Characteristics of by-product and animal waste: a review

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SUMMARY

Animal waste is one of the waste products from the livestock industry's production process. The waste can be either solid, liquid or gas. Solid waste is all solid waste such as livestock, animal carcasses or the remainder of the slaughter process at slaughterhouses. Liquid waste is waste in the form of liquid that comes from the urine of animal as well as remnants from the washing process of cages and animal itself. Gas waste is all the results of a gas phase discharge. The animal waste has a great influence on humans and the environment, but also has very important benefits. Animal waste can used as a source of nutrition for plants, energy sources in the form of methane gas, alternative animal feed sources and growing media for earthworms. The Animal waste that not processed optimally can be cause environmental pollution.

KEY WORDS

By-product, animal waste, livestock industry.

INTRODUCTION

Livestock is one of the creatures intended to meet human food needs. Therefore, we must make maximum use of it to meet human needs. Human needs for fulfillment of food, especially animal food, are constantly increasing along with the increasing human population. As an illustration, from only one meat-producing livestock, only around 30-35% of the meat can be obtained as the main product, while the remaining 65-70% is the by-product which until now has not been utilized optimally. Livestock by-product and waste have the connotation meaning as "harmful waste material". However, if you get a touch of technology, it will have a very beneficial impact on human benefit and the environment[1,2,3]. The terms by product and waste are different in terms of how to obtain them. Livestock waste is the residual product in the form of biomass that has been obtained since the on-farm process, such as: faeces and urine, while the follow-up results are obtained from the rest of the slaughtering process such as skin, bones, blood, innards, fur, horn and the organs that make up the digestive tract.

MANAGEMENT AND UTILIZATION OF LIVESTOCK WASTE

Animal manure and urine are waste groups. Waste in its form always has a negative connotation. Waste has a bad influence on humans. Wastes are containing toxic substances or pollutants exceeding the level of tolerance limits adversely affect humans. This can also occur in the survival of various other biodiversity. The waste treatment process is one source of livelihood for the poor in developing countries. Contamination of waste has a very significant impact on the health of workers[4]. Lately, livestock businesses in developing countries such as in Indonesia have been quite advanced and growing rapidly compared to the last three decades. This is as a result of the entry of superior seeds from abroad that have been intensively developed. One result of the development of the livestock business is the accumulation of animal waste in the form of feces and urine.

Stool produced by ruminants (cows, buffaloes, goats and sheep) brings problems in global warming, especially the production of methane gas. At present, feces and urine as well as other organic material remnants have been utilized by the world community as the main raw material for producing methane gas. It is formed as a result of the aerobic metabolism of microorganisms in the hulls of animal. This model was later developed by people in the world to design biogas reactor systems[5].

The use of biogas is now growing rapidly as one of the solutions to obtain alternative energy sources. The energy crisis in the 1970s caused economic problems in several countries in the world. Many countries that are classified as poor are still dependent on imported oil and natural gas products. Biogas can be used on a household scale for cooking, heating and lighting. Biogas can be produced from raw materials for lignocellulose biomass such as feces and agricultural waste[6]. In addition, it can also be used by larger industries as heaters or as the main energy source. The animal feces used as raw materials for biogas installations. However, it can also using feces from human, municipal wastes, plant and vegetables wastes. These ingredients are rich in nutrients and suitable for the growth of several an-aerobic bacteria. The composition of biogas are depends on the composition of the raw material, the load of organic matter that included in the digester, time and temperature of an-aerobic and then decom-

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position process[7]. The production of energy sourced from biogas in several countries in the world in full was presented in Table 1.

Feces from the animal has been developed as a base for producing biogas by adding several types of organic waste, lime fertilizer and ethanol industrial waste known as vinasse. The use of additional materials in the biogas production process is an effort to improve and utilize the potential of waste. At present, approximately 22.4 gigiter of vinasse material is produced worldwide. This amount has the potential to produce 407.68 gigabytes of biogas[8].

Biogas is the result of anaerobic digestion from organic waste which can be used as an alternative energy source. One type of organic waste used is faeces from livestock. Increasing production of organic waste will have an impact on increasing the potential for energy production. The use of biogas as a renewable energy source has been developed on a very large scale in South Africa and Germany[9].

The use of organic materials to produce biogas using renewable hydrogen aid has been developed by several previous researchers. This process involves the activity of CO_2 as a carbon source[10,11].

Besides as biogas, animal feces has also used as a alternative natural energy source in the form of bio-charcoal briquettes. In China, the biomass combustion process is a concern because of its enormous effect on the environment, especially

Table 1 - Comparison of energy production from biogas in several countries in the world in 2015[7].

	Electricity capacity	Average capacity	Electricity production	Heat production	Derived heat
EU	MW	kW	GWh	TJ	TJ
Belgium	183	897	955	4272	388
Bulgaria	20	1818	120	182	24
Czech Republic	368	664	2611	6491	623
Denmark	102	671	485	3265	2099
Germany	4803	443	33,073	69,047	9285
Estonia	11	611	50	286	112
Ireland	53	1828	202	370	0
Greece	49	1750	230	661	0
Spain	224	1612	982	2474	0
France	320	446	1783	6859	1432
Croatia	28	1217	177	219	219
Italy	1336	859	8212	10,469	8604
Cyprus	10	769	51	214	51
Latvia	60	1017	391	1256	892
Lithuania	21	583	86	403	91
Luxembourg	12	400	62	390	80
Hungary	69	972	293	667	131
Malta	3	1500	7	30	6
Netherlands	239	892	1036	0	48
Austria	194	437	624	2036	145
Poland	216	780	906	3703	436
Portugal	66	1031	294	336	0
Romania	14	1273	61	303	156
Slovenia	32	1231	132	383	304
Slovakia	91	650	541	2122	473
Finland	0	0	358	1600	763
Sweden	95	337	62	2150	274
UK	1488	2845	7189	6641	0
Switzerland	74	116	303	1342	1199
Iceland	0	0	0	37	0
Norway	17	138	7	834	118
FYROM	4	1333	20	37	0
Serbia	5	714	23	45	0
Moldova	3	750	15	159	11
Ukraine	18	1125	10	282	360
EU	10,107	609	60,973	126,829	26,636
Europe	10,228	588	61,351	129,565	28,324

