Food and Agriculture Organization of the United Nations

Summary Document of the FAO e-mail conference "Utilization of Food Loss and Waste as well as Non-Food Parts as Livestock Feed"

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EXECUTIVE SUMMARY

Large quantities of food get lost and wasted globally every year, with enormous environmental, social and economic costs. Food loss and waste has an impact on food security and on local and national economies. Finding efficient ways of reduction requires a good understanding of what is lost and why. Both humans and livestock partly consume the same plant materials for their living which is then called food in case of humans and feed in the case of animals. Planning crop production for both food and feed is a common feature of farmers in most food production systems and more so in the integrated crop-livestock systems, whereby all or parts of the main crop and its by-products are allocated to animal feeding. With respect to cereals, multiple uses for either food or feed are very common both in developed and developing economies. Maize is a crop that is frequently cultivated for both food and feed; and fruits, vegetables and root crops may also be directed to feeding of livestock depending on quality of products and market circumstances. In both developed and developing countries it is generally not clear at the time of production of an agricultural product if the final product will be destined for food or feed.

The potential and worldwide common practices of using food plants for both food and feed raises the question of how to view this situation in the efforts to reduce food loss and waste. A common understanding of the food loss and waste in context to food use for animal feeding is a prerequisite for developing a simple but robust methodology for food loss and waste estimation. While the FAO "Definitional framework of food loss" presently defines redirection of food to animal feed as food loss and waste, a large majority of contributions found this inappropriate and a correct representation of the, missing in the definition. It was concluded that there is need to have a new holistic all-inclusive definition of food loss and waste. It should accommodate both humans and animals such that if a food destined for human use is allocated or diverted to animal feeding, then such a food is not truly lost, and should be considered as transformed or recycled. It was also concluded that the efficient use of feed resources and feeding of 'non-food parts' of crops or agricultural products to livestock should be priorities in countries that suffer from food shortages.

There is a large variety and big quantities of 'non-food parts' of crops that are utilized for animal feeding and the utilization of former foodstuffs is a growing segment in the feed supply chain. The presence of hazards can make their use for feeding unsafe and knowledge about suitability and safety of materials from food loss and waste and 'non-food parts' of crops are essential requirements for their safe and efficient use as animal feed. It is essential that the feed chain must not be used as a means to dispose of degraded or contaminated foodstuffs. Countries need to prepare national legislation and regulations and ensure that these are enforced through licensing, standards of operation, auditing and management of controls; and implemented by the feed businesses through risk based HACCP programmes. Through good cooperation, both the food industry and the feed manufacturing industry can play an important role in developing feed processing technologies that process food lost and wasted and 'non-food crop parts' into safe livestock feed. Implementation of efficient and safe use of food loss and waste and 'non-food parts' of crops for animal feeding should be supported through effective, reality-focused research by multidisciplinary teams to address technical, social and economic aspects of the issues. Such research should also address the development of systems for salvaging crops that are damaged by natural calamities either for animal feed or *in situ* feeding. NGOs and Civil Societies also have important roles in dissemination of the information and messages to the final target groups.

Policy guidelines, legislation, regulations and national standards should facilitate the reduction of food loss and waste and allow for a safe use of food loss and waste and 'non-food parts' of agricultural products for animal feeding. Legislation should also ensure that food wastes and losses are preferably processed for animal feed at their production site to minimize environmental pollution. Legislations for feed quality assurance and assisting farmers with insurance schemes that can protect them from losses due to natural disasters are also need to be enacted. Equally important will be to put in place mechanisms to enforce the regulations and standards.

1. INTRODUCTION

The electronic conference on 'Utilization of Food Loss and Waste as well as Non-Food Parts as Livestock Feed' was held from 1 October to 30 October 2015. A background document was distributed before the conference introducing the topics of the conference and providing definitions and terms for a framework and an action plan on 'Food Loss and Waste plus Non-Food Part to Livestock Feed'. The document highlighted the importance and magnitude of food loss and waste and its impact on food security and on local and national economies. Without compromising animal health and welfare and animal product safety and quality, and meeting legislative requirements plant resources that are not used as food can be used as animal feed. The aims of the electronic conference were to discuss the scope and boundaries of the framework including the definition of food loss and waste; and explore the opportunities and possible constraints in implementation of the framework.

The conference generated considerable interest, as shown by the large number of subscribers (630) and 254 messages that were received from 123 participants from 47 countries. During the first three weeks the conference was structured through a set of leading questions. The leading questions for the first week were about the definition of food loss and waste related to feed and an inventory of plant resources used for food and/or feed. The leading questions for the second week addressed issues of feed safety and technologies to utilize food loss and waste as animal feed including the roles of the food industry and the feed manufacturing industry, while those for the third week addressed the roles of researchers, Non Governmental Organizations (NGOs), civil societies, farmers and policy makers in making use of food loss and waste and non-food parts of crops as feed. The fourth week provided opportunity to again discuss topics of the first three weeks and others not raised before. Most messages addressed either the leading questions or responded to previous messages.

