products could not be obtained.

*Table 5. Fruit by-products produced**

Region	Production (tonnes DM)
Addis Ababa and surrounding areas	26 371
Tigray	551 004
Amhara	--
Afar	--
Oromia	521 601
SNNPR	217 455
Benishangul-Gumuz	3 772
Somali	103 127
Gambela	--
Harari	--
Diredawa	--
Total	1 423 330

**Mix of peels of banana, mango, avocado, orange, lemon, apple, papaya, guava and cactus*

Sugar factory by-products

Sugar factories found in different parts of the country produce by-products that can be used as feed resources. The whole operation produces molasses and bagasse at the factories and sugarcane tops on the sugar plantation fields. A number of additional factories are also under different stages of establishment and expected to become operational in a short span of time. This will enhance the availability of potential feed resources for the livestock sector. Currently a concerted effort is being made to integrate livestock production with the sugar factories using the by-products. The Ethiopian Sugar corporation is leading this effort.

This survey data include bagasse, molasses and sugarcane tops produced by large public farms, which could not be included in the previous FAO (2018) study. The reason for this is that the FAO (2018) study was based on the CSA data, which captures data from only the private farms and does not include the sugar estates that are the major sources of the by-products. Comparatively higher amounts of these sugar industry by-products are contributed by large public farms as is evident from this survey.

Molasses. Approximately 3 to 7 tonnes of molasses can be produced from 100 tonnes of fresh sugarcane (Feedipedia, 2018). It is a major feed ingredient used as an energy source and as a binder in compound feeds. A very large proportion of the molasses produced goes to the production of ethanol, leaving a small proportion available for animal feeding.

Bagasse: A highly fibrous and bulky by-product produced in a very large quantity. Almost all the bagasse produced is used as a fuel for the factories and the rest a small portion is discarded. However, new upcoming sugar factories will use electricity for their running and the bagasse would then be available for use as animal feed.

Sugarcane tops: This is a potentially high-value feed resource. Very little is used as feed and is mostly burnt. Its use as animal feed is nevertheless increasing. Use of modern sugarcane top harvesters in the sugar plantation would enhance the availability of the tops for use as animal feed. Table 6 presents the amounts of sugar factory by-products produced.

Table 6. Sugar factory by-products produced

Region	Molasses DM	Bagasse as DM
Afar	26 460	393 488
Oromia	129 975	1 932 853
SNNPR	15 000	223 065
Total	171 435	2 549 420

Slaughter house by-products

Almost 30 percent of the live weight of an animal ends up as offal. Offal consists of animal parts that are not suited for human consumption. Animal offal contains fat, meat, organs, bones, and blood.

Recycling of slaughterhouse by-products into animal feed can bring major benefits to livestock production and the environment. Bone meal and meat meal are by-

products of the rendering industry made from animal processing offal and turned into animal feed.

A large quantity of offal is processed in the Addis Ababa Abattoir. The individuals that perform informal slaughters and informal slaughterhouses do not process offal. The offal thus is largely wasted and dumped, causing environmental pollution.

Fishery by-products are produced as a result of the inappropriate fishing (fishing very small fish using inappropriate fishing nets and discarding them on the shore) and poor management of the catch (disproportionately high losses during filleting). These by-products are not processed and are wasted, and become a source of pollution (Silva et al., 2017). These by-products have high nutritive value and can be excellent feed.

A summary of the production of slaughter house (abattoir) and aquaculture/fishery by-products is presented in Table 7.

Table 7. Categories, production process and quantity (tonnes DM) of slaughter house (abattoir) and aquaculture/fishery by-products produced

Region	Categories of slaughterhouse and fishery by-products produced (tonnes DM)			Total (tonnes DM)
	Cattle offal	Sheep and goat offal	Fish offal	
Addis Ababa and surroundings	339 993	35		340 028
Tigray	2 143	969	636	3 748
Amhara	4 885	302	8 642	13 829
Afar	--	--	--	0
Oromia	13 460	24 902	6 516	44 878
SNNPR	8 406	757	3 570	12 733
Benishangul-Gumuz	1.9	2.4		4.3
Somali	--	--	--	0
Gambela	777	203		980
Harari	83			83
Diredawa	60.9	6.5		67.4
Total	369 810	27177	19 364	416 351

List of agro-processing companies producing by-product and their production capacity

Wheat is the major cereal crop utilized as an industrial raw material input by flour and food-based factories in Ethiopia. The total milling capacity of these factories is estimated as 3.7 million tonnes per year. Out of the total of 300 factories, 140 factories with a daily capacity from 28.8 tonnes to 120 tonnes are located in and around Addis Ababa.

The number of establishments in the food and beverages category is increasing. According to Central Statistical Agency (CSA, 2016) the number of food and beverage manufacturing industries across the regions in the county has reached 837. Out of these, 223 are located in Addis Ababa and surroundings, and the Oromia Special Zones. Public owned ones are 14, while the remaining 738 are privately owned. Within this category there are 33 animal feed manufacturing industries that use agro-industrial by-products as input for compound feed production.

All factories are operating below capacity. The primary reason for this was reported to be the shortage, inconsistent supply and poor quality of raw materials. The other constraints raised were the unavailability and high price of spare parts for the maintenance of machinery and shortage of working capital. The current long market chain (involvement of too many intermediaries) was also mentioned as one of the constraints, which results in high prices of the by-products at the user level.

Feed mass balance

The mean feed mass balance for the different categories of by-products is shown in the following Table 8. A large proportion of the biomass goes into by-products, which could have several uses. However, their use as animal feed would bring the 'wasted' nutrients (nutrients embedded in by-products) into the human food chain through the production of animal source foods.

Current status of by-product utilization

The proportion of AIBPs that goes for animal feeding varies by type of the by-product, level of technology use, alternative uses and location of production. The status of utilization is summarized in Table 9.