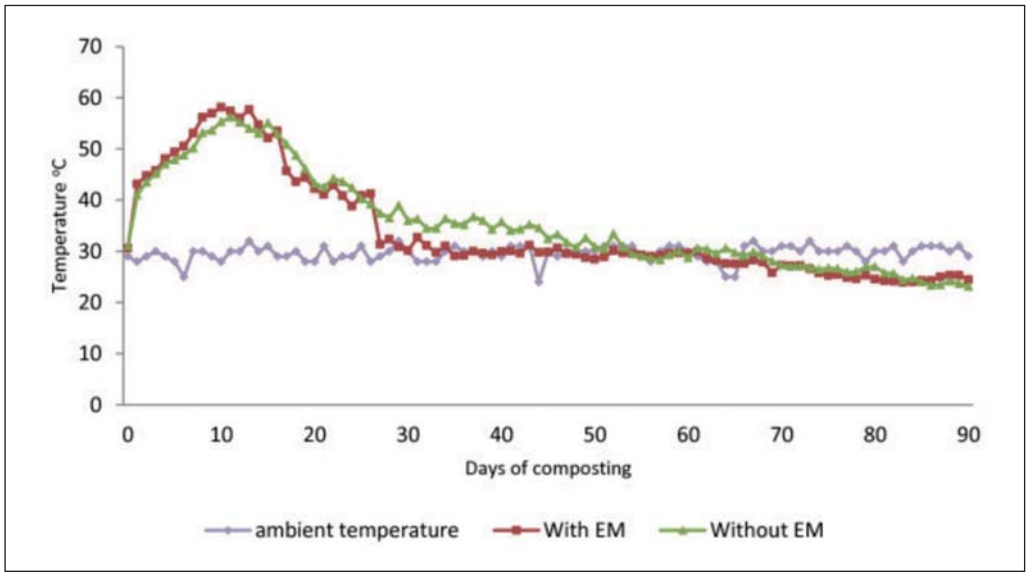

Figure 1
Changes in compost temperature during the composting process[17].

related to air emissions[12,13,14,15,16]. The process of forming bio-charcoal briquettes was done through the process of burning dry biomass without using air (pyrolysis). Some of the advantages of using bio-charcoal briquettes are: 1) the heating system produced is natural or traditional heating (without using oil), 2) bio-charcoal briquettes are safe for human health because they do not contain smoke, soot and odor, 3) production costs relatively cheaper than kerosene or wood charcoal, 4) fuel power is much longer with high enough heat energy, 5) its use is relatively safer because it does not contain emissions of sulfur and nitrogen free into the air, 6) briquette has produce a distinctive aroma, 7) reducing environmental pollution.

The other uses of animal feces are raw material in making organic fertilizers. The application of organic fertilizer to the soil has carried out by humans. This is done to improve soil fertility and productivity on agricultural and plantation land. The use of effective microorganism (EM) in the compost production process has been widely applied. The use of goat feces as raw material for fermented compost using EM has been developed by researchers previously. The use of EM affects the temperature of fermentation. This can be seen in Figure 1.

Based on Figure 1, it can be seen that the temperature of the compost gradually increases until the tenth day and then decreases. In fermentation for 30-35 days the temperature of the compost with EM decreases and stabilizes near the ambient temperature. Compost without EM down at 48-52 days of fermentation[17].

In Indonesia, several types of fertilizer production have been developed. For example manure, green manure and compost. At present, feces was produced by cattle, buffalo, horses, goats, sheep, ducks, chickens, etc. The feces have been widely used as raw material in the process of making organic fertilizers. The business of producing organic fertilizer is currently growing rapidly along with the development of organic farming systems. The use of feces as fertilizer for plants is done by giving directly to plants after passing the drying period. In addition, it can also be processed into a compost product. Composting is a process and effort to decompose and stabilize biologically organic substrates under conditions that allow for the development of thermophilic bacteria. The end result is heat production and stability, free of pathogenic bacteria and plant residues, and can be used as natural fertilizer.

The process of composting using a mixture of water hyacinth (Eichhornia crassipes), livestock feces and sawdust has been developed by researchers. This is done to reduce the use of chemical fertilizers. In addition to reducing the population of water hyacinth that is developing rapidly. Livestock feces are used as carbon sources. Nutrient content (nitrogen, phosphorus, Na, K, and Ca) increases significantly in the final process of composting. The content of pathogenic bacteria, especially coliform, is significantly reduced. This is an indicator of the presence of pathogenic bacteria in compost[18]. Data related to changes in physicochemical properties during the composting process in several locations were presented in Table 2.

In the past few years, the type of animal waste in the form of urine has been developed and used as a raw material in the manufacture of liquid organic fertilizer (LOF). This is because the material contains elements that are needed by plants in full[19].

An adult cow of a particular breed can produce as much as 8 liters of urine perday. For the livestock industry, urine is a very potential commodity to produce high economic value. The urine from the cow has contains chemical elements that needed by plants, such as N, P, K, Ca, and Mg, which are bound in the form of organic compounds, including: urea, ammonia, creatinine and keratin, uric acid, amino acids, alantoin, chloride, sulfate, phosphate, vitamins, hormones, and enzymes. Early research related to the potential urine of rabbits as a LOF base material has been developed by the author using fecal extract and banana buds as natural decomposers.