This summary document presents a synopsis of the main themes discussed during the conference based on the participants' messages. Specific references to posted messages are included, with an indication of the message number or with the participant's name and message number. The individual messages can be consulted at: http://www.fao.org/save-food/news-and-multimedia/events/detail/fr/c/325893/

The main themes of the discussion are given in Section 4 of this document under seven heading (4.1-4.7) corresponding to the 21 leading questions (termed as Q1, Q2,….Q21). Geographic and institutional distributions of participants are summarised in Section 2, and abbreviations used in this report are explained in Section 3. Section 5 provides conclusions and suggestions for future action and Section 6 a list of the participants who sent messages with their country of work.

2. PARTICIPATION

The conference was held for four weeks from 1 October to 30 October 2015, and 630 people subscribed. Two hundred fifty-four messages were received in total from 123 participants from 47 countries. Among the participants submitting messages, 47 came from African countries, 43 from Asian countries, 9 from Latin America and 17 from Europe, Australia or the United States of America. The countries with the largest number of submissions were India with 22 participants and 62 contributions and Nigeria with 23 participants and 41 contributions. About 54 percent of the participants sent one message, 41 percent between two and four messages and few even more. Roughly two thirds of the messages came from people working in universities or research institutions (168 messages) and about an equal number from either Government and international institutions (40 messages) or the feed industry and private sector (42 messages).

3. ABBREVIATIONS

EU = European Union; FAO = Food and Agriculture Organization of the United Nations; FLW = Food Loss and Waste; HACCP = Hazard Analysis and Critical Control Points; NFPC = Non-food parts of crops; NGO = Non Governmental Organizations;

4. MAIN THEMES DISCUSSED

4.1 Utilization of food plants for food and feed (Q2,Q3,Q4)

Both humans and livestock consume partly the same plant materials for their living which is then called food in case of humans and feed in the case of animals. The definitions of food[1] and feed[2] by the Codex Alimentarius Commission (Procedural Manual, 2013; CAC/RCP 54-2004) define both categories independently and do not reflect a clear allocation of plant materials as either food or feed.

The conference discussed local practices of multiple uses of plant materials for food or feed in particular with respect to cereals. It was stated that in the EU, 53 percent of cereals grown are fed to farm animals (27) and in the United States of America, many grains (maize, wheat, sorghum) that could be used for human consumption are also used for livestock feed (40). Cereals grown in the EU are rarely planted for an 'exclusive' feed use but a significant volume of cereals in Europe is indeed specifically grown for food use under 'Identity Preserved' growing programmes and contracts (45). In the United States of America maize and wheat are planted with the understanding that the resulting grain may go to either food or feed uses (40). Exclusive cultivation of grains as feed that could potentially be used by humans was reported by few participants from developing regions. Examples were mentioned for

[1] *Food: Any substance, whether processed, semi-processed or raw, which is intended for human consumption, and includes drink, chewing gum and any substance which has been used in the manufacture, preparation or treatment of "food" but does not include cosmetics or tobacco or substances used only as drugs.*

[2] *Feed (Feedingstuff): Any single or multiple materials, whether processed, semi-processed or raw, which is intended to be fed directly to food producing animals.*

maize in Burkina Faso, Cameroon, Kenya, Zambia, Bangladesh, Pakistan, Sri Lanka, Costa Rica and Uruguay (77, 34, 38, 24, 48, 61, 30, 100, 7) for sorghum in Kenya, India, Pakistan and Argentina (38, 13, 80, 90) and soybeans in Argentina (79).

Even if crops are exclusively grown for food, participants from many countries reported that parts are later also used for feeding livestock. Reasons for the change of direction of use include harvest failures (80), overproduction mainly of fruit and vegetables (90), poor quality for human use and grading for quality (16, 40, 100, 128) including the separation of broken rice for feed (7, 65, 105, 108) and market forces (30, 61). In Argentina maize yield depends, among other things, on proper amount of rain and temperatures, but in some marginal areas, if corn yield is not high enough as to harvest it for food, it is used as bovine feed (deferred standing corn) (90). Sometimes the harvest is in excess for human use like in Sri Lanka that was self sufficient in recent years in rice and saw the surplus production used for animal rations (30). Ursal (16) reported from the Philippines that maize kernels that do not pass the standards for human food production are sold to animal feed producers or traders of raw materials. According to Pezo (100) at least 20 percent of the banana fruits in Costa Rica cannot meet the quality requirements for exportation, a small proportion of those can be consumed locally, either in fresh or used for producing banana puree (baby food), but there is still a significant amount that is used as an energy source for feeding dairy cattle, pigs, etc. Rodriguez (128) reported that certain varieties of durum wheat that are produced for food (pasta) sometimes do not comply with the specifications of the food industry and must be diverted to other uses such as feed. In Pakistan farmers feed sugar cane to animals instead when prices offered by sugar mills are low. Same is the case with turnips, pulses crops and small size potatoes. Some farmers prefer to feed the standing wheat crop to their animals as fodder and find this practice more income rewarding in the form of milk sale as immediate return (61).