Table 8. *Feed mass balance*

Category of by-products	Type of by-products	Average feed mass balance (percent of original product)
Cereal milling by-product	Wheat bran	24
	Wheat shorts	5
	Wheat screenings	4
	Maize bran	37
Oil milling by-products	Sesame cake	50
	Noug cake	50
	Groundnut cake	45
	Cotton seed cake	58
Brewery by-products	Brewers grain	32
	Local brewing by-products (Atella)	43.2
Horticultural by-products	Fruit and vegetable waste	40
Sugar factory by-products	Molasses	3.5*
	Bagasse	28* [a]
	Sugarcane tops	25* [a]
Slaughter house by-products		46
Fish waste		30

**of the sugarcane processed on wet basis*

[a] for converting wet weight to DM, use a factor of 0.5 i.e. 50 percent is moisture in both products

Table 9. Current status of by-product utilization

Types of by-product	Total amount of by-product produced (tonnes DM)	Current use of by-products					Remarks
		Feed (tonnes DM)	Disposed of in the environ-ment (tonne DM)	Burnt (tonnes DM)	Other industrial applications (tonnes DM)	Other uses	
Wheat milling by-products							
Wheat bran	1 872 368	1 872 368	Nil	Nil	Nil	Nil	Effectively used as feed
Wheat shorts/middlings	144 668	144 668	Nil	Nil	Nil	Nil	Effectively used as feed
Accumulated or flour sweeping aspiration dust, fine impurities	--	--	Almost all	Some burnt (un-quantified)		--	
Wheat grain screenings	57 670	57 670	Nil	Nil	Nil	Nil	Efficiently used as feed
Maize bran	714	714	Nil	Nil	Nil	Nil	Effectively used as feed
Rice bran	6 099	6 099	Nil	Nil	Nil	Nil	Effectively used as feed
Oil mill by-products	202 134	202 134	Nil	Nil	Nil	Nil	There is a high demand for oilseed cakes; therefore, according to a few oil producers there is no accumulation of the cakes. All are sold to feed producers and farmers
Sugar factory by-products							
Molasses	171 435	85 718	Some wastage but unaccoun ted	Nil	85 718		Large proportion used for ethanol production and as an input for liquor factories
Bagasse	2 549 420	1 274 710	Nil	1 274 710[a]	Nil	Nil	[a] A major portion is used as fuel in the factories
Sugarcane tops	209 040	131 760	Nil	77 280[b]	Nil	Nil	[b] Burnt

Brewery by-products							
Spent grain	102 319	102 319	Nil	Nil	Nil	Nil	Effectively used as feed
Domestic brewing by- products	515 097	515 097	Nil	Nil	Nil	Nil	Effectively used as feed
Food industry by-products	2 724	2 724	Nil	Nil	Nil	Nil	Pig and poultry farmers buy it
Horticulture-fruit/vegetable by-products	1 423 330	440 100	983 230	Nil	Nil	Nil	Their use as animal feed can be enhanced
Slaughterhouse by-products	396 987 (does not account for informal slaughters)	353 709	43 278	Nil	Nil	Nil	Backyard slaughter is prevalent. By-products from such slaughters and informal slaughterhouses are dumped
Fishery by-products	19 364	Nil	19 364	Nil	Nil	Nil	Illegal fisheries using inappropriate equipment and high wastage during processing results in a large amount of potentially useful feed resources being dumped.

Cereal milling by-products

The by-products of cereal milling are used as animal feed.

Horticultural/fruit and vegetable by-product

Fruits and vegetables are sold in many whole sale and retail shops, supermarkets and open markets. Fruit and vegetable wastes are generally dumped by primary trash collectors. Some youth sell the relatively fresh leftovers of fruits and vegetables, which are not sold for human consumption, to livestock producers. They sell around 10 car loads (equivalent to 3.5–5.0 tonnes per car) of cabbages

(the outer layers), bananas (broken) and banana leaves (Figure 4) for use as animal feed in urban and peri-urban dairying.

Figure 4. Cabbage (left) and banana (right) leaves for use as animal feed (Credit: Adey Melesse)

Food industry by-products

The food industry by-products are the potential feed sources in the country. Due attention is not given to handling and utilization of by-products from this industry as potential inputs for the feed processing industry.

Brewery by-products

There is a high demand for brewers spent grain. According to dairy farmers in Sebeta area, the supply is very low, and the price could vary from 4 000 birr/tonne on DM to as high as 12 000 birr/tonne on DM basis (assuming DM of 25 percent). The latter price exceeds that of most oilseed cakes (ca 10 000 birr/tonne).

Slaughterhouse (abattoir) by-products

Most slaughter activities take place at household level during public and religious holidays. There are several municipal abattoirs managed under different municipalities across the country. Unauthorized abattoirs also operate in many parts of the country. About 14 new and modern export-oriented abattoirs are also operational. Most by-products from these sources are not processed into feed. Some amount of offal is processed by the Addis Ababa Abattoir. An ultra-modern

abattoir and rendering plant (the Alana complex) has recently been set up at Adami Tulu. It will go into production very soon. This facility is expected to process all its by-products and to also procure by-products from other slaughter houses and convert them into useable products.

The Addis Ababa Abattoir sells all by-products in some form, except the blood that is discarded into a septic tank. The main by-products are meat and bone meal (Figure 5), pet meal and fat (Figure 6).

Figure 5. Meat and bone meal (Credit: Adey Melesse)

Figure 6. Pet food in one kg packing (left) and fat in barrel (right) for delivery to soap factory respectively (Credit: Adey Melesse)

Other by-products from this abattoir such as horns are sold for making buttons and decoration pieces. Testicles and eyes are usually exported.

Buyers and users of cereal milling by-products and competitive uses of by-products

The buyers and users of different by-products are shown in Table 10. Users sometimes purchase the by-products directly from the producers. In most cases, the transaction is, however, through a series of intermediaries.

Table 10. Transaction of agro-industrial by-products

Type of by-product	Buyers	Users	Price in Birr/kg as sold	Purpose for which by-product was purchased
Cereal milling by-products				
Wheat bran	Traders, local farmers and feed processors	Feed processors and livestock keepers	2.8–7.8	Livestock feeding, feed processing (users), and profit making (traders)
Wheat shorts/middlings	Traders, local farmers and feed processors	Feed processors and livestock producers	7.3–7.7	
Wheat grain screenings	Traders, local farmers and feed processors	Feed processors and livestock producers	2.0	
Maize bran	Traders, local farmers and feed processors	Feed processors and livestock producers	4.5	
Rice bran	Traders, local farmers and feed processors	Feed processors and livestock producers	2.2	
Oat bran	Traders, local farmers and feed processors	Feed processors and livestock producers	3.9	
Oil Milling by-products				
Noug seed cake	Traders, local farmers and feed processors	Feed processors and livestock producers	5.4–6.5	Livestock feeding, feed processing (users), and profit making (traders)
Sesame seed cake	Traders, local farmers and feed processors	Feed processors and livestock producers	9.3	
Cotton seed cake	Traders, local farmers and feed processors	Feed processors and livestock producers	6.0	
Groundnut seed cake	Traders, local farmers and feed processors	Feed processors and livestock producers	5.0	
Pulse milling by-products				
Fieldpea waste	Traders, local farmers and feed processors	Traders, local farmers and feed processors	7.9	Livestock feeding, feed processing (users), and profit making (traders)
Grasspea waste	Traders, local farmers and feed processors	Traders, local farmers and feed processors	10.8	
Lentil waste	Traders, local farmers and feed processors	Traders, local farmers and feed processors	10.8	
Brewery by-products				
Spent grain	Traders, local farmers and feed processors	Producers in the vicinity of the breweries use it mainly as dairy feed	2.1–3.0	Livestock feeding, feed processing (users), and profit making (traders)
Local “Atella”	Local livestock producers	Locally used, mainly peri-urban farmers use it for fattening and dairying	2.2	Livestock feeding by local farmers