MANAGEMENT AND USE OF BY-PRODUCT OF ANIMAL

Animal by-product has a positive correlation with the rate of slaughter of animal. The types of by-products produced from slaughterhouses business activities include: skin, blood, bones, fat and offals. The potential by-product will have economic value and impact on humans if it is processed by involving technological processes.

Table 2 - Changes in physico-chemical parameters during the composting process (Mean ± SD, n = 3)[18].

Days	Nutrients concentration							
	BRS Total Nitrogen (%)	AS	BLS	IS	BRS NH4-N (mg/kg)	AS	BLS	IS
0	0.85 ± 0.13	0.83 ± 0.07	1.05 ± 0.07	0.64 ± 0.02	253.49 ± 0.26	42.26 ± 0.53	223.31 ± 4.38	70.67 ± 0.17
3	1.05 ± 0.21	0.74 ± 0.02	1.05 ± 0.07	0.64 ± 0.03	377.9 ± 1.23	43.33 ± 0.32	206.04 ± 1.88	74.21 ± 0.03
6	1.05 ± 0.07	0.84 ± 0.14	1.05 ± 0.21	0.68 ± 0.02	156.36 ± 0.09	42.46 ± 0.0	193.03 ± 4.52	78.78 ± 0.06
9	0.98 ± 0.14	0.81 ± 0.03	1.19 ± 0.07	0.68 ± 0.02	167.69 ± 8.88	35.61 ± 0.0	182.79 ± 2.59	60.5 ± 0.13
12	1.12 ± 0.14	0.84 ± 0.0	1.26 ± 0.14	0.77 ± 0.07	105.13 ± 6.51	32.95 ± 0.50	94.08 ± 2.59	54.24 ± 0.08
15	1.19 ± 0.07	0.98 ± 0.14	1.47 ± 0.07	0.91 ± 0.07	93.32 ± 0.06	32.48 ± 0.09	92.20 ± 1.43	51.61 ± 0.34
18	1.33 ± 0.07	0.98 ± 0.0	1.33 ± 0.21	0.98 ± 0.0	91.86 ± 0.04	26.76 ± 0.57	99.18 ± 0.54	50.85 ± 0.03
21	1.26 ± 0.14	0.91 ± 0.07	1.19 ± 0.07	0.98 ± 0.0	85.3 ± 0.04	26.79 ± 4.26	94.045 ± 1.2	50.76 ± 0.10
24	1.33 ± 0.07	1.05 ± 0.07	1.267 ± 0.01	0.98 ± 0.0	69.42 ± 0.03	29.19 ± 0.07	96.49 ± 3.76	42.71 ± 0.14
27	1.47 ± 0.07	1.12 ± 0.14	1.4 ± 0.14	0.98 ± 0.0	67.76 ± 6.41	27.12 ± 0.08	103.83 ± 4.38	36.28 ± 0.35
30	1.56 ± 0.02	1.19 ± 0.1	1.47 ± 0.07	1.05 ± 0.07	61.91 ± 0.10	21.53 ± 0.01	94.30 ± 2.82	34.82 ± 0.07
Days	Total phosphorus (g/kg)				Available phosphorus (g/kg)			
0	3.05 ± 0.24	1.57 ± 0.14	3.14 ± 0.12	2.19 ± 0.0	2.8 ± 0.05	1.32 ± 0.08	1.59 ± 0.05	1.43 ± 0.14
3	3.16 ± 0.19	1.7 ± 0.01	3.41 ± 0.01	2.22 ± 0.02	3.07 ± 0.07	1.55 ± 0.16	1.51 ± 0.03	1.52 ± 0.07
6	3.16 ± 0.23	1.96 ± 0.0	3.92 ± 0.0	2.51 ± 0.0	3.1 ± 0.05	1.52 ± 0.01	1.61 ± 0.03	1.54 ± 0.08
9	3.22 ± 0.29	2.02 ± 0.01	4.04 ± 0.01	2.6 ± 0.0	3.1 ± 0.24	1.44 ± 0.04	1.64 ± 0.02	1.6 ± 0.09
12	3.38 ± 0.51	2.26 ± 0.01	4.53 ± 0.01	2.73 ± 0.01	3.01 ± 0.03	1.28 ± 0.04	1.75 ± 0.01	1.63 ± 0.03
15	3.50 ± 0.23	2.27 ± 0.03	4.53 ± 0.05	2.87 ± 0.01	3.13 ± 0.03	1.49 ± 0.17	1.81 ± 0.01	1.67 ± 0.01
18	3.46 ± 0.2	2.28 ± 0.01	4.56 ± 0.02	2.95 ± 0.0	3.45 ± 0.07	1.57 ± 0.13	1.88 ± 0.09	1.69 ± 0.0
21	3.03 ± 0.21	2.38 ± 0.0	4.76 ± 0.01	3.04 ± 0.01	3.52 ± 0.04	1.63 ± 0.14	2.37 ± 0.02	1.8 ± 0.04
24	3.53 ± 0.26	2.54 ± 0.02	5.07 ± 0.04	3.16 ± 0.0	3.64 ± 0.05	1.57 ± 0.03	2.33 ± 0.04	1.9 ± 0.11
27	4.0 ± 0.23	2.54 ± 0.0	5.07 ± 0.0	3.2 ± 0.0	3.53 ± 0.07	1.89 ± 0.11	1.95 ± 0.0	2.28 ± 0.10
30	5.37 ± 0.79	2.76 ± 0.01	5.52 ± 0.02	3.37 ± 0.0	3.57 ± 0.07	2.2 ± 0.23	1.91 ± 0.09	2.38 ± 0.10

Note: BRS = Bharalu river site; AS = low-lying area near agriculture site; BLS = Boragaon landfill site; IS = Amingoan industrial site.