Growing competition for grain between humans and animals especially for maize was reported from Uganda and Nepal where food and feed dealers buy maize from the same markets (33, 94, 54). Ghulam Habib (61) reported that 80 percent of the total maize produce in Pakistan is used as animal feed. The estimates for wheat, broken rice, millet and sorghum as feed are 3, 19, 61 and 5 percent of total produce, respectively and fluctuate over time in response to market dynamics (61), although the use of wheat for livestock feeds was legally prohibited for the last decade (80). The market cost of wheat and rice will decide in India whether they can be used for human consumption or as animal feed (66). According to Bakshi (13) about 10-20 percent of wheat, maize and rice which are the staple food for human consumption are diverted for feeding to livestock and poultry. Teleu Ngandeu (68) reported that maize in Cameroon is primarily meant for human consumption but parts are used for compound feed for poultry and pigs. At the time of cultivation/production farmers who are in search of revenues are on the watch to see where they can get more out of their products. This situation is a matter of permanent concern because the quantity of corn produced locally is very low, and thus high prices directly effect in the production cost of meat (68). Participants from Burkina Faso (77), Cameroon (34), Egypt (113), Ghana (46, 110), Nigeria (6, 12, 21, 43), Niger (114), Bangladesh (76), India (13, 49), Indonesia (41, 102), Nepal (54) Brazil (83) and Uruguay (7) also reported that parts of crops that are originally grown for food are used for livestock feeding in their countries. Crops that were mentioned by them included maize, sorghum, cassava, soybeans, sweet potatoes, bananas and groundnuts. By-products from food processing like wheat and rice brans are also commonly used as feed in many countries (24, 95, 105, 107, 108).

Planning crop production for both food and feed is a common feature of farmers in integrated crop-livestock systems, whereby both the by-products and parts of the main product are allocated to animal feeding (6, 7, 21, 77). Ghulam Habib (61) reported that while cultivating grain crops, sugar cane, sugar beet or pulses, the farmers in Pakistan aim for quality and quantity of crop residues for use as animal feed in addition to the yields of the main cash crops. The monetary value of crop residues as feed varies up to 60 percent of the value of main crop. The farmer's choice for selecting grain varieties also depend on how much straw/stover it would yield as feed for animals. Ursal (16) reported that many farmers in the Philippines are partitioning their lands to grow crops for human foods AND animal feeding. Some farmers allocate a portion of their land to growing maize for silage purposes; instead of raising them to full maturity at 110-120 days, they can harvest the whole plant at 70-80 days and produce silage for animal feeding (16). In Uganda a majority of farmers in the dominant mixed crop-livestock system set goals right at the beginning of production which parts of the crop will be consumed by the household, sold for income, or given to their own animals. This refers to many crops including maize, sorghum, sweet potatoes, rice, and cassava (33). Abukari (46) reported that peasant farmers in Ghana produce maize, sorghum and millet solely for family (human) consumption, but that surpluses from subsistence production could end up in feeding animals when bought by a pig or commercial poultry producer. However, commercial producers might be producing for any of the outlets that would give a better price (46). In Mexico sorghum and yellow maize is produced to a high percentage (about 98 percent and 70 percent of the entire production, respectively) to feed animals, but these crops are also used for human consumption (47). Participants from several others countries also mentioned maize as a crop that is frequently cultivated for both food and feed (12, 34, 40, 43, 49, 54, 65, 69, 76, 77, 80, 90, 105, 113, 114).

Participants also discussed the ethics and efficiency of utilizing grains for livestock feeding. Rust (27, 63, 92) argued against the use of resources (human edible) for livestock feeding because of energy inefficiencies and stated that a varied plant-based diet will provide just as much nutrition (and a healthier balance) for humans than when adding meat and this would also be better for the environment. From the efficiency point of view Capper (75) replied that dairy and beef cattle in a grazing and supplemental feed system produce more human-edible energy and protein than they consume and cautioned that full-scale vegetarianism and veganism may lead to other inefficiencies of food production. Wadhwa (85) supported this opinion stating that animals are an integral part of sustainable agriculture, sustainable food security and sustainable nutritional security. Walli (53) mentioned that with growing prosperity and better purchasing power in the developing world, the demand for food products of animal origin is showing a steep rise. Chander (31) highlighted that thanks to growing demand for livestock feeding poor farmers are getting good prices for their crops when diverted to animal feeding. When improving returns from the farm is the goal, farmers would benefit more if they grow for both food and feed depending on the market demand (31). Kumar (71) further added that shortage of land for fodder production in developing countries favours the use of agro-industrial by-products for animal feeding. Weerasinghe (78) even considers food preference, including whether food is of plant or animal origin, as a human right. He further argued that modern livestock feeding is needed to supply animal based products and that this cannot rely 100 percent on crop residues and agricultural by products without compromising the production and profitability. Carralero (70) argued for an inclusive methodological framework from the point of view of pastoralists for whom supply of feed provided to their herds is a guarantee of obtaining milk and dairy products, meat and animal fibers for themselves.

He mentioned that agro-pastoralists may use part of their crops intended initially for human consumption to save their animals if winter hazards make the access to grass very difficult (70).