Horticulture by-products	NA	NA	NA	NA
Sugar factory by-products				
Molasses	Traders, local farmers and feed processors, and liquor factories	Feed processors and mainly poultry producers, and distilleries		Ethanol production and liquor production (major part); and feed ingredient and feed binder
Bagasse	Generally, not sold	The factories largely use it as fuel	NA	NA
Sugarcane tops	Generally, not sold	Very limited quantity used for feeding in the vicinity of the plantations; Mostly burnt	NA	NA
Slaughter house by-products	The processed meal bought by traders and feed processors	Feed processors, mainly poultry producers		A limited quantity processed into meals and used mainly as poultry feed ingredients
Fishery by-products	NA	NA	NA	NA

NA: Not applicable

Price information was taken during March–April 2018

The points in the by-product production and utilization chain at which the wastage of by-products takes place, and their prevention

Wastage of by-products takes place at different stages including, during and just after production, during transport, processing, handling and utilization (Table 11). This table also presents some possible measures to prevent the losses.

Table 11. The point(s) at which wastage of by-products takes place and its prevention

Name of by-product	Point(s) at which the wastage occurs	How wastage can be prevented	Technological processing required for making efficient use of by-product as animal feed	Storage practices of by-products on the site of production	Storage practices of by-products on-farms	Transport methods used to transport by-products from the production site to end users	Risks involved in the current methods of transport
Wheat bran maize bran wheat shorts/ middlings, and grain screenings	Poor quality wheat as input - about 10 percent of the weight removed as an impurity; and during storages, transport, loading, and unloading (Note: a very small part of maize is processed)	Proper storage and packaging; storage on pallets; greater care during loading and unloading; and creation of awareness on the degree of wastage and its prevention	No process required	Few mills use pallets and most store on the floor; and storage away from walls (provision of space for ventilation) was practiced in some factories	Since many farms buy small quantity, pallets to prevent direct contact with the floor and adequate ventilation are not used	Most Flour factories use vehicles; a few use carts; and pack animals are sometimes used for transport to end users	Rain and moisture accumulation during transport; contamination with previously loaded items in the vehicles; and contamination from several times used old bags
Oilseed cakes	Storage at the site of production, resulting in mold growth; and during transport, loading and unloading	Proper storage; and awareness creation on losses and their prevention	Monitoring for aflatoxins and application of their mitigation approaches	Floor storage without proper ventilation; storage in a store containing other items; and pallets not used	Floor storage without proper ventilation; storage in a store containing other items; and pallets not used	Vehicles; wheel carts; and pack animals	Rain and moisture accumulation; contamination with previously loaded items in the vehicles; and contamination from old bags used several times

Pulse milling by-products	At each point of the milling process (washing, sun drying, screening, roasting, crushing, and sieving); storage at the site; and improper drying	Proper storage practices on site of production, during transport and on-farm	No process required	Floor storage without proper ventilation and in a place containing other items; and pallets not used	Storage in bags and in the open	Vehicles; wheel cart; and pack animals	Rain and moisture accumulation; contamination with previously loaded items in the vehicles; and contamination from several times used old bags
Spent grain	At loading and unloading and during transport; and during storage on production sites and farms	Proper loading, unloading and storage practices	Drying would enhance its shelf life	Concrete silos at some production sites but to a limited extent (mold and mycotoxins could be present)	Spreading on a plastic sheet; concrete floors (open to air); plastic bags and containers (generally kept closed). Used in both wet and air-dried forms (mycotoxin presence cannot be ruled out)	Bulk transport with vehicles	Contamination with items previously loaded in the vehicles
Brewers yeast	In some cases, heat treatment is used to kill or inactivate yeast cells and then disposed of	Proper storage and establishment of linkages with the feed industry	Technology to separately process yeast and avail it as a valuable supplement	Disposal in soil	NA	NA	NA
Local brewing by-product (Atella)	Transport and use	Proper transport and storage; and use of appropriate feeders	Proper low-cost drying for enhancing shelf life	Plastic or clay containers	Plastic or clay containers	Pack animals; wheel barrows; and animal-drawn carts	Moisture accumulation; and mycotoxins presence

Molasses	Storage at the site of production; and during transport, loading and unloading	Proper transport, loading, unloading, and storage	Enhance utilization as feed through production of multi-nutrient blocks	Concrete structures at some places; largely in pits and plastic containers	Plastic or clay containers; and concrete structures at some places	Barrels	Contamination with soil and items previously loaded in the vehicles
Sugarcane bagasse	Storage on soil surface at the site of production	Proper storage conditions	Physical and chemical means of improving its use as feed	In the open, mostly on the soil surface	NA	NA	NA
Horticulture/ fruit and vegetable wastes	Site of production due to improper harvesting; During transport and at the point of sale due to improper handling and storage	Proper handling, storage (use of cold chain) and packaging; greater care during loading and unloading; and creation of awareness on the degree of wastage and its prevention	Processing technologies for efficient use of wasted fruits and vegetables as animal feed	On the soil surface; and in plastic containers and bags	On the soil surface; and in plastic containers and bags	Mainly human labour; pack animals; and carts	Improper packaging and bad roads lead to increased spoilage
Slaughter house offal/fish waste	Slaughter houses, and at points of fish harvest and processing	Proper collection, transport and management of by-products	Drying and processing to meal	On the ground (dumped)	NA	NA	NA