Leather

Skin in livestock is the largest biological protector that serves to protect from dehydration, injury, environment and microbes. Besides that, it also functions as an immune response organ. The skin epidermis consists of layered and multilevel epithelial cells that regenerate through cell proliferation and differentiation[20].

The leather processing industry is one of the strategic industries that has the potential to develop in countries rich in potential ruminants. Every leather processing industry certainly has needed sufficient raw materials so that the industry can continue to run. In general, the potential of leather raw materials can be predicted by looking at the potential availability of raw materials in an area. The skin consists mostly of collagen protein. Skin needs strength and flexibility. The skin contains most of the water. Higher moisture content with greater flexibility results in greater lateral distances between collagen molecules. When collagen molecules are aligned, the skin tightens. Collagen molecules close together will reduce the ability of molecules to move relative to each other (Figure 2)[21].

Utilization of livestock skin by-products is not only for non-food purposes. However, the use for food purposes lately has been widely used and developed both in the form of research and mass-produced. One example is gelatin. Efforts to find alternative materials through research using the region's potential have developed rapidly. The hide of cattle and goat as one of the most abundant plasma livestock has the potential to be a source of gelatin. Gelatin is a hydrocolloid compound obtained from the hydrolysis of animal protein compounds partially which has hydrophilic properties. Various physicochemical properties possessed caused gelatin to be applied to various industries such as: food industry (foam forming, stabilizer, binder and emulsifier), pharmaceutical and laboratory fields (capsule shells and agar media), cosmetics industry, printing industry and photography. Gelatin extracted from goat skin can be applied as a basic ingredient in making hard capsules.

Environmental factors are the main problem experienced by the leather processing industry. Waste produced from the leather processing industry is liquid or solid. Based on existing data that for one ton of wet skin produces about 650 kg of solid waste. The resulting waste is in the form of pieces of leather or the result of liming process[22].

The use of vegetable tanners is considered to reduce the production of chemical waste. The type of vegetable tanner that can be used is tannin. This material can be obtained from quebracho and mimosa extracts. Tanin with higher reactivity produces more stable skin. This happens because it uses a higher decomposition temperature[23].

One of the most important factors to consider in the leather processing industry is microorganism contamination. The

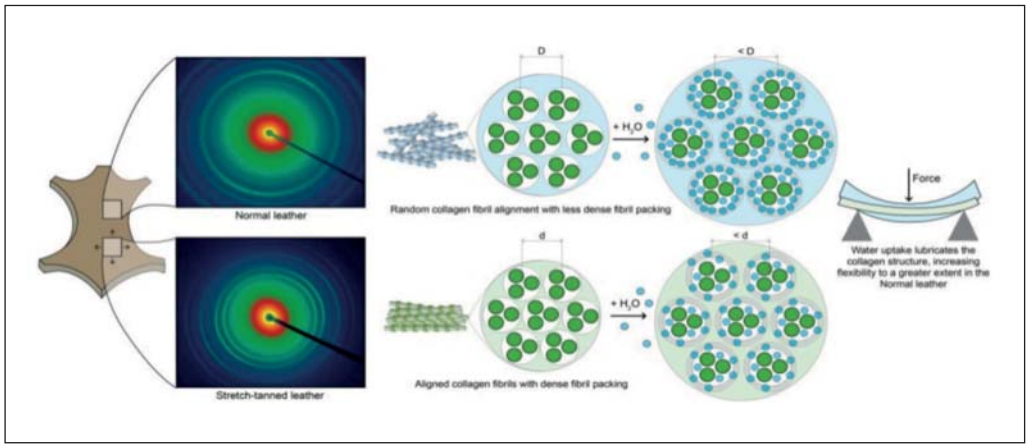

Figure 2
Description of the difference in collagen fibers in the skin due to penetration of the number of water molecules[21].

growth of microorganisms such as fungi is very easy to develop in skin products. Giving antimicrobials especially those that are volatile such as volatile organic compounds must be careful. This is because these phenolic and heterocyclic compounds are carcinogenic and toxic[24].

Blood

Anaerobic fermentation system model is one model that can be applied in treating blood waste from poultry slaughterhouses. The use of microorganisms Methanobrevibacter and Methanobacterium beijingense is used as a bio-carrier. Biocarrier is used as a medium to eradicate microflora and increase cell residence time in a digester. This model is able to reduce COD levels from waste[25].

Animal by-products are animal parts or products that come from animals that are not intended for human consumption. By-products are divided into three categories based on the risk or potential risk associated with domestic animals, communities, or the environment including wild animals. The process of removing blood from the pelagic fishing industry increases environmental pollution[26].

The process of removing blood from cattle cutting activities has been reviewed by previous researchers. The process of removing blood from the body of the animal is carried out through halal (traditional) cutting or using Electric Head-Only Stunning (EHOS). The result is no real difference from the two methods[27].

Bone

The bone is by-product that has high calcium and phosphorus compounds. At present, bone has been widely used by the animal feed industry as a source of mineral feed in the form of bone meal. The resulting bone weight is on average 15% of the carcass weight. However, these weights vary according to animal breeds, feed types and age. In addition, bone has been used also as a mixture in making organic fertilizers[28]. Bone meal is rich in calcium and phosphorus compounds which are needed in plant growth. In health research, bone from animal has been developed as a raw material for producing hydroxyapatite (HAp). In the medical world, HAp is widely applied to bone and dental objects[29,30,31]. The use of bone from animal as a catalyst has been also developed. Catalysts are used to accelerate the occurrence of a chemical reaction process in a system[32]. In relation to design art, bone has been developed as a basic material in producing accessories and handicrafts.