4.2 Feed in relation to Food Loss and Waste (FLW) (Q1,Q5)

The potential and worldwide common practices of using food plants for both human consumption (food) and livestock (feed) raises the question of how to view this situation in the efforts to reduce food loss and waste. The FAO "Definitional framework of food loss" (http://www.fao.org/fileadmin/user_upload/save-food/PDF/FLW_Definition_and_Scope_2014.pdf) defines redirection of food to animal feed and utilization of by-products or secondary products in principle meant for human consumption as food loss and waste. Further explaining this definition, van Otterdijk (197) also stressed the importance to agree on, and accept, a common definition of food loss and waste. The participants of the e-conference were asked to comment and give their views on these definitions and 80 of the messages addressed this topic, leading to a very active exchange of views and discussion. More than 80 percent of the participants consider the present definition inappropriate, incomplete or wrong and asked for change. The other participants presented three main arguments in favour of the definitions. The first type of argument was that the definition of food itself has the consequence that any other use than for humans is a loss (2, 9, 24, 28, 41, 60, 68, 80, 83, 102). The second type of argument was the need to prioritize the use of food plants for human consumption in countries that suffer from food shortages (39, 56, 65, 104) and the third argument was the comparatively inefficient utilization of human edible plant resources if converted to human food by livestock (7, 16, 27, 28). Kumar (66) somehow questioned the second argument stating that animal play a crucial role and provide food security and products of high nutritional values especially for low income families in developing countries where food insecurity and poor nutrition are major issues.

A large majority of participants presented arguments for a change of the definitions in the FAO "Definitional Framework of food loss" and found a correct representation of the livestock feeding situation missing. The FAO definitions of food and feed do not allow to clearly allocate any particular plant material to any of the two categories and Rangnekar (215) argued that the use of the term food for humans only is not universal. For example, in Nigeria food is defined from a regulatory point of view as any substance, whether processed, semi processed or raw, which is intended for HUMAN and ANIMAL consumption (44, 205). Tunde Sigbeku (205) suggested to strongly think about the definition of FOOD before re-defining FLW. If feed is not captured with the definition of food then the argument on the definition of FLW would persist (205).

Many participants highlighted the importance of livestock production for human requirements (15, 31, 34, 45, 48, 70, 107) and the high biological value of its products (13, 17, 18, 33, 46, 61, 104, 112) achieved through the conversion of feed. Huque (48) stated that the present FLW definition partly undermines the synergistic role of animals to humans, and Abiola (88) asked for considering animals as an integral part of the food supply chain to make it complete. Participants explained that they see livestock as transformers of feed into higher quality products for human consumption (1, 18, 34, 38, 48, 59, 61, 76, 79, 238) as part of a value chain; and therefore, the use of plant resources as feed cannot be considered FLW but should be rather seen as inputs (14, 15) or multi or alternative utilization (51, 97, 105, 108, 112, 113).

All participants were directly asked whether they consider usage of parts of the food for animal feed as food waste in case where agricultural products are not produced for a single purpose. Thirty-nine out of forty-one participants who answered said that they do not consider this as food waste. According to Yakubu (32) only strict vegetarians would see the use of grains, pulses and root crops for feed as loss while consumers of both plants and animals see it as 'value addition'. Döring (45) expressed that the main purpose of animal feed used for food producing animals is to produce food of animal origin for human consumption; feed is therefore integral part of the food supply chain and cannot be considered as food loss. Only the part of food production which leaves the food supply chain for various reasons (pre- and post-harvest losses) should be referred to as food loss (45). Featherstone (96) also considers it wise to amend the FAO definition in a way that food eaten by humans and feed eaten by food-producing animals are seen as one from a food supply chain perspective.

The efficiency aspects of using plant materials as either food or feed was discussed from two main perspectives. Although livestock products are highly valuable, using food materials for its production could be considered a waste of energy for humans (7, 16, 42, 70). Several participants therefore raised the importance of using as many non-food parts of crops (NFPC) as possible for feeding livestock and in the best and most efficient way (16, 32, 95, 107). In this context Bartle (208) suggested a concept of 'Net Food Loss or Gain' representing 'Food Gained' reduced by 'Gross Food Loss'. 'Gross Food Loss' would be defined as in the present FAO definition considering food diverted to animal feed as loss while giving credit back for the food produced (food gained) by livestock. Most foods diverted to animal feed would receive a negative value because the loss would be greater than the gain thus resulting in a partial loss (77). While presenting a more accurate estimation of the effects of diverting food probably also by taking into account nutrient composition (211) of the different products, Bartle (224) admitted that it may be difficult to implement this theoretical concept in practice. Rodriguez (128) suggested focusing more on how best to utilize the resources in animal feed rather that entering in a discussion on the competition between food and feed resources. In this context several participants (15, 34, 37, 59) mentioned the positive impacts of livestock in using resources that are still safe for use as feed but no longer suitable for human consumption.

The second perspective of efficiency relates to the manner in which producers/farmers decide to use a crop. Farmers may intentionally redirect food originally intended for human consumption to animal feed depending on prevailing circumstances if this results in higher returns and income either by selling or using it for their own livestock (26, 31, 33, 43, 94). Redirection may also be done for pastoralists to protect their livestock from winter hazards (70). Abukari (46) stated that a business oriented farmer who intends to produce maize for human consumption will not sell if prices are low but will sell for poultry feed production if this offers better price and Weerasinghe (78) added that modern livestock feeding cannot rely 100 percent on crop residues and agricultural by products without compromising the production and profitability. According to Abukari (46) a definition of FLW based on intention and not on the final product for human consumption seems flawed and Okoli (8) stated that the manner and type in which a product is to be used should not only reside with its designer or producer as both users and consumers continue to adapt product to suit their specific needs.