NA: Not applicable

Discussion and way forward

Agro-industrial by-products are potential feed resources that are subject to dynamic changes. Their supply is strongly influenced by the land area under production of the main crops, yield determinant inputs and environmental factors. The processing technologies used by the industry also determine the nature and amount of by-product produced. Oilseed by-products such as Niger cake/meal are traditionally used as important sources of protein in animal diets, the area under production is shrinking due to the lack of adapted and productive planting materials. Similarly, the cotton mealy bug pest has markedly reduced the production of cotton and hence the supply of cotton seeds. On the contrary, prices of pulses and oil crops such as beans and sesame are increasing in the international markets, encouraging the expansion of pulses and some oilseed crops. Unfortunately, sesame seed is exported intact without processing. As a result, the growing trend in the production of this oil crop has little contribution to the local supply and availability of sesame cake for use as animal feed and of oil for human consumption. There is a commitment to encourage value addition of such important crops. To this end, the government is developing agro-industrial parks in selected locations in the country where prospective investors can establish agro-industrial plants including oil-extraction units. Likewise, considerable public investment in sugarcane production and industry in the country is also expected to substantially increase the supply of sugarcane by-products, such as molasses, bagasse, and sugarcane tops in the coming one to two years. Livestock production especially fattening enterprises are planned to be integrated with these sugar factories/plantations to make more effective use of the by-products. Such developments clearly indicate the likelihood of an increased supply and utilization of agro-industrial by-products.

All the available by-products of cereal, pulse and oilseed milling units, and brewery by-products are used as animal feed. On the other hand, fishery by-products are not at all used and slaughterhouse offal, bagasse, molasses, sugarcane tops, and fruit peels are used as feed to the extent of 89, 50, 50, 63 and 31 percent of their availability. Molasses is used for ethanol production, while the extent of use of other above-mentioned by-products as animal feed can be enhanced.

A total of 7.58 million tonnes (DM) of by-products with embedded crude protein (CP) and metabolizable energy (ME) of 762846 tonnes and $73.34x10^9$ MJ were recorded in this survey. Out of these, the use of the by-products as animal feed was 5.1 million tonnes containing 639 559 tonnes of CP and 52.15 $x10^9$ MJ of ME.

Slaughterhouse offal, brewery by-products, food industry by-product (mainly biscuit waste) and molasses could not be included in the feed inventory and feed balance conducted for Ethiopia (FAO, 2018). These additional feed resources would add an additional 1 084 770 tonnes of DM, 213 389 tonnes of CP and $11.28x10^9$ MJ of ME to the national feed inventory. Their contribution to the total actual feed DM, CP and ME availability in Ethiopia is only 1.08, 3.08 and 1.42 percent respectively. This would lead to a reduction in national feed balance of DM, CP and ME to -20.07, -45.06 and -50.26 percent from -21.6, -48.24 and -51.70 respectively. Currently, the contribution of these by-products to the total feed use is negligible.

The available brans and oilseed cakes are well utilized as livestock feed in Ethiopia; however, there is a need to enhance utilization of other by-products such as brewers grains, fruit and vegetable wastes, food wastes, slaughterhouse offal, molasses, bagasse and sugarcane tops. Use of bagasse, sugarcane tops and a small amount of urea (< 0.5 percent in the diet) in a densified block or pellet form can be a good emergency feed, capable of sustaining ruminants in challenging situations. Proper storage of the by-products at the production site and on-farms, transport of the by-products to the users in a timely manner and in proper containers, proper loading and unloading of the by-products to and from vehicles, directly linking the industries that produce by-products with the feed industries, without intermediates, and introduction of drying technologies at the production site to increase shelf life are likely to reduce the wastages. Equally important is to enhance awareness of the importance of the by-products as animal feed and built capacity to properly manage (store, handle) them at the production site, and inculcate thinking that *these are valuable resources and not waste* would enhance utilization of the by-products as animal feed. Introduction of the concept and practice of balanced feed formulation and feeding using these currently unconventional (in the Ethiopian context) feed resources would enhance the profitability of the livestock production systems. Development of guidelines and

directives for the efficient and safe use of AIBPs would also further commercialization of these by-products and promote the development of the industrial sector including the feed industry; and at the same time would decrease environmental pollution and improve public health.

Brewers grains, fruit and vegetable wastes and by-products, slaughterhouse by-products get spoiled due to their high water content. Development and use of simple and efficient dryers (including solar and wind dryers) would help to reduce wastages of these invaluable resources and decrease the cost of transport and storage. Brewers grain (*ca* 25 percent crude protein) is a very good feed for dairy and fattening animals and could also be fed to poultry after drying. Absorption of the moisture using ground crop residues and/or hay, followed by compaction using mild muscle force and then drying could be another option for enhancing utilization of brewers grains and fruit and vegetable wastes (Wadhwa and Bakshi, 2013). Silage making of fish wastes could also be an attractive approach (Guerouali, 1999).

Presence of mycotoxins would be one of the biggest challenges in the safe and efficient use of most of the by-products discussed in this report. Prevention of mold growth using good management practices should be the priority. This should also go hand-in-hand with the infrastructure and capacity building for monitoring mycotoxins in both public and private laboratories. The AIBPs can contribute substantially to enhancing livestock production in mixed crop-livestock systems, agro-pastoral systems, and peri-urban and urban livestock systems. In the raw form, their contribution to the pastoral system is little. However, after processing to multi-nutrient blocks, they can also be used in pastoral systems especially during droughts.

Given the difficulty experienced by the enumerators to get the full confidence of the private actors involved in the processing and manufacturing industries, the data generated in the present survey need to be taken cautiously. Since the private sector actors associate disclosure of actual production records with high rate of taxation, they tend to report lower quantities than actually produce. During the course of the field survey, thorough authentication of information provided by the private sector actors through triangulation via other means was not possible.

Also the tense security situation prevailing during the survey period did not allow a complete collection of the data. In the light of this, it would be prudent to regard the values reported here on current level of by-products production as an under estimate.

In summary, AIBPs could play an important role in the sustainable development of the livestock sector in Ethiopia, given the scarcity of land to grow fodders and the poor quality of available feed. Yet the efficiency at which these by-products are currently utilized is very low. In order to improve the efficiency of their use, as a start, it will be fundamental to take the actions suggested above. In addition, there is a need to conduct indepth assessment of the different aspects of production and use chain for each of the nine categories of AIBPs identified in this study and to introduce transparency in the value chain.

