Sources of Food Loss and Waste in the Mississippi-Grown Sweetpotato Supply Chain

MISSISSIPPI STATE UNIVERSITY EXTENSION

Food loss is the accidental or intentional decrease in the quantity or quality of food produced for human consumption. It can occur at any stage of the food supply chain, including production, harvest, post-harvest, processing, and distribution. Food may be spilled, spoiled, or lost before reaching its retail stage or final product form because of problems in harvesting, transportation, packing, storage, infrastructure, market/price mechanisms, and institutional and legal frameworks (FAO, 2018). For example, a small but edible sweetpotato that falls through the digger chain during harvest would be considered food loss.

Food losses that take place in the later stages of the supply chain (retail and consumption) are referred to as **food waste**. Food waste is the discarding or alternative (non-food) use of food that is fit for human consumption. It can largely but not exclusively take place at the retail and consumption stages of the food supply chain. Food may be discarded or left to spoil by retailers or consumers because of misunderstood expiration date labels, improper storage, buying or cooking practices, and strict aesthetic requirements for fresh produce (FAO, 2018). For example, blemished but edible sweetpotatoes thrown away by a store due to appearance would be considered food waste.

The Food and Agriculture Organization of the United Nations estimates that one-third of all food produced for human consumption is lost or wasted each year worldwide (FAO, 2011), with about 40 million tons being wasted in the United States in 2015 alone (EPA, 2018). Given the social, environmental, and economic implications associated with wasting food, many initiatives have been launched to reduce food loss and waste. As part of its Sustainable Development Goals, the FAO wants to halve the per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains by 2030. The United States Department of Agriculture (USDA) and the Environmental Protection Agency (EPA) want to halve U.S. food loss and waste by the same year.

However, accurately measuring food loss and waste across diverse supply chains is a challenge in itself. Not only do different organizations define and measure food loss and waste differently depending on the organization's objectives, but the exact causes of food loss and waste in a given food supply chain vary all over the world and depend on the economic conditions in a given region (FAO, 2011). In fact, existing measurements of food loss and waste sometimes rely on limited datasets collected across different food supply chains at different times and extrapolated to the larger picture (Parfitt et al., 2010).

A better understanding of the sources of food loss and waste along the entire supply chain of a particular commodity in a given region may help growers, retailers, policymakers, and other stakeholders accurately measure loss and waste, identify points of intervention for policy, and design better reduction strategies. In this publication, we focus on identifying potential sources of food loss and waste along the supply chain of Mississippi-grown sweetpotatoes, from production to end user/consumer, and discuss strategies that could possibly reduce the food loss and waste generated by these sources.

A major supplier of sweetpotatoes, Mississippi has consistently ranked second in the United States in terms of acreage and third in production. In 2018, its producers planted approximately 27,000 acres of sweetpotatoes, which produced about 4.5 million hundredweight (450 million pounds) with an estimated value of $106.9 million (USDA-NASS, 2019a; USDA-NASS, 2019b). Sweetpotatoes are commercially important to other U.S. states and are consumed worldwide, often as a staple food.

We start by dividing the Mississippi sweetpotato supply chain into two broad categories: 1) production, harvest, and post-harvest, and 2) processing, distribution, and consumption. Production, harvest, and post-harvest (**Figure 1**) includes all practices related to growing, harvesting, and storing the crop. Processing, distribution, and consumption (**Figures 6–8**) is often determined by the size and quality of sweetpotatoes, which can range from No. 1 grade (firm, smooth, well-shaped roots with a maximum diameter of 3.5 inches) to canners (processor grade roots). We then adopt the FAO's definitions of food loss and waste and, for each supply chain category, pinpoint potential sources of food loss and waste, possible strategies to reduce them, and suggestions for future studies and Extension initiatives.