Summarizing the intensive discussions of the participants Famuyide (238) concluded that there is a need to have a holistic all-inclusive definitions of food, accommodating both humans and animals; and according to which if a food destined to feed humans is diverted (through various circumstances) to animal feeding, then such food is not truly lost, but transformed or recycled. The definitions and terms

should facilitate accurate but at the same time simple calculations of food losses and waste including 'transformation' (80). While McThenia (230) argued that even food reused to make nutrient rich fertilizer should not be considered lost or wasted, the more common view of the participants was that FLW occurs if food is not consumed (either by human/animals) nor converted to other more stable products but lost due to several factors including spoilage, disease, pest infestation, low quality (6, 26, 44, 81, 100, 113) and deliberately dumped as waste (38) or sent to a landfill (42) and thus benefit neither humans nor livestock in any form (46, 76, 202).

4.3 Resources of NFPC and FLW as feed (Q6, Q7, Q8)

Participants mentioned a large variety of items as NFPC that are utilized as animal feed, which vary widely depending on the crops grown. Also different crops are grown in different agro-ecological zones giving different NFPC. However, what was mentioned was also affected by different views about what is food and what is feed as explained above. Cereal straws, husks, stovers, and legume straws were most frequently mentioned (6, 11, 12, 13, 16, 21, 24, 33, 38, 39, 40, 43, 46, 48, 50, 61, 62, 65, 66, 68, 76, 80, 89, 90, 95, 102) and although no quantities were given they very likely constitute the bulk of the crop by-products in most countries. If not reported by all participants it was probably because these are so common that participants considered no need to mention. Wheat and rice brans were also often mentioned under NFPC (24, 30, 33, 46, 49, 54, 61, 62, 66, 80, 95, 110, 113). Other items that are being used as NFPC are sugar cane tops and molasses (16, 54, 61, 65, 80, 102) and by-products from food processing or breweries such as spent brewer's grains, maize gluten meal, maize oil cake, sugar beet pulp, tomato pulp, distillery products (13, 34, 50, 65). Interestingly not many participants mentioned NFPC that have potential for use as animal feed but that are not currently used, although some reported fruit and vegetable waste from industrial processing (65, 66, 80, 90, 114).

In the EU the utilization of former foodstuffs is a growing segment in the feed supply chain (45) with products like broken biscuits and misshaped or mislabeled products. Most of these originate at the place of food processing, but there is still potential to expand the activities at both the food distribution and food retail level (96). Utilization of wasted bread and bakery items was also reported from Pakistan (80) India (66) or as potential resource (65). Other food items that are used as feed are fruits, vegetables, grains and wheat by-products that due to poor quality or damages are not sold for human consumption (16, 33, 41, 43, 62, 105). Unused fruits and vegetables and their residues from industrial processing were also reported as untapped resources for livestock feeding from Kenya (38), Nigeria (43), Tunisia (50), Uganda (33), Zambia (24), Bangladesh (48), India (13, 49, 65, 112), Nepal (54) and Peru (42).

Crops may be affected through natural disasters like droughts, floods or hail storms that make them unsuitable for human consumption. With a focus on field crops, participants discussed the opportunities and conditions to salvage these crops for animal feed. This conversion to feed was considered useful and its practice reported from Brazil (118), Pakistan (124, 142), the United States of America (160), Mongolia (165) and North Africa and West Asia (166). If crop insurance schemes exist, their state with respect to extent of damage may have to be observed, before their utilization for feed is possible (160, 130). However, more commonly it will be up to the individual farmers to decide on the utilization

of damaged crops (118, 132). Moreover crop farmers may not have their own livestock or face difficulties to make arrangements with livestock owners to allow for utilization as feed (133). In addition to grazing, several participants suggested conservation of the damaged crops through drying or making of silage (121, 122, 123, 125, 129, 131, 144). However, no actual experiences were reported to show that such proposals are feasible in response to disaster conditions and training of farmers and policy support would be required to make them work (123, 125, 132, 133, 143). Yunus (142) cautioned that facilities to preserve affected crops are usually not in place and farmers in Pakistan thus mostly decide to allow damaged crops to mature which may then also lead to contaminated grains that are still used as food. The presence of hazards in the damaged crops like mycotoxins can make their use also for feeding dangerous and not advisable (126, 130) or this can only be done after laboratory testing (124, 143, 156). Developing countries should therefore first establish regulations to allow for safe use of affected crops for animals (142).

4.4 Safe use of FLW and NFPC as feed (Q9, Q10)

Several participants (119, 130, 136, 137, 142, 149, 171) mentioned the prevention of unnecessary crop losses as an important way to increase the availability of resources, both for food and feed. This could be achieved through modern harvesting technologies (136), better post harvest management (119) and reduction of losses during processing and distribution (119, 134, 149).