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Annexes

Annex 1. List of companies contacted

Annex 1 Table 1. Flour mills

Region/companies	Location
Western Oromia, Gambella, Asossa, Mizan and Bonga	
GG Flour Factory	East Wollega
Jirra Flour Factory	West Shoa
Mati Flour Factory	West Shoa
Amarti Flour Factory	West Shoa
Keneni Flour Factory	West Shoa
Wodessa Flour Factory	West Shoa
Hay Soft Flour Factory	West Shoa
Ambo farmers' union Flour Factory	West Shoa
STAR/Teltelle Flour Factory	West Shoa
Woliso Flour Factory (two)	S/W/Shoa
Sisay Geletu Flour Factory	S/W/Shoa
Baro Flour Factory	Gambela
SNNPR	
Sisay Zegeye Flour Factory	Halaba
Hashu Flour Factory	Sodo
Awol Flour Factory	Sodo
Ersedi Flour Factory	Doyo Gena
Walya Flour Factory	Doyo Gena
Fedlu Flour Factory	Worabe
Aberus Flour Factory	Worabe
Sumege Flour Factory	Worabe
Adazer Flour Factory	Worabe
Bereda Flour Factory	Worabe
Hindia Flour Factory	Worabe
Kedija and her Family Flour Factory	Worabe
Ekram Flour Factory	Worabe
Sumeya Flour Factory	Worabe
Zeman Flour Factory	Worabe
Momina Flour Factory	Worabe
Tigray region	
Huda Abiy Adi	Abiy Adi
Mesob Flour Factory	Adigrat
Walia Flour Factory	Adigrat
Omina Adwa food complex	Adwa
Betel Flour Factory	Alamata
Axumawit Flour Factory	Axum
Dejen Flour Factory	Axum
Lemlem Food Complex	Mekelle
Huda Food Complex	Mekelle
Diplomacy Flour Factory	Mekelle

Weather Flour Factory	Mekelle
Romanat Flour Factory	Mekelle
Tigray Flour Factory	Mekelle
Momona Flour Factory	Mekelle
Enderta Flour Factory	Mekelle
Mejer Flour Factory	Sheraro
Muna Flour Factory	Shire
Master Flour Factory	Shire
Omina Shire Food Complex	Shire
Zagra Flour Factory	Shire
Adiyabo Flour Factory	Shire
Addis Ababa and Oromia Special Zone	
Ten Day Belt General Trading Plc	Dukem
Hayat Food Complex	Burayu
Alhamdu Flour Factory	Burayu
DH Geda Flour Factory	Gerji
Boni Food Complex	Sebeta
Nura Seadu Flour Factory	Akaki
Habesha Flour Factory	Akaki
Wabeshebele Flour Factory	Saris abo
Yamrot Food Complex	Burayu
Haymen Flour Factory	Sebeta
Kebron Flour Factory	Burayu
Mohamed Awol Flour Factory	Alemgena
Meseret Flour Factory	Dukem
Huruta Flour Factory	Aweliya
Atsede Abebe Flour Factory	Eyasu Tsebel
Birwonz Flour Factory	Rufael
Almaz Hare Ggewoin	Rufael
K.O.J.J Food Complex	Asko
Wakene Food Complex	Burayu
Nyala Flour Factory	Burayu
Meshobiya Food Complex	Burayu
Emran Food Complex	Burayu
Berhobot Food Complex	Burayu
Afia Food Complex	Burayu
Kana Industry and Trade	Abariy Gulit
Ethio Flour Factory	Burayu
Agape Flour Factory	Burayu
Suyum Defere Flour Factory	Burayu
Assefa Negasa Flour Factory	Burayu
Rahmet Flour Factory	Alemgena
Al-Kemer Flour Factory	Burayu
Misrak Flour Factory	Gotera
Yabez Food Complex Plc	Kotebe
Harbu Flour Factory	Gelan
Gohe Flour Factory	Saris
E Class Plc.	Alemgena
Melkam Flour Factory	Akaki
Nigat Flour Factory	Kality
Betel Flour Factory	Akaki

Universal Food Complex	Kality
Asteco Food Complex Factory	Gelan
Ethiopian Spice Extraction Factory	Kality
Tewekel Food Complex	Burayu
Nahili Flour Factory	Gelan
Hanan Flour and Bakery	Alemgena
Fiseha Eshete Flour Factory	Kality
Nas Foods Plc.	Legetafo
Echa Food Complex Plc.	Gelan
Kokeb Flour and Pasta Factory	Saris
Hora Food Complex	Alemgena
Kality Food Share Company	Kality
Amhara region	
Mifah Flour Factory	Woldia
Seid Mohamed Flour Factory	Kobo
Estifanos Mekasha Flour Factory	Kobo
Kameyash Flour and Food Processing Factory	Kobo
Wollo Flour Factory	Dessie
Keneane Flour Factory	Dessie
Fabre Flour Factory	Dessie
Fauabele Flour Factory	Dessie
Amin Flour Factory	Dessie
Adem Flour Factory	Kombolcha
Hussien Ahemedena Lejochu Flour Factory	Kombolcha
Ras Guba Flour and Biscuit Factory	Kombolcha
Flower Flour Factory	Kombolcha
Zara Flour Factory	Kemessie
Bati Flour Factory	Bati
Fawez Flour Factory	Kemessie
Belay Flour Factory	Gondar
Kokeb Amba Flor Factory	Gondar
Mesdes Flour Factory	Gondar
Jantekel Flour Factory	Gondar
Dogaw Food Complex	Gondar
Haki Flour Factory	Gondar
Tiss Abay Flour Factory	Bahir Dar
Ethiocalfornia Flour Factory	Bahir Dar
BDR Flour Factory	Bahir Dar
Selal Flour Factory	Bahir Dar
Fire Flour Factory	Bahir Dar
Shigez Flour Factory	Bahir Dar
Walelegn Flour Factory	Bahir Dar
Smart Flour Factory	Bahir Dar
Mareza Flour Factory	Bahir Dar
Merekeb Union Flour Factory	Bahir Dar
Unique Pasta and Makaroni Factory	Bahir Dar
Erebe Flour Factory	Bahir Dar
Horizon Flour Factory	Bahir Dar
Tana Haik Flour Factory	Bahir Dar
Abayena Tana Flour Factory	Bahir Dar
Berekat Flour Factory	Bahir Dar