In Europe, there are approximately 17 million tons of by-products derived from livestock produced every year. The process of by-product processing was done through the rendering method. This method aims to process by-products into meat bone meal (MBM). In the slaughterhouses industry, when producing 1 kg of meat for human consumption, it also produces 1 kg of animal by-products. It is no longer consumed by humans but is used as animal feed ingredients. The process of producing MBM has stopped since the outbreak of bovine spongiform encephalopathy (BSE). This certainly results in an increase in the number of animal by-product[33].

Fat/Tallow

Animal fat has a solid form and contains a lot of sterols (cholesterol). Animal fats are known as tallow and lard. The term tallow is usually used for fats derived from cows and goats, while the lard for fat is extracted from pigs. Animal fats are widely used in the food sector to increase palatability and flavor enhancers. The potential of animal fat as a raw material for energy sources in the form of biodiesel has also been widely studied. One type of fat that was developed as a source of biodiesel raw material is mutton tallow through the transesterification system[34].

Tallow has a low value. If it can be converted into biodiesel, it will provide benefits as an energy source, environmental improvements and economic benefits[35]. Animal fat has also been used as a mixture in animal feed to increase the palatability of feed and bind particles of feed ingredients.

For environmental reasons, various countries are trying to find alternative energy sources. One of them is the use of biodiesel by utilizing tallow as raw material. Some of them have also mixed tallow with waste cooking oil as an energy source. This is an effort to reduce the production of waste cooking oil[36].

Brazil is a country that ranks second in the world in producing biodiesel. In the Central-West region of the country is the largest part in producing biodiesel (44.4%) and livestock slaughter activities (37.5%)[37]. Biodiesel production from tallow waste can be increased through the use of the enzyme Candida antarctica Lipase B (CALB). The results of the analysis using chromatography showed that biodiesel production reached 85.6 ± 0.08%[38].

Biodiesel consists of several components such as low alkyl fatty acids (chain length C14-C22), short chain alcohol esters, especially, methanol or ethanol. The use of biodiesel fuel is a consideration to replace fossil fuels. Making biodiesel can be

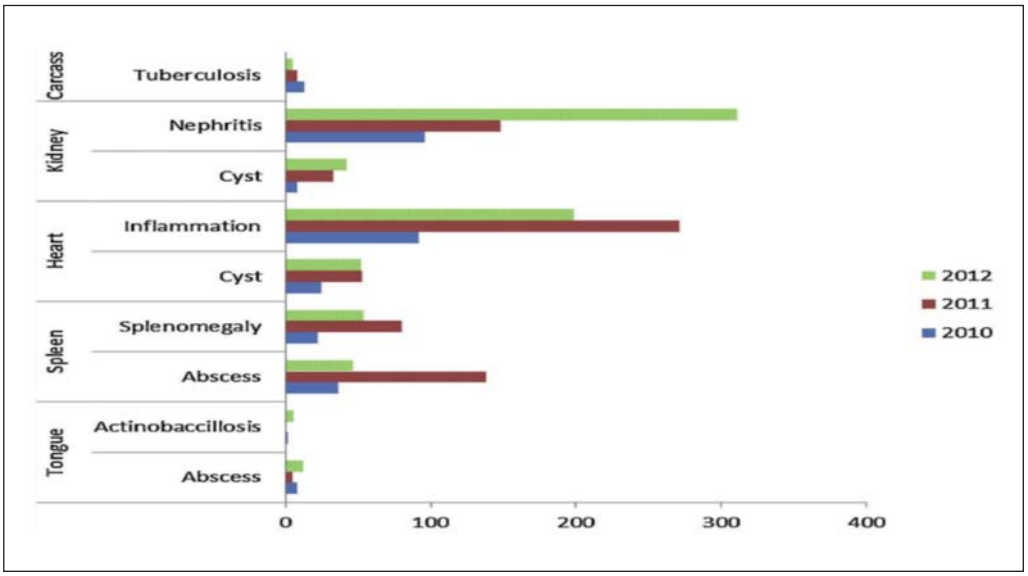

Figure 3
Description of the number of organs and carcass lost in 2010-2012[45].

done using several methods such as mixing, microemulsification, pyrolysis, and transesterification. The transesterification process is a method that is widely applied in industry. Biodiesel fuel can be produced from vegetable or animal fats[39].

Offal

Offal are internal organs and the stomach contents of animals are slaughtered without muscles and bones. Offal consist of red and white offal. Red offal consist of parts that are immediately edible, can be consumed and are considered delicious food in certain parts of the world. Red innards are used in mixed processed meats and additives in sausages. White offal are parts that can be consumed but still need further processing, such as the stomach and intestines[40].

Lately, offal have been developed as food ingredients. In certain countries use pig innards as a mineral source. Consideration of high mineral content (iron and zinc) causes the innards to be widely used[41]. Improving the quality of processed products can be improved by applying liquid smoke. This process can extend the shelf life of processed products from livestock[42].

The use of offal as food is growing rapidly along with the development of culinary variants. Offal is a collection of several organs such as the liver, heart, kidney, brain, pancreas, and tongue. Offal consists of 20% of the live weight in each animal. Offal is not much favored by consumers even though it is a very good source of protein, vitamins and minerals. Meat forgery activities are often carried out by the community on the grounds of gaining profits. This is very contrary to religion, economics, and ethics. One technique that has been developed to identify cases of counterfeiting is to use laser induced breakdown spectroscopy (LIBS)[43].