Efficient utilization of FLW and NFPC for feeding of animals is influenced by the characteristics of the materials, the feasibility of their collection and distribution and their safety of use. Drying is the only conventionally and socially adopted and accepted technique that has been helping preservation of NFPC for feeding animals (133). Material with high moisture content like fruits and vegetables or their residues from processing should be used almost directly to prevent spoilage, whereas others could be sun-dried, conserved by using drying devices (157) or made into silage (134). This would be an important factor for the utilization of excess fruit and vegetable production or their waste from markets. Interestingly this material was identified as a significant untapped source in Bangladesh (133, 137), India (119, 134, 146, 149, 152, 167), Uganda (132) Indonesia (123) and Cameroon (171). The amount of the material that might be available may need further study as the reported range from 0.8-1 percent (137) to 10-20 percent (123) was very wide. Food losses that could be utilized for feeding may also occur in storage facilities for vegetables (167). Dried cereal and pulse residues (straw and stovers) and by-products that become available during processing of cereals, pulses and oilseeds, and undersized and/or broken seeds are generally utilized (152, 167) either directly by farmers or by the commercial feed industry. There is scope of processing for improved utilization. Mandal (152) reported that several experiments have been conducted and several methods have been suggested to utilize NFPC for ruminants but could not be implemented at small scale, except for chaffing, soaking, 'Total Mixed Rations' (136, 151, 154), feed blocks (130) and supplementation of green.

Areas of crop production and creation of FLW may be inaccessible at times (171) or far from the main livestock areas (160, 171). In India regional and seasonal variation in availability of fodder creates areas that are deficit, while others that are surplus in fodder. Similarly in Bangladesh production and supply of NFPC mismatch demand from livestock due to seasonal and regional differences, distant locations

between producers and consumers and absence of policy supports (133). In this situation, private entrepreneurs can play an important role for securing non-food parts of agricultural products (146). While some of the utilization could be done by individual producers or farmers, especially if they own livestock, collective action may be required considering the monetary and/or labour requirements for collection, transport and processing (157). This may also require interventions of government and NGOs (142), investment of the private sector (137) and capacity development of all actors (producers, transporters, processors etc.) across the value chain (144). However, Sager (149) argued that NFPC are really difficult to manage since many of them have no commercial value until they are recognized as animal feed.

Knowledge about suitability and safety of material from FLW and NFPC are essential requirements for its use as feed. The nutritional status of material may need to be investigated and checked (122, 131, 143) and made available to its users together with information about its safe/effective inclusion levels in diets (152, 157), in particular for unconventional resources. The range of hazards relevant to feed could be very broad and may include potential feed contaminants like aflatoxins, heavy metals and pesticides. There could also be the possibility to transmit diseases like Foot-and Mouth Disease and transmissible spongiform encephalopathies (TSEs). With good knowledge of the level of contamination and the dilution with unaffected material their use may become possible to some extent for feeding of ruminants, but not for poultry or pigs (136).

From a safety perspective it is critical that the feed chain is not used as a means to dispose of degraded or contaminated foodstuffs (192). The World Organisation for Animal Health (OIE) and the Codex Alimentarius Commission have established standards to prevent the entry and spread of animal diseases and zoonoses and for food safety, respectively (186). The implementation in countries however need national legislation (118, 130, 132, 133) and its implementation by the feed businesses through risk based programmes like HACCP (Hazard Analysis and Critical Control Points) and their enforcement through licensing, standards of operation, auditing and management of controls (127, 144, 170). The EU feed hygiene regulation is one of the key elements to ensure that feed is produced, harvested, processed and placed on the market without compromising feed safety and specifies hygienic and traceability requirements for primary production including the feeding of animals (188). The EU feed marketing legislation establishes conditions for placing a feed on the market to ensure traceability, information to the user for the proper use of the feed and information that ensures an adequate management during transport and storage, e.g. indication of storage life, storage conditions etc (188). Because of the risks of transmitting animal diseases the feeding of food waste in the EU (170) and also, as in many other countries, the use of by-products that contain animal products (139, 188) is illegal. However, zu Ermgassen (139) reported that South Korea and Japan both recycle ca. 40 percent of their food waste as animal feed, which is made possible by regulation of food waste collection, transport, storage, heat treatment, and feed manufacture.

4.5 Roles of the food industry and the feed manufacturing industry (Q11-Q14)

The food industry and the feed manufacturing industry both play an important role in developing feed processing technologies that will process food lost and wasted and NFPC into livestock feed that is safe (130, 133, 144, 146, 188). The food industry should consider food wastes and losses as a value

added product, not a “waste” *per se* by prioritising the recycling of food wastes and losses as animal feed over alternatives such as composting, anaerobic digestion, or land filling, which all have an environmental burden (127, 139). Döring (170) stated that the food industry holds an important responsibility to maintain safety and integrity of former foodstuffs destined for animal feed use, by storing such products in good condition. And Featherstone (168) mentioned that the food industry plays a key role in ensuring the application of the best circular solution to its FLW.

Oyediji (252) emphasized the need for legislation in the recycling of food wastes for feeding livestock and suggested that this is still lacking in many countries. Based on a broad legislation that will cover several aspects of feed quality including laboratory analyses (118, 129) the food business and non-food business operators that are delivering co-products from their industrial processes to the feed chain, must have robust, risk-based own-control systems in place to ensure safety and integrity of these co-products and “fit for purpose” status, e.g. with no risk for animals, humans and the environment (170). As the vast majority of feed safety risks have its origin in raw materials Döring (170) suggested that suppliers of such products have to intensify their efforts to carry out risk assessments, increase testing of their products and share any risk-related information with their customers. The food industry should also be educated to understand the value of NFPC as animal feed with explanations of where the material will be used, methods of preserving the quality of the material, regular inspection or management (127, 130). This can be best achieved by a good cooperation and linkages between the food industry and the feed manufacturing industry (133, 140, 149, 150, 156, 171, 192). The optimisation of resources and the prioritisation for animal feed should be an important element to consider by the food industry bearing in mind the risks associated. Food operators must therefore also be regarded as feed business operators and should be aware of the requirements of the feed industry (188). In the EU the feed industry has developed high level technologies to ensure best utilisation of products from the food industry and from harvested crops to ensure the economic viability of the livestock sector (188).