Kale Flour Factory	Bahir Dar
Zeyien Flour Factory	Bahir Dar
Leza Flour Factory	Bahir Dar
Top Flour Factory	Bahir Dar
Meron Flour Factory	Bahir Dar
Tessema Mekonnen Flour Factory	Markos
Abantena Mehari Agro Processing Plc.	Markos
YAAG Plc.	Markos
Gozamen Union Agro Industry	Markos
Sekina Food Processing	Debre Birhan
Daniel Mengistu Flour Factory	Debre Birhan
Aseres Getaneh Flour Factory	Shewa Robit
Wodera Union Bread Flour Factory and Animal Feed Processing	Debre Birhan
Tera Agro Industry	Dessie
Sehina Flour Factory	Dessie
Kalekidan Flour Factory	Dessie
Tafete Flour Factory	Sekota
Yisemaw Alemayehu Flour Factory	Injebara
Derisa Flour Factory	Chagni
Ntwo East Flour Factory	Debre Tabor
Oromia, Afar, Harari, Dire Dawa and Somali Regions	
Awol kasim Flour Factory	Shashemene
Kubesa Flour Factory	Shashemene
Minyahel Flour Factory	Shashemene
Shala Maize Factory	Shashemene
Kiya Food Complex	Dukem
Asela Ketar Flour Factory	Assela
Awfat Flour Factory	Adama
Eshet and Tesfa	Adama
Fana Flour Factory	Adama
Mulan Flour Factory	Adama
Weba Flour Factory	Adama
Africa Plc Flour Factory	Adama
Gondi Adama Flour Factory	Adama
Sofia Alemayehu Flour Factory	Adama
Fiker Flour Factory	Adama
Abewan Food Plc.	Adama
Bereket Flour Factory	Adama
Shoa Flour and Bread	Adama
Family Flour Factory	Adama
Brothers Flour and Biscuits	Adama
Tegem Flour Factory	Adama
Kiya Food Complex	Adama
Redeat Flour Factory	Adama
Anhdwa Flour Factory	Adama
Shamil Flour Factory	Adama
Bolo Flour Factory	Adama
Mohammed Abubker Flour Factory	Adama
Ahmed Beshir Flour Factory	Adama
Africa Flour Factory	Adama
Wondmamachoch Flour Factory	Adama

Fentale Flour Factory	Metehara
Bishoftu Flour Mill	Bishoftu

Annex 1. Table 2. Oil mills

Region/companies	Location
Western Oromia, Gambella, Asossa, Mizan and Bonga	
Assosa Farmers' Union Oil Factory	Assosa
Tsehay Kuma Oil Extraction Mill	Guder
SNNPR	
Mensa Farmers' Cooperative	Wolaita
Admas Farmers' Cooperative Union	Silite/ Wolkite
Tigray region	
Dingil Zeiti Setit Humera Factory	Humera
Tsion Oil Processing	Axum
Tigray Oil Processing	Axum
Addis Ababa and Oromia Special Zone	
Altaye Yeshtila	Kolfe Qraniyo
Osman Abdu	Kolfe Qraniyo
Negist Adenew	Gulele
Mehamed Husen	Gulele
Webnesh Gebeyhu	Gulele
Qebe Lemine	Burayu
Mengistu and Habtamu Oil Millers Association	Gulele
Negra Oil Factory	Sululta
Amhara region	
Ashiraf	Bahir Dar
Alemitu Wube Oil Extraction	Lumame
Alemu Bayih Oil Extraction	Lumame
Geremew Zewdie Oil Extraction	Anjene
Zenetalem Dessalegn Oil Extraction	Denebecha
Semeneh Mulat Oil Extraction	Jigga
Muchit Engedaw Oil Extraction	Woreta
Nuru Ibrahim Oil Extraction	Woreta
Zehara Nigussie Oil Extraction	Woreta
Useman Mohammed oil extraction	Woreta
Zewedie Hassen Oil Extraction	Addis zemen
Hussien Yesuf Oil Extraction	Semada
Gete Hailu Oil Extraction	Semada
Fikir Melkamu Oil Extraction	Essetie
Netef Birhan Oil Extraction	Essetie
Mebiratu wedie Oil Extraction	Essetie
Abubeker Essa Oil Extraction	Dera
Hamid Mohamed Oil Extraction	Dera
Birtukan Nega Oil Extraction	Dera
Mamo Aragaw Oil Extraction	Dera
Amdihun Aminu Oil Extraction	Dera
Zemenu Adebabay	Dera
Haji Ali Oil Extraction	Gondar

Meseret Melekamu Oil Extraction	Gondar
Getaneh Belete Oil Extraction	Gondar
Wudie Menberu Oil Extraction	Bahir Dar
Yetemwork Zewdu Oil Extraction	Bahir Dar
Seleman Oil Extraction	Bahir Dar
Getachew wudu Oil Extraction	Bahir Dar
Mesrete Takele Oil Extraction	Bahir Dar
Ahemed welo Oil Extraction	Bahir Dar
Abeje Ayalew Oil Extraction	Sekota
Daniel Arega Oil Extraction	Sanja
Getinet Gelet Oil Extraction	Layaremacho
Yeshiwa Tiruye Oil Extraction	Dembecha
Melaku Chanie Oil Extraction	Jigga
Asemamaw Mengist Oil Extraction	Funeteselam
Shumet Alene Oil Extraction	Jigga
Nistuh Yeshaneh Oil Extraction	Demebecha
Mulalem Tesema Oil Extraction	Essetie
Meseganaw Getu Oil Extraction	Semada
Ayalenesh Derebew Oil Extraction	Semada
Zemenay Negatu Oil Extraction	Semada
Ameha Aseffa Oil Extraction	Gondar
Mekonnen Mola Oil Extraction	Bichena
Tsehay Adane Oil Extraction	Markos
Oromia, Afar, Harari, Dire Dawa and Somali Regions	
Daniel Oil Mill	Adama
Negash Betru Oil Mill	Adama
Hamaressa Edible Oil Mill	Hamaressa
Shemu Edible Oil Mill	Dire Dawa

Annex 1. Table 3. Sugar factories

Region/companies	Location
Western Oromia, Gambella, Asossa, Mizan and Bonga	
Arjo Didessa Sugar Factory	Arjo
Fincha Sugar Factory	Finch'aa
SNNPR	
Omo Kuraz Sugar Factory	Jinka
Oromia, Afar, Harari, Dire Dawa and Somali Regions	
Metehara Sugar Factory	Metehara
Wonji Sugar Factory	Wonji
Kessem Sugar Factory	Afar