Increasing the use of offal as food is actually an option. This is due to the high price of meat. Based on the price, offal is much cheaper than the price of meat. However, some countries have not recommended using offal as human food. one reason is an impact factor on human health. The low price of offal has increase in the use as an alternative food. Several types of food have been developed by replacing tallow beef with de-fatted bovine heart. As in frankfurter processed meat products. This replacement is done for health reasons such as obesity and chronic diseases[44].

The rate of loss due to offal damage such as the tongue, spleen, heart and kidneys is experienced by many abattoirs. A study on 3 abattoirs namely: Adeliade (Ad), Queenstown (Qu) and East London (EL). The results of the study showed that the causes of tongue organ damage were caused by abscesses (0.08%, 0.03% and 0.05%) and actinobacillosis (0.02%, 0% and 0.02%) respectively. In the spleen organs caused by abscesses (0.35%, 0.94% and 0.17%) and splenomegaly (0.21%, 0.55% and 0.2%). The heart is caused by cysts (0.24%, 0.36% and 0.2%) and inflammation (0.9%, 1.85%, and 0.75%). Whereas in kidney organs caused by cysts (0.08%, 0.23% and 0.16%) and nephritis (0.94%, 1.01% and 1.18%). An overview of the number of organs and carcasses lost in the 2010–2012 period at 3 abbattoir locations is presented in Figure 3[45].

Feather

The feather waste is one type of by-product produced by the poultry slughterhouses (PSh) industry[46]. Globally, the poultry industry produces around 6 million tons of fur as a by-product every year. The main constituent of fur is protein (80-90%), where the type of protein dominated by keratin[47]. Feather waste is a product that needs to utilize to reduce PSh waste production. The use of chicken feather waste as a protein source for animal feed carried out. However, chicken feather waste still has weaknesses. One of them is the level of digestibility that is still very low[48]. Therefore, several studies developed to increase the digestibility of fur products. One of them is by using pressurized, chemical heating techniques and using the help of bacterial microorganisms (*Bacillus subtilis* sp)[49].

Effect of Animal waste

The therapeutic and sub-therapeutic application of antibiotics in the livestock industry has long been practiced in several parts of the world. Bioactive organic compounds have short retention periods and partial uptake into the livestock industry cycle. Livestock manure containing biosolid and antibiotics has the potential to affect the health of animal. Antibiotic response can be phytotoxic, hormetic and mutational. Remnants of antibiotics can contaminate animal waste which will cause animal to become resistant. The cycle of antibiotic use and its effect on livestock is presented in Figure 4[50].

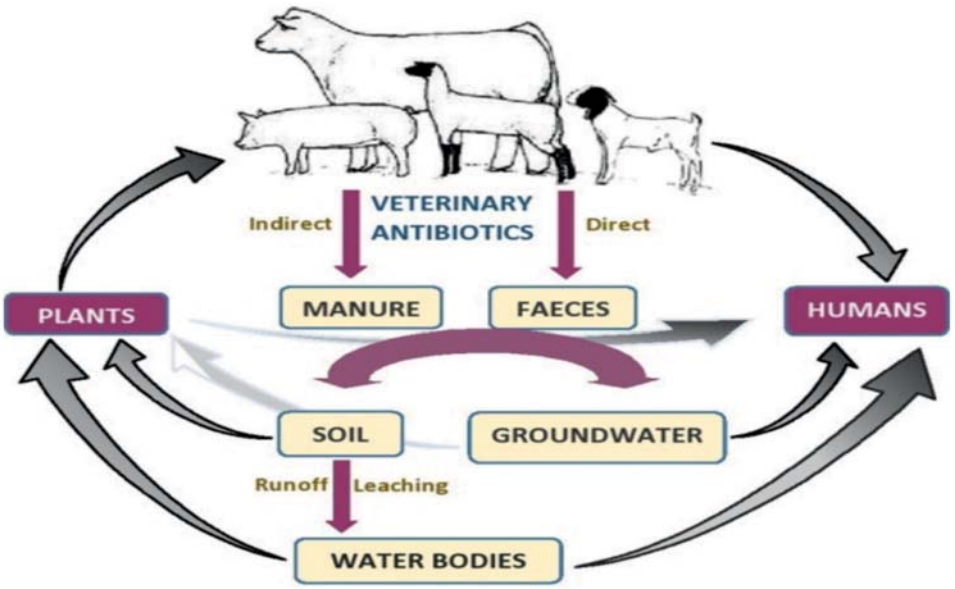

Figure 4
The process cycle of the use and spread of antibiotics through animal waste and its effect on animal health.

CONCLUSION

In animal, approximately 1/3 of its body is used as a food source in the form of meat, while the remaining 2/3 is non-meat. Actually, the economic potential of the non-meat portion can be maximized if it receives technology input. Livestock by-product applications can be used in a variety of industries, both large and small scale industries. Along with the government's efforts to increase the livestock population, of course the potential of by-products will also increase. Animal skin as one type of livestock product exported. The quality of leather exported is strongly influenced by the pattern of livestock maintenance in the cultivation process. The quality of feed, management and management of maintenance and handling of livestock in slaughterhouses (RPH) greatly determine the quality of the final skin.