While NFPC coming from post harvesting and processing are very much in use in the feed industry Sager (149), reporting from Argentina and Pezo (157) from Costa Rica suggested that without change of present procedures the feed manufacturing industry may not consider the use of FLW as animal feed. This is because of difficulties to manage the material due to low dry matter, fast decay, difficulties to preserve, variable quality and anti-nutritional factors and hazards which often lead to animal health problems (132). However, according to zu Ermgassen (139) the feed industry could do more to create value from food waste. He reported that in Japan pig feed produced from food waste is certified as “Ecofeed” (because of the environmental benefits of recycling food waste as animal feed) and animal products that are reared on Ecofeed are eligible for a price premium (139). Pacheco (140) reported how the food industry developed a procedure to make ‘spent grain’, which is a brewery by-product, suitable for feeding to non-ruminant livestock whereas in Cameroon this material is still dumped along the highways (171). In the Punjab state of India food processing industries are now sun drying tomato pomace and sell it to feed manufactures while in the past it was dumped as waste in landfills (167). In the United States of America, traditional feed companies work with 90 percent dry ingredients and getting to that level with food waste may not be economical (160), although Russick (236) reported good results from a small scale prototype operation of drying fruit and vegetable waste at high temperature to under 12 percent to kill pathogens and have a shelf life for distribution to swine producers. Governments may need to support the development of new technologies, supporting businesses that

are recycling food waste as feed, or creating incentives for food businesses to link with farms which can use their food waste (139, 166) but the market and economics will finally determine success (252).

4.6 Role of researchers, NGOs, Civil Societies and farmers (Q15-Q18, Q21)

Participants unanimously agreed that research and researchers play a very important role in promoting safe and efficient utilization of FLW and NFPC as feed. In agreement with many submissions (173, 174, 176, 178, 184, 196) Sager (187) summarized these roles as follows:

- identifying, describing and quantifying residues that could be available in different value chains in their countries or in the region where they develop their research;
- analyze its chemical composition: nutrients and xenobiotics, and ensure feed safety;
- evaluate different treatments/processes for conservation and value addition;
- evaluate animal feeding behavior and feeding response;
- investigate effect (smell, taste, fatty acid composition, palatability, etc.) on fresh or processed food products (milk, meat, eggs);
- publish information in different formats (research paper, technical information, media articles, etc.); and
- Train professionals, consultants and producers.

The research efforts may be constrained in developing countries by lack of resources (187, 193) or could take many years as explained by Bartle (194) with an example of the research efforts concerning distillers grains with solubles (DGS) in the United States of America. Rodriguez (226) reported that the EU is substantially investing in research and innovation for a European bioeconomy that makes the most of renewable biological resources. That includes projects for turning agricultural waste into animal feed (NOSHAN project), optimizing the use of food processing by-products into food or feed (NAMASTE project) and the FUSIONS project that will contribute to the harmonisation of food waste monitoring; improved understanding of the extent to which social innovation can reduce food waste; and the development of guidelines for a common Food Waste policy for EU-27 (226). Nagpal (233) commented on the quantification of FLW and NFPC, for possible use as animal feed and suggested to derive approximate figures by conducting standard proforma surveys to generate information on actual FLW at harvest, transport, storage, distribution and consumption points. This also found support from others (179, 250), and Chong Wang (235) further highlighted that very different conditions in a large country like China would require specific regional approaches.

While in several countries significant research has already been done for better utilization and development of technologies for NFPC this was less so for food waste. However, the adoption of these technologies is generally very limited (173) and participants therefore raised the need to ensure that research is done in such a way that it results in development of market-oriented technology, practice or processes based on locally available biomass (180). Huque (180) stated that applied research, gaining of knowledge or understanding to convert ideas into operational businesses often remains unattended or neglected in developing countries. Research is often performed in isolation that seldom finds adoption by farmers or industry. Multidisciplinary teams are important to address technical, social and economic aspects of the issues (179, 181, 185). Rangnekar (215) emphasized that compartmentalizing

working or roles of research/extension and development organizations (GOs or NG*Os)* and livestock keepers is not desirable. There is a need for solutions or technologies that are not only technically sound and economically beneficial but also socially acceptable/adaptable (215, 176) and that there may be several aspects other than technical such as environmental, legislative, economic, and social (in case of diverting food losses to animal feed) that need to be addressed (185). Investment of the private sector in research and development would be important to establish linkages between the different stakeholders of feed development (180), but this was not a major point of the discussion.