Annex 1. Table 4. Breweries

Region/company	Location
Western Oromia, Gambella, Asossa, Mizan and Bonga	
Bedelle Brewery	Bedelle
SNNPR	
Hawasa BGI, Hawassa	Hawassa
Zebidar Brewery	Wolkite
Tigray region	
Raya Brewery	Maichew
Addis Ababa and Oromia Special Zone	
St. George Brewery, Addis Ababa	Addis Ababa
Meta Abo Brewery	Sebeta
Amhara region	
Balageru Beer	Debre Birhan
Dashen Beer Share Company	Gondar
Gondar Malt Factory	Gondar
Oromia, Afar, Harari, Dire Dawa and Somali Regions	
Assela Malt Factory	Assela
Harar Brewery	Harar

Annex 1. Table 5. Slaughterhouses

Region/company	Location
Western Oromia, Gambella, Asossa, Mizan and Bonga	
Mattu Town Municipality	Mettu
Assosa Town Municipality	Assosa
Nekemte Town Slaughter House	Nekempte
Jimma Municipality	Jimma
Shambu Town Municipality	Shambu
Slaughterhouse Gambella Region	Gambella
SNNPR	
Hawasa Abattoir	Hawasa
Slaughterhouse Bench Maji and Kafa Zones of SNNP Region	Bonga
Tigray region	
Aberegelle Slaughter House	Mekelle
Municipality abattoirs in Five zones (South, East, Central, North Western and West)	Zonal capitals
Addis Ababa and Oromia Special Zone	
Addis Ababa Abattoir	Addis Ababa
Akaki Abattoir	Akaki
Karralo Slaughter House (abattoir)	Karra
Sululta Slaughter House (abattoir)	Sululta
Amhara region	
Elefora PLC Abattoir	Kombolcha
Municipal Abattoir in the region	Bahir Dar and zonal towns in the region
Oromia, Afar, Harari, Dire Dawa and Somali Regions	
Modjo Modern Abattoir	Modjo
Organic Export Abattoir	Modjo
Luna Export Abattoir	Modjo
Metehara Export Abattoir	Metehara
Elfora Export Abattoir	Bishoftu
Helmex Export abattoir	Bishoftu
Abyssinia Export Abattoir	Dukem
Municipal Abattoirs (East Hararghe, West Hararghe, East Shoa)	Harar/Chiro/Adama

Annex 1. Table 6. Food industry by-products

Region/company	Location
Addis Ababa and Oromia Special Zone	
Kality Food Complex Plc.	Kaliti/Addis Ababa
NAS Foods	Alemgena

Annex 1. Table 7. Horticultural/fruits and vegetable by-products

Region/company	Location
SNNPR	
Fruit Juice Houses Bench-Maji and Kafa zones	Bench Maji/Kafa zones
Addis Ababa and Oromia Special Zone	
Atikilt Tera	Addis Ababa
Oromia, Afar, Harari, Dire Dawa and Somali Regions	
Merti (upper awash agro-industry)	Merti

Annex 1. Table 8. Pulse milling by-products

Region/company	Location
Addis Ababa and Oromia Special Zone	
Oromia Special Zone, Beke Woreda Cooperative	Beke
Amhara region	
Smallscale Pea Crushing Mills	Bahir Dar
Oromia, Afar, Harari, Dire Dawa and Somali Regions	
Oromiya Select Seed Enterprise Arsi Zone Branch	Assela
Oromiya Select Seed Enterprise Bale Zone Branch	Robe
Exporters of Pulse Crops around Adama	Adama

Annex 1. Table 9. Fisheries by-products

Region/company	Location
SNNPR	
Arba Minch Fisherman Cooperative	Arba Minch
Walesa Erego Fisherman Cooperative	Arba Minch
Harura Goche Fishermen Cooperative	Arba Minch
Sebo Fishermen Cooperative	Arba Minch
Leto Fishermen Cooperative	Arba Minch
Chamo Fishermen Cooperative	Arba Minch
Tigray region	
Hashenge Lake	Hashenge
Tekeze Reservoir	Abergelle
Addis Ababa and Oromia Special Zone	
Oromia Special Zone, Beke Woreda Cooperative	
Amhara region	
Lake Tana	Bahir Dar
Oromia, Afar, Harari, Dire Dawa and Somali Regions	
Zeway Lake	Zeway
Koka Lake	Koka
Awash River Fishing	Awash
Bishoftu Lakes	Bishoftu
Beseka Lake	Metehara
Lange Lake	East Hararge
Haromaya Lake	East Hararge

Annex 2. Questionnaire used for data collection

Region and category-wise inventory of agro-industrial and food processing by-products, their uses (including quantity for each of the uses) and approaches to efficiently utilize them

The following set of questions may be used for each of the nine regions (Afar, Tigray, Oromia, Amhara, Somali, SNNPR, Gambela, Benshangule Gumuz, and Harari), and for each of the nine feed categories

Note: The questions below are guiding questions and may need to be modified depending on the situation in the field. It is suggested that the Resource Persons should be in regular contact with the field workers and guide them so that right data are collected. The questions may be modified without compromising the objective of this exercise and depending on the situation

Another important point to keep in mind is not to mix fresh weight and dry weights.

REGION:

1. Categories of by-products produced

Location:

Categories of the by-products	Amount (kg)		
	Fresh weight	Dry weight (DM)	The process (1-2 lines) followed for obtaining the by-product
Cereal milling by-products 1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …
Oil seed cake/meals (please ensure that it is cake or meal)* 1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …
Pulses milling by-products 1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …
Brewery and malt factory by-products 1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …
Food industry by-products 1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …
Horticultural/fruits and vegetable by-products 1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …

Sugar factory by-products 1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …
Slaughterhouse (abattoir) by-products 1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …
Aquaculture/fisheries by-products 1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …

** Cake: residue obtained after oil extraction using extrusion (mechanical pressing); meal: residue obtained after oil extraction using solvent treatment or combination of mechanical and then solvent treatment (oil content in the residue obtained using a mechanical press (i.e. in the cake) is higher, while that in a meal is lower.*

2. List of companies (organized and large as well as small ones) producing by-product and capacity in the region

Location:

Name of the company that produce the by-products	Type of by-product	During which months by-product is produced	Quantity produced annually, fresh form*	Quantity produced annually, as dry form	Potential Processing capacity (yearly)	Current yearly operational capacity
	Cereal milling by-products 1….. 2…..	1…. 2….	1….. 2…..	1….. 2…..	1. 2……..	1…… 2…….
	Oilseed cake/meals 1… 2….	1…. 2….	1….. 2…..	1….. 2…..	1. 2….	1…. 2….
	Pulses milling by-products 1….. 2….	1…. 2….	1….. 2…..	1….. 2…..	1. 2….	1…. 2….
	Brewery and malt factory by-products 1…. 2….	1…. 2….	1….. 2…..	1….. 2…..	1. 2……..	1…. 2….
	Food industry by-products 1…. 2….	1…. 2….	1…. 2….	1…. 2….	1. 2….	1… 2….
	Horticultural/ fruits and vegetables by-products 1…. 2….	1…. 2….	1….. 2…..	1….. 2…..	1…. 2…	1… 2….
	Sugar factory by-products 1…. 2….	1…. 2….	1…. 2….	1….. 2….	1. 2…	1… 2….