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References

1. Said M.I. (2014). By Product Ternak. Teknologi dan Aplikasinya. IPB.Press, Bogor.
2. Enginuity worldwide LLC. (2017). Researchers submit patent application, "process and products using a rotary compression unit", for approval (USPTO 20170073598). Ecology, Environment & Conservation., 1222.
3. Bodirsky B.L., Popp A., Lotze-campen H., Dietrich J.P., Rolinski S., Weindl I., Stevanovic M. (2014). Reactive nitrogen requirements to feed the world in 2050 and potential to mitigate nitrogen pollution. Nature Communications, 5: 3858.
4. Amankwaa E.F., Adovor-Tsikudo K.A., Bowman J.A. (2017). 'Away' is a place: The impact of electronic waste recycling on blood lead levels in Ghana. Science of The Total Environment, 601-602: 1566-1574.
5. Wang H., Xu J., Sheng L., Liu X. (2018[a]). Effect of addition of biogas slurry for anaerobic fermentation of deer manure on biogas production. Energy, 165(B): 411-418.
6. Zieliński M., Dębowski M., Kisielewska M., Nowicka A., Rokicka M., Szwarc K. (2019). Cavitation-based pretreatment strategies to enhance biogas production in a small-scale agricultural biogas plant. Energy for Sustainable Development, 49: 21-26.
7. Scarlat N., Dallemand J.F., Fahl F. (2018). Biogas: Developments and perspectives in Europe. Renewable Energy, 129(A): 457-472.
8. Parsaee M., Kiani M.K.D., Karimi K. (2019). A review of biogas production from sugarcane vinasse. Biomass and Bioenergy, 122: 117-125.
9. Govender I., Thopil G.A., Inglesi-Lotz R. (2019). Financial and economic appraisal of a biogas to electricity project. Journal of Cleaner Production, 214: 154-165.
10. Hernández B., León E., Martín M. (2017). Bio-waste selection and blending for the optimal production of power and fuels via anaerobic digestion. Chem. Eng. Res. Des, 121: 163-172.
11. Curto D., Martín M. (2019). Renewable based biogas upgrading. Journal of Cleaner Production, 224: 50-59.
12. Shen Z., Cao J., Arimoto R., Han Z., Zhang R., Han Y., Liu S., Okuda T., Nakao S., Tanaka S. (2009). Ionic composition of TSP and PM2.5 during dust storms and air pollution episodes at Xi'an, China. Atmospheric Environment, 43: 2911-2918.
13. Ni H., Han Y., Cao J., Chen L.W.A., Tian J., Wang X., Chow J.C., Watson J.G., Wang Q., Wang P., Li H., Huang R.J. (2015). Emission characteristics of carbonaceous particles and trace gases from open burning of crop residues in China. Atmospheric Environment, 123: 399-406.
14. Niu X., Ho S.S.H., Ho K.F., Huang Y., Sun J., Wang Q., Zhou Y., Zhao Z., Cao J. (2017). Atmospheric levels and cytotoxicity of polycyclic aromatic hydrocarbons and oxygenated-PAHs in PM2.5 in the Beijing-Tianjin-Hebei region. Environmental pollution, 231: 1075-1084.
15. Shen G., Chen Y., Xue C., Lin N., Huang Y., Shen H., Wang Y., Li T., Zhang Y., Su S. (2015). Pollutant emissions from improved coal-and wood-fuelled cookstoves in rural households. Environmental Science & Technology, 45: 6590-6598.
16. Tao J., Zhang L., Zhang R., Wu Y., Zhang Z., Zhang X., Tang Y., Cao J., Zhang Y. (2015). Uncertainty assessment of source attribution of PM2.5 and its water-soluble organic carbon content using different biomass burning tracers in positive matrix factorization analysis - a case study in Beijing. Sci. Total Environ, 543: 326-335.
17. Jusoh M.L.C., Manaf L.A., Latiff P.A. (2013). Composting of rice straw with effective microorganisms (EM) and its influence on compost quality. Iranian J Environ Health Sci Eng, 10(1): 17.
18. Singh J., Kalamdhad A.S. (2015). Assessment of compost quality in agitated pile composting of water hyacinth collected from different sources. Int. J. Recycl. Org Waste Agricult, 4: 175-183.