The participant expressed the role of NGOs and Civil Societies largely as interlocutors between research and the potential creators or users of FLW and of NFPC, mainly with the focus on livestock owners or farmers. They were seen mostly to educate people to reduce potential FLW through extension works (172, 173, 174, 184, 187, 196, 207) and get involved in collection and distribution of material and in demonstrations and awareness programmes for farmers and the public (176, 178, 179, 190, 191, 237). Participants saw NGOs and Civil Societies also as pressure groups in forcing the government to make appropriate laws. They were also considered to play an important role in creation of infrastructures, provision of basic farm inputs, and conducting feasibility evaluation for example on transporting food wastes and non-food parts from areas of production to areas of utilization, as well as raising awareness to minimize environmental pollution (193, 196) by using FLW or former foodstuffs as feed for food-producing animals (180, 182). Featherstone (182) however, cautioned that activities of NGOs and Civil Societies for promoting use of food waste as animal feed may get in conflict with feed safety regulations in the EU which could also create confusion at the consumer level (182).

Rangnekar (215) and others (174, 184) stated that farmers have a great wealth of knowledge on how to utilize non food parts of crops and food co-products for livestock feeding. Other participants (173, 178, 179, 190, 191, 193, 196) stressed the needs of farmers to get more knowledge and experiences about efficient use of feeds including those originating from FLW and NFPC. From an environmental point of view Sager (187) suggested that farmers could be rewarded/recognized if they manage losses and waste in an environmental friendly way and could through "demonstrator farms" become an example of what and how things should be done. There was no contribution that mentioned concrete ideas or initiatives how farmers could be directly and effectively involved in developing better utilization of crop by-products and FLW.

4.7 Role of policy makers (Q19, Q20)

The important role of policy makers for developing frameworks that reduce FLW and encourage the appropriate utilization of co-products from the food industry and NFPC as feed was stressed by many contributors. There is a need for policy guidelines, legislation, regulations and national standards that facilitate the reduction of FLW (173, 174, 178, 184, 187, 190) and allow for a safe use of food losses as animal feed (172, 176, 181, 182, 190, 193, 201, 226, 237) including the promotion of the HACCP approach for those ingredients that are brought by suppliers on the market (201). Legislation should also ensure that food losses/wastes are processed for feed at production site to minimize environmental pollution (as in breweries). Legislations for ensuring quality (176) and for assisting farmers with insurance schemes that can protect them from losses due to natural disasters (178, 179, 184) are also required. Featherstone (182) gave an example of the EU directive, according to which a material that is classified as “waste” is no longer fit for feed production. He made a point that a mere description of a

material as waste, without evaluating its safety and quality, can have a huge impact on its utilization because processors in the EU can currently utilize former foodstuffs of vegetable origin as feed only if they are defined as by-product (Art 5 Waste Framework Directive)[3] . He suggested that policy makers worldwide should make clear that former foodstuff processing for feed is an operation within the food supply chain and it fully falls under food and feed regulations, leaving no room for interpretation that may prevent the use of material on other than safety reasons (182). Talking on behalf of the European Former Foodstuff Processors Association (EFFPA) Featherstone (182) also suggested that EU policy makers should remove any financial incentives for bioenergy producers to use former foodstuffs as a source of renewable energy.

Habib (185) stated that the on-going research in local universities in the developing world is seldom geared towards measurements of economic impact of challenges being faced by the sector and of the respective government interventions; thus fails to provide valuable inputs to policy makers. However, legislative and policy reforms must be backed up by applied research with strong economic analysis and constant feeding of evidence based data and information to policy makers (180, 185, 230). Institutional policy makers should develop strategies to give academic support and ensure funding to state programmes dealing with issues related to FLW and the utilization of NFPC (187, 173, 174, 179, 196, 226). Private-public partnerships with institutional funding may be required under certain conditions to create or develop improved facilities and procedures at farm level and for the food and feed industries (178, 179, 184, 191, 226).

5. CONCLUSIONS

The participants of the electronic conference represented a wide range of countries and the diversity of views expressed yielded a wealth of information for the discussed topics. The issues of FLW, its definition with respect to the use of foodstuffs as feed, the better utilization of NFPC and the role of different stakeholders were all of great interest and considered important for the countries and institutions represented by the participants. Despite the different characteristics of agricultural production including livestock, the type of FLW and of NFPC and of institutional and policy support in the different countries the participants agreed on many issues. This included the important role of livestock for converting plant resources into highly nutritious products for human nutrition, the need to ensure safe and efficient use of feedstuffs through appropriate research, legislation, knowledge transfer and policies, and the need to reduce FLW. The discussions also yielded suggestions for future needs and actions. These include:

- FAO should revise the livestock related definitions in the 'Definitional framework of food loss' either by removing them or by reflecting the use of foodstuffs for feed as conversions and value addition rather than as FLW. A harmonization with the EU definition may be considered.
- Countries to quantify food losses and waste and non-food parts from agricultural products, so as to develop strategies for their reduction and for their possible use as animal feed.

[3] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0098&from=EN

- Countries to establish clear legislation to regulate the safe use of FLW and NFPC as animal feed.
- Identify existing approaches for safe use of food waste and loss and non-food parts as animal feed and policies and strategies developed for its upscale.
- Evaluate impact of using FLW and NFPC as animal feed on parameters such as: decrease in food-feed competition; decrease in use of resources such as land, water, energy and other resources; decrease in environmental pollution; employment generation among others.
- Provide technical support to small scale industries to utilize food wastes and losses and non-food parts as animal feed.
- Raise awareness and develop partnerships including cooperation between the food industries and feed manufacturing industries.

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