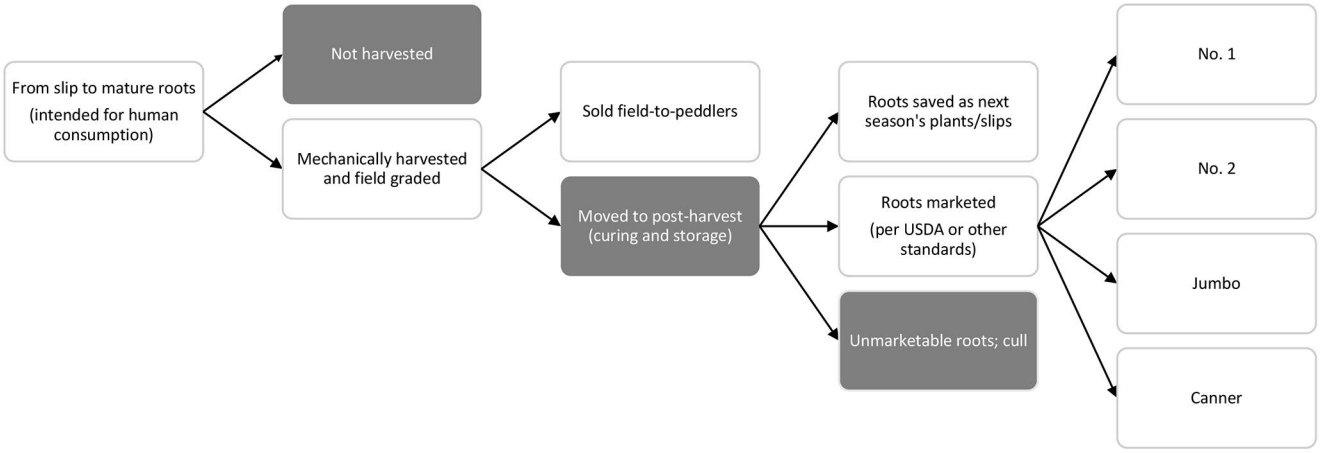

Figure 1. Production, harvest, and post-harvest handling of sweetpotatoes in Mississippi.

Production, Harvest, and Post-Harvest Handling

Figure 1 shows a simplified overview of the commercial production, harvest, and post-harvest handling of sweetpotatoes in Mississippi. We assume that plants (slips) have been successfully planted, sweetpotato storage roots have formed and enlarged, and a crop intended for human consumption is ready to be harvested[1].

At the end of the production season, sweetpotatoes are harvested with platform diggers and "bucket crews," which conduct an initial field grading according to size and quality (**Figure 2**). Sweetpotatoes may be sold in bulk directly from the field to "peddlers" or moved into curing and storage facilities where they are stored year-round.

Every year, growers may save a portion of the sweetpotato crop to produce slips for the next growing season. The remainder of the crop will be marketed according to USDA standards or other standards agreed upon by the buyer and seller. In general, sweetpotatoes are classified according to length, width, and weight parameters as No. 1, No. 2, jumbo, canner, and cull (**Figure 3**). Culls are sweetpotatoes that are typically considered unmarketable; however, they may still have the same nutrition properties as premium sweetpotatoes found on grocers' shelves.

Food Loss During Harvest and Post-Harvest Handling

Food loss is likely to occur during harvest and post-harvest handling of sweetpotatoes (highlighted in dark gray in Figure 1). During harvest, small sweetpotatoes can fall through the digger chain of the harvester, and even larger sweetpotatoes can be lost if the digger is moving too quickly, laborers are not thorough, or the soil conditions are cloddy or muddy. Market/price mechanisms also influence how much and what kind of sweetpotatoes cannot be profitably harvested. Particularly in the case of canners, which are sweetpotatoes of processing grade, marketing

Figure 2. A commercial "bucket crew" harvesting sweetpotatoes in Mississippi.

[1]The FAO's definitions of food loss and waste assume that a crop is purposely being grown for human consumption and not for alternative uses such as the manufacturing of cosmetics, dyes, or pet food. Other definitions consider these alternative uses as productive and thus not part of food loss and waste.

opportunities may be limited for small sweetpotato producers without processing contracts. Canner prices may be too low to cover the costs of harvest and post-harvest handling, thus resulting in edible canners being left in the fields. Sweetpotatoes may also intentionally be left in the field if they have mechanical injury, sunburn (greening), or other imperfections that may limit their storability and marketability (**Figure 4**). Because the supply chain we are considering starts with the harvest of sweetpotatoes suitable for human consumption, sweetpotatoes that are not harvested because they are rotten or are otherwise unsuitable for human consumption would not be considered food loss.

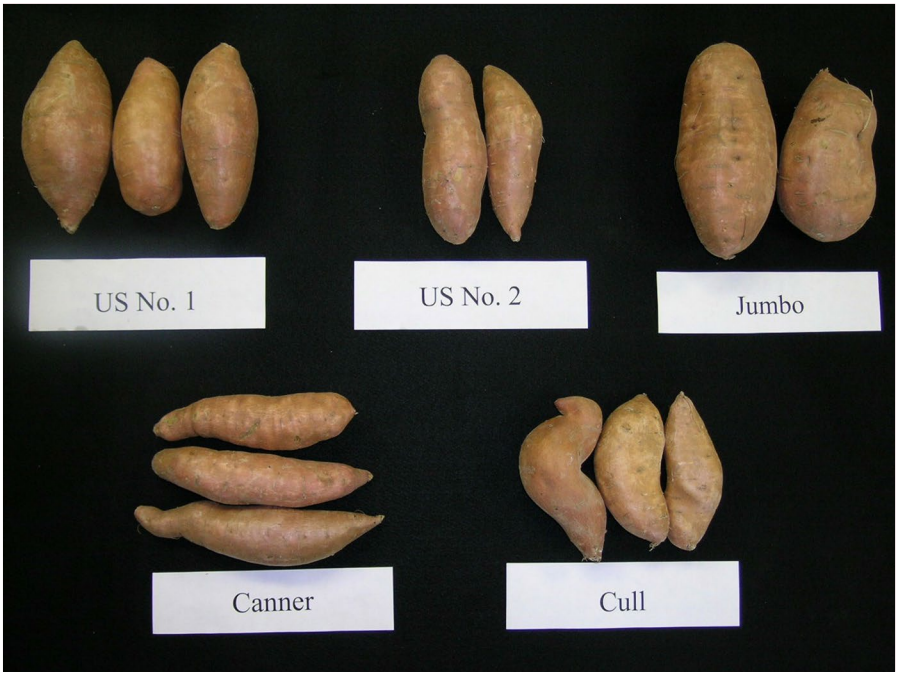

Figure 3. Sweetpotatoes representing No. 1, No. 2, jumbo, canner, and cull sizes. Photo credit: Mark Shankle, PhD, Mississippi State University.

In post-harvest handling, sweetpotatoes may fall out of harvest or storage bins while being transported to and within post-harvest storage facilities. Once in storage, inadequate curing and storage conditions may contribute to food loss. Sweetpotatoes that are not properly cured have an increased likelihood of post-harvest decay and water loss (shrinkage), while sweetpotatoes that are stored at an improper temperature are likely to result in food loss. Sweetpotatoes stored above the ideal storage temperature (55–60°F) respire more, lose more water and carbohydrates (weight), and are prone to sprouting and pithiness (**Figure 5**). In contrast, sweetpotatoes stored below this range are subject to chilling injury and may not present symptoms

Figure 4. Sweetpotatoes exhibiting mechanical injury (a), rodent feeding injury (b), insect damage (c), and greening caused by sun exposure (d).

Figure 5. Sweetpotato roots stored under warm conditions sprout and become pithy.

until they are exposed to warmer conditions or, in the case of "hard core," after they have been cooked. Food loss also occurs when harvested sweetpotatoes are thrown out because they are considered unmarketable due to their appearance.

Processing, Distribution, and Consumption

The processing, distribution, and consumption processes differ slightly based on size and quality of sweetpotatoes. **Figures 6–8** show an overview of the processing, distribution, and consumption chain for Mississippi-grown sweetpotatoes of varying sizes. Once graded by size, sweetpotatoes vary in quality and can be generally classified as optimal quality, suboptimal quality, poor quality, or badly damaged. Sweetpotatoes of optimal quality are well-shaped and have good skin color and texture and no skin blemishes. Most optimal sweetpotatoes, particularly No. 1s, jumbos, and No. 2s, will be sold fresh in 40-pound cartons to retailers or to wholesalers that supply restaurants, institutions, and other retailers. A limited amount will be sold directly to the consumer.

Sweetpotatoes of sub-optimal quality are often misshapen and have moderate blemishes yet are fit for human consumption. These may be sold to value-added food or non-food processors, either directly by the grower or through another grower/packer, normally by the pound or in 20-bushel bins (approximately 1,000 pounds). Non-food processors use sweetpotatoes to manufacture products such as cosmetics and cloth dyes, while food processors use sweetpotatoes to manufacture products such as canned foods, frozen foods, dehydrated foods, juice, and ingredients used by other food processors. Because of strict aesthetic requirements, sweetpotatoes of sub-optimal quality are usually not sold in the U.S. fresh market. Instead, any excess not sold for processing that cannot be profitably stored for future sales may be donated, used as livestock feed, or disposed of on-farm or at a landfill as agricultural waste. Sweetpotatoes of poor quality are often highly misshapen, have excessive blemishes, and are not fit for human consumption. As with excess sub-optimal sweetpotatoes, these will be either used raw as livestock feed or dumped. Badly damaged sweetpotatoes, which are often rotten and not fit for human nor livestock consumption, are treated as agricultural waste and dumped.

As can be seen in Figures 6–8, the main difference between the supply chain of No. 1 and jumbo sweetpotatoes (**Figure 6**) and that of No. 2 sweetpotatoes (**Figure 7**) is that No. 2s of optimal quality are also commonly sold in the fresh market using value-added packaging such as mesh bags, shrink-wrap, or microwaveable steamer bags. Most optimal sweetpotatoes of these three sizes will be sold in the fresh market. If market prices are too low for optimal jumbos or No. 2s to be profitably stored in the hot Mississippi weather, any unsold roots may be donated, used as livestock feed, or disposed of as agricultural waste. In contrast with other

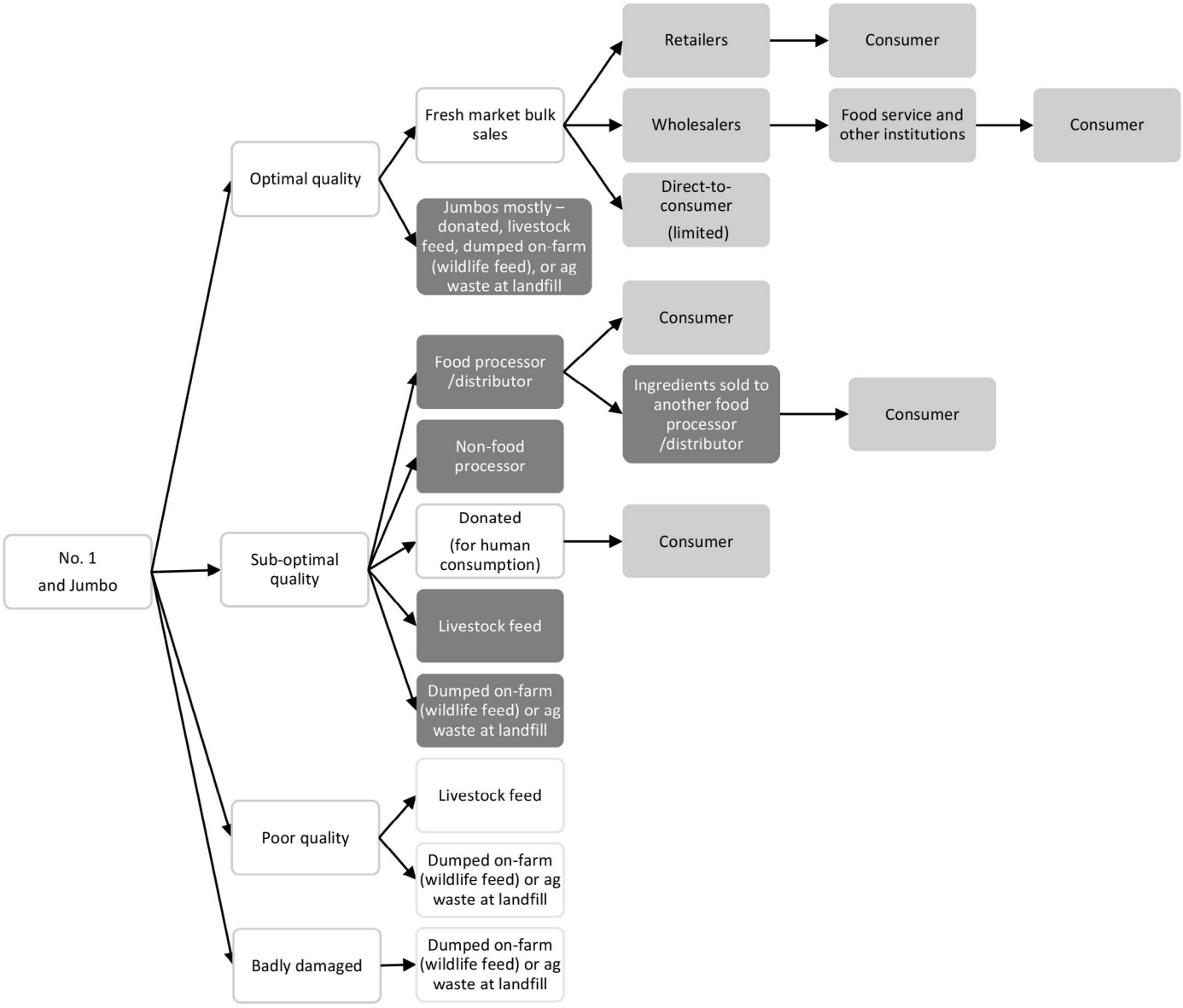

Figure 6. Processing, distribution, and consumption of Mississippi-grown sweetpotatoes, No. 1- and jumbo-sized.

sizes, canners of optimal quality are not sold in the fresh market (**Figure 8**). Any optimal/suboptimal canners not sold for processing and that cannot be profitably stored may also be donated, used as livestock feed, or disposed of as agricultural waste.

Food Loss and Waste During Processing, Distribution, and Consumption

Besides edible sweetpotatoes falling off of a truck on their way to processing or during distribution, food is likely to get lost at various stages highlighted in dark gray in Figures 6–8. Food can be lost during food processing, for example, if a french-fry manufacturer intentionally disposes of edible portions of a sweetpotato when slicing it into uniform pieces and either discards these portions or redirects them to non-food use. Moreover, food is lost if market prices for sweetpotatoes of optimal or sub-optimal quality are so low that they cannot be profitably stored and marketed or donated for human consumption, and become agricultural waste or wildlife feed instead. This is particularly important to small farmers who may not have access to food processing contracts to initially market their sub-optimal goods. Food can also be considered lost when sweetpotatoes grown for the purpose of human consumption are alternatively used as livestock feed or when sweetpotatoes of sub-optimal quality are sold to non-food processors, even though, from a farmer standpoint, both activities could be profitable undertakings (if the economic benefits outweigh the costs).

Food losses that take place in the later stages of the supply chain (retail and consumption) are referred to simply as food waste. Food can be considered wasted at various stages highlighted in light gray in Figures 6–8. For instance, food is wasted if a person chooses not to buy or eat edible

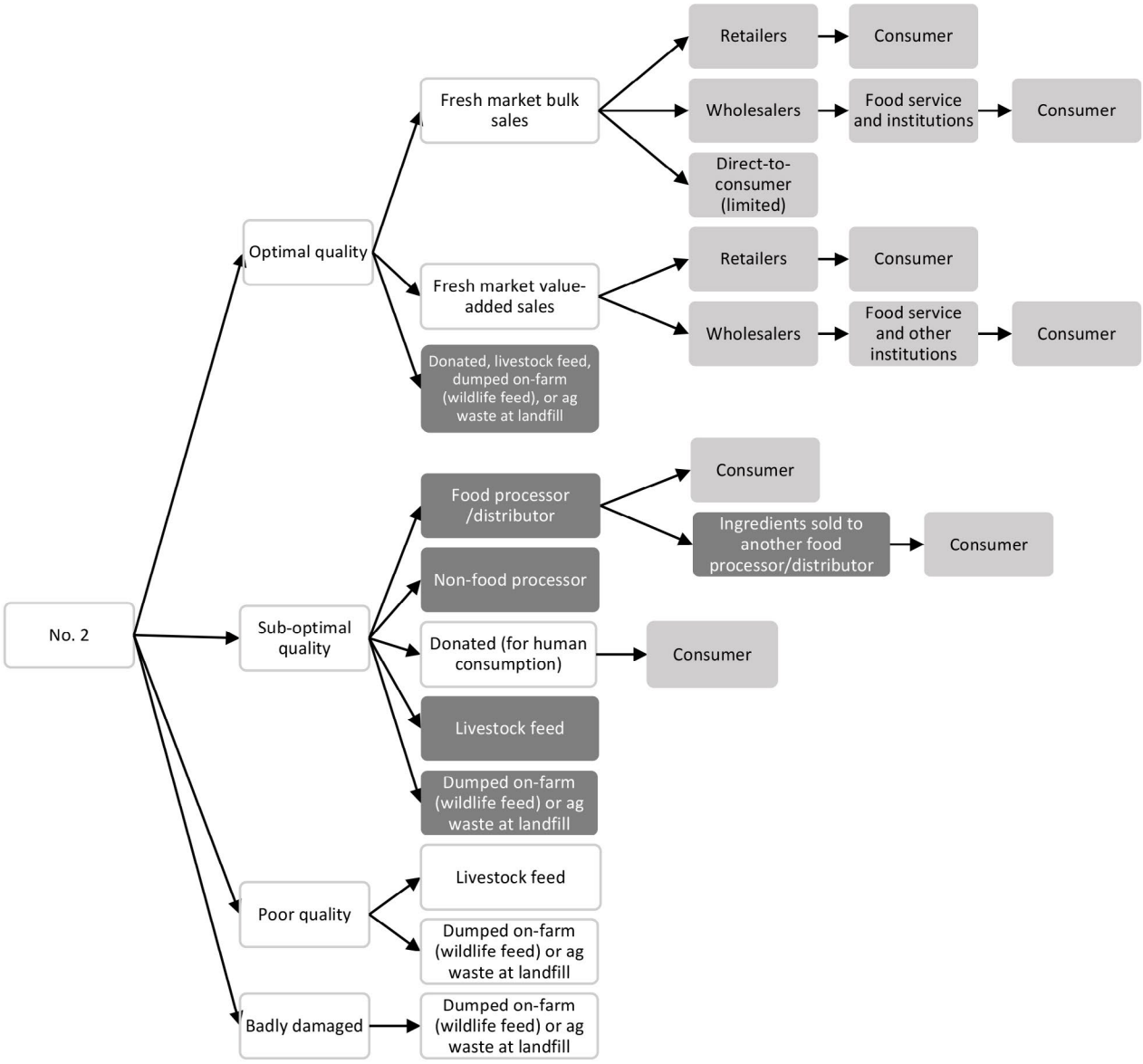

Figure 7. Processing, distribution, and consumption of Mississippi-grown sweetpotatoes, No. 2-sized.

sweetpotatoes because they deviate from what is regarded as optimal or "normal" and if, as a result, the sweetpotatoes are ultimately not used for human consumption (Aschemann-Witzel et al., 2015). Food is also wasted if a person chooses to buy or obtain sweetpotatoes but does not store or cook them appropriately and leaves them to spoil.

Strategies to Reduce Food Loss and Waste

Growers can donate their edible surplus—and some do—through gleaning projects and food banks. Although a noble undertaking, donating produce can involve logistical costs and potential liability issues. It can also make it harder for growers to continue producing food in the long term by decreasing the economic value of the crop to them. Certain growers are able to donate produce while staying profitable, but more effective, long-term solutions are needed, particularly for smallholder farmers who are subject to the industry's aesthetic standards and have limited access to processing contracts and markets to sell their goods.

During the production stages, modifications to harvest operations could help prevent food loss. For example, removing sweetpotato foliage (referred to as devining) approximately 5 days before harvest and harvesting sweetpotatoes in fields with ample soil moisture are two practices that help to toughen the skin of sweetpotato roots and reduce skinning injury, which increases their marketability. Improved worker training to carefully handle the crop during harvest and post-harvest would also be beneficial.

At the distribution and consumption stages, a first strategy could be to open the fresh market to sub-optimal produce. Sub-optimal sweetpotatoes intended for food that are sold for non-food processing, used as animal

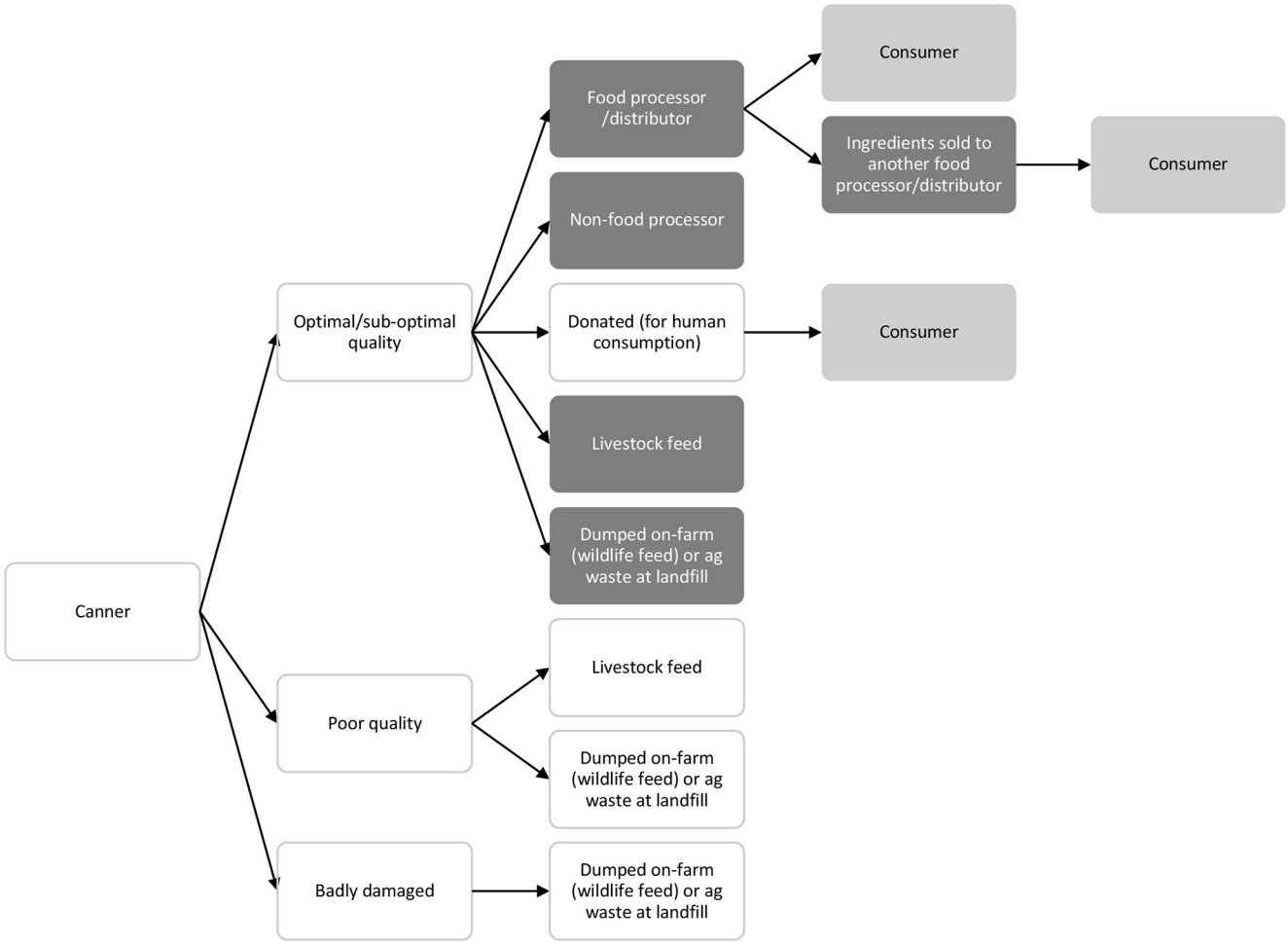

Figure 8. Processing, distribution, and consumption of Mississippi-grown sweetpotatoes, canner-sized.

feed, or simply disposed of, are usually not redirected to the fresh market because they do not meet specific aesthetic requirements. Unless donated, these sub-optimal sweetpotatoes are not consumed (by humans) because of problems in market/price mechanisms during distribution, which are influenced by retailer and consumer aesthetic standards. Yet studies point to evidence that consumers are willing to buy different types of produce as long as its taste and safety are not affected (Stuart, 2009).

If there is demand in the fresh market, retailers could analyze whether it would be economically beneficial to sell sub-optimal sweetpotatoes at discounted prices while marketing their waste-reduction initiatives to their customers. Subject to a favorable cost-benefit analysis, this strategy could be a way to reduce food loss and waste while providing farmers and retailers with new, profitable markets. Because of the strong seasonality in sweetpotato purchases, relaxing aesthetic requirements may be beneficial during certain seasons, such as Thanksgiving or Christmas.

Assuming again that there is consumer demand, a second strategy could be for growers to sell fresh sub-optimal sweetpotatoes directly to consumers in order to bypass retailers' aesthetic standards. This could be achieved through alternative outlets such as farmers markets, roadside stands, and community-supported agriculture operations. Whether sub-optimal fresh sweetpotatoes are sold via conventional (retail) or alternative (direct-to-consumer) marketing channels, educating customers on the relationship between aesthetic standards in fresh produce and food loss and waste may be beneficial. Moreover, conducting public awareness campaigns in supermarkets and schools about aesthetic standards in fresh produce and appropriate food