	Slaughterhouse by-products 1…. 2….	1…. 2….	1….. 2….	1….. 2….	1… 2…	1… 2….
	Aquaculture/ fisheries by-products 1 2….	1…. 2….	1….. 2….	1….. 2….	1…. 2…..	1… 2….

**Approximate dry matter would be required to arrive at the dry weight quantity*

3. Feed mass balance

Location, address:

Name of company that produce the by-products	Type of by-product	Amount of original material used as DM	Amount of the by-product produced as DM	Amount of by-product as % of the original material used
	Cereal milling by-products 1…. 2….	 1…. 2….	 1…. 2….	 1…. 2….
	Oilseed cake/meals 1…. 2….	 1…. 2….	 1…. 2….	 1…. 2….
	Pulses milling by-products 1…. 2….	 1…. 2….	 1…. 2….	 1…. 2….
	Brewery and malt factory by-products 1…. 2….	 1…. 2….	 1…. 2….	 1…. 2….
	Food industry by-products 1…. 2….	 1…. 2….	 1…. 2….	 1…. 2….
	Horticultural/ fruits and vegetables by-products 1…. 2….	 1…. 2….	 1…. 2….	 1…. 2….
	Sugar factory by-products 1…. 2….	 1…. 2….	 1…. 2….	 1…. 2….

	Slaughterhouse (abattoir) by-products 1…. 2….	1…. 2….	1…. 2….	1…. 2….
	Aquaculture/ fisheries by-products 1… 2….	1…. 2….	1…. 2….	1…. 2….

4. Currently status of by-product utilization

Region /Location:

Name of company that produce the by-products	Type of by-product	Current by-product in the category used				
		Feed (kg DM)	Disposed of in the environment (kg DM)	Burnt (kg DM)	Industrial application (kg DM)	Any other uses (kg DM)

5. Buyers and users of the by-products and competitive uses of the by-product

Type of by-product	Buyers	Users	Quantities purchased fresh form weight	Quantities purchased (DM) Weight	Price/unit of fresh form	Price/unit of DM	Purpose for which the by-product was purchased
Cereal milling by-products 1. 2. 3. ….	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …
Oilseed cake/meals 1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …
Pulses milling by-products 1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …
Brewery and malt factory by-products 1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …

Food industry by-products 1. 2. 3. …..	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …
Horticultural/fruits and vegetables by-products 1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …
Sugar factory by-products 1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …
Slaughterhouse (abattoir) by-products 1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …	1. 2. 3. …

6. The points in the by-product production and utilization chain at which wastage of by-product takes place, and how it can be prevented.

	Name of by-product	Point at which the wastage takes place	How wastage can be prevented
1			
2			
3			
4			
5			

7. Technological processing required for enhancing efficiency of by-product as animal feed

	Name of by-product	Technological processing required for making efficient use of the by-product as animal feed	Remark
1			
2			
3			
4			
5			

8. Storage practices of by-products at the site of production

	Name of by-product	Storage practices of the by-products on the site of production	Remark
1			
2			
3			
4			
5			

9. Storage and use of by-products on-farm

	Name of by-product	How the by-products are stored and used on-farm	Remark
1			
2			
3			
4			
5			

10. Transport methods used to use by-products

	Name of by-product	Transport methods used to transport the by-products from the production site to end users	Risks involved in the current methods of transport
1			
2			
3			
4			
5			

11. Conversion factors used for conversion to dry matter (DM)

11.1 Conversion factor: - Percentage of by-product on dry matter base.

By-product of large capacity and modern flour factory

1 kg Wheat	0.21 kg Wheat Bran
	0.5 kg Wheat Shorts
	0.1 kg Grain Screenings

By-product of small – medium capacity flour factory

1 kg Wheat	0.26 kg Wheat Bran
	0.1 kg Grain Screenings

By-product of oil processing factory

1 kg Sunflower seed	0.5 kg Sunflower seed cake
1 kg Noug/Niger seed	0.6 kg Noug seed cake

By-product of brewery factory

1 kg Malt	0.378 kg Spent grain

By-product of fruit

1 kg Fruit	0.4 kg Fruit waste

By-product of slaughterhouse

1 kg live weight	0.3 kg offal

By-product of sugar factory

1 kg Sugar cane	0.035 Molasses
0.28 kg Bagasse	

By-product of fish

1 kg Nile perch	0.65 kg offal
1 kg Tilapia	0.68 kg offal
1 kg Brabus	0.68 kg offal
1 kg Catfish	0.62 kg offal

11.2 Dry matter content of by-products

Wheat Bran	89.7%
Wheat Shorts	82.7%
Grain Screenings	91.1%
Sun flower seed cake	93.1%
Noug/Niger seed cake	92.3%
Spent grain	24%
Fruit waste	25%
Molasses	75%
Bagasse	50%
Slaughter offal	12.5%
Fish offal	35%

13. Crude protein (CP) and metabolizable energy (ME) values used for converting dry matter (DM) feed resource availability

By-product	CP (kg/tonne)	ME (MJ/tonne)
Sugarcane tops	49	8 000
Brans	150.5	12 480
Oilseed cakes	362	11 317
Pulse by-products	192	10 800
Brewery by-products	25.8	9 500
Backery waste	124	14 500
Fruit peels	60.9	10 264
Molasses	26.7	14 533
Bagasse	18	6 700
Slaughterhouse offal	549	11 000

Saving livelihoods saves lives

Contact

Fatouma Seid

FAO Representative
Addis Ababa, Ethiopia
FAO-ET@fao.org

Shukri Ahmed

Deputy Strategic Programme Leader – Resilience
Rome, Italy
Shukri.Ahmed@fao.org

Food and Agriculture Organization of the United Nations

www.fao.org/emergencies
www.fao.org/resilience

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