19. Raden I, Fathillah S.S., Fadli M., Suyadi. (2017). Nutrient content of liquid organik fertilizer (LOF) by various bio-activator and soaking time. Nusantara Bioscience, 9(2): 209-213.
20. Jennifer Y., Zhang J.Y. (2017). Chapter 15-Animal Models of Skin Disorders, Editor(s): P. Michael Conn. Animal Models for the Study of Human Disease (Second Edition). Academic Press: 357-375.
21. Kelly S.J.R., Weinkamer R., Bertinetti L., Edmonds R.L., Sizeland K., Wells H.C., Fratzl P., Haverkamp R.G. (2019). Effect of collagen packing and moisture content on leather stiffness. Journal of the Mechanical Behavior of Biomedical Materials, 90: 1-10.
22. Sathish M., Madhan B and Rao J.R. (2019). Leather solid waste: An ecobenign raw material for leather chemical preparation - A circular economy example. Waste Management, 87: 357-367.
23. Sebestyén Z., Jakab E., Badea E., Barta-Rajnai E., Şendrea C., Czégény Zs. (2019). Thermal degradation study of vegetable tannins and vegetable tanned leathers. Journal of Analytical and Applied Pyrolysis,138: 178-187.
24. Carvalho I., Ferdov S., Mansilla C., Marques S.M., Cerqueira M.A., Pastrana L.M., Henriques M., Gaidau C., Ferreira P., Carvalho S. (2018). Development of antimicrobial leather modified with Ag-TiO2 nanoparticles for footwear industry. Science and Technology of Materials, 30. Supplement 1: 60-68.
25. Wang S., Hawkins G.L., Kiepper B.H., Das K.C. (2018[b]). Treatment of slaughterhouse blood waste using pilot scale two-stage anaerobic digesters for biogas production. Renewable Energy, 126: 552-562.
26. Hayes M., Gallagher M. (2019). Processing and recovery of valuable components from pelagic blood-water waste streams: A review and recommendation. Journal of Cleaner Production, 215: 410-422.
27. Khalid R., Knowles T.G., Wotton S.B. (2015). A comparison of blood loss during the Halal slaughter of lambs following traditional religious slaughter without stunning, electric head-only stunning and post-cut electric head-only stunning. Meat Science, 110: 15-23.
28. Gousterova A., Nustorova M., Christov P., Nedkov P., Neshev G., Vasileva-tonkova E. (2008). Development of a biotechnological procedure for treatment of animal wastes to obtain inexpensive biofertilizer. World J. of Microb and Biotech, 24: 2647-2652.
29. Kattimani V.S., Kondaka S., Lingamaneni K.P. (2016). Hydroxyapatite-past, present, and future in bone regeneration. Bone and Tissue Regeneration Insights, 7: 9-19.
30. Pepla E.M.D., Besherat L.K.M.D., Palaia G.D.D.S., Tenore G.D.D.S., Migliau G.D.D.S. (2014). Nano-hydroxyapatite and its applications in preventive, restorative and regenerative dentistry: A review of literature Annali Di Stomatologia, 5: 108-114.
31. Görken F.N., Erdem A.P., Ikikarakayali G., Sepet E. (2013). The effects of nano-hydroxyapatite (n-HAp) toothpastes on remineralization of enamel. Istanbul Üniversitesi Dis Hekimligi Fakültesi Dergisi, 47: 81-88.
32. Corro G., Sánchez N., Pal U., Bañuelos F. (2016). Biodiesel production from waste frying oil using waste animal bone and solar heat. Waste Management, 47: 105-113.
33. Fontanier V., Zalouk S., Barbati S. (2011). Conversion of the refractory ammonia and acetic acid in catalytic wet air oxidation of animal by-products. Journal of Environmental Sciences, 23(3): 520-528.
34. Faleh N., Khila Z., Wahada Z., Pons M.N., Houas A., Hajjaji N. (2018). Exergo-environmental life cycle assessment of biodiesel production from mutton tallow transesterification. Renewable Energy, 127: 74-83.
35. Nelson R.G., Schrock M.D. (2006). Energetic and economic feasibility associated with the production, processing, and conversion of beef tallow to a substitute diesel fuel. Biomass and Bioenergy, 30(6): 584-591.
36. Hazrat M.A., Rasul M.G., Khan M.M.K., Ashwath N., Rufford T.E. (2019). Emission characteristics of waste tallow and waste cooking oil based ternary biodiesel fuels. Energy Procedia, 160.
37. Esteves V.P.P., Esteves E.M.M., Bungenstab D.J., Feijó G.L.D., Araújo O.Q.F., Vas- Morgado C.D.R. (2017). Assessment of greenhouse gases (GHG) emissions from the tallow biodiesel production chain including land use change (LUC). Journal of Cleaner Production, 151: 578-591.
38. Adewale P., Dumont M.J., Ngadi M. (2015). Enzyme-catalyzed synthesis and kinetics of ultrasonic-assisted biodiesel production from waste tallow. Ultrasonics Sonochemistry, 27: 1-9.
39. Demirbas A. (2009). Progress and recent trends in biodiesel fuels. Energy Conversion and Management, 50(1): 14-34.
40. Mullen A.M., Álvarez C. (2016). Offal: Types and Composition. Editor(s): Benjamin Caballero, Paul M. Finglas, Fidel Toldrá, Encyclopedia of Food and Health. Academic Press.152-157, ISBN 9780123849533.
41. Tomovic V., Jokanovic M., Sojic B., Skaljac S., Tasic T., Ikonic P. (2015). Minerals in Pork Meat and Edible Offal. Procedia Food Science, 5: 293-295.
42. Abustam E., Said M.I., Yusuf M. (2018). Antioxidant activity of liquid smoke in feed supplement block on meat functional of Muscle Longissimus Dorsi. IOP. Conference Series: Earth and Environmental Science. 119.
43. Velioglu H.M., Sezer B., Bilge G., Baytur S.E., Boyaci I.H. (2018). Identification of offal adulteration in beef by laser induced breakdown spectroscopy (LIBS). Meat Science, 138: 28-33.
44. Rahman M.S, Seo J.K., Zahid Md.A., Park J.Y., Choi S.G., Han-Sul Y.H.S. (2019). Physicochemical properties, sensory traits and storage stability of reduced-fat frankfurters formulated by replacing beef tallow with defatted bovine heart. Meat Science, 151: 89-97.
45. Jaja I.F., Mushonga B., Green E., Muchenje V. (2018). Factors responsible for the post slaughter loss of carcass and offal's in abattoirs in South Africa. Acta Tropica, 178: 303-310.
46. Darah I., Nurdiyana A., Nurulhusna S., Jain K., Lim S. (2013). Microsporum fulvum IBRL SD3: As novel isolate for chicken feathers degradation. App. Biochem and Biotech, 171(7): 1900-10.
47. Mazotto A.M., Ascheri J.L.R., Godoy R.L.O., Damaso M.C.T., Couri S., Vermelho A.B. (2017). Production of feather protein hydrolyzed by B. subtilis AMR and its application in a blend with cornmeal by extrusion. In LWT-Food Sci and Tech, 84: 701-709.
48. Pruekvimolphan, S., Grummer R.R. (2011). Lactation responses to sulfur-containing amino acids from feather meal or rumen-protected methionine. J of Dairy Sci, 84(11): 2515-2522.
49. Said M.I., Abustam E., Yuliati F.N., Pakiding W., Mide M.Z. (2018). Characteristics of feather protein concentrates hydrolyzed using *Bacillus subtilis* FNCC 0059. OnLine J. on Biol. Sci, 18(2): 138-146.
50. Tasho R.P., Cho J.Y. (2016). Veterinary antibiotics in animal waste, its distribution in soil and uptake by plants: A review. Science of The Total Environment, 563: 366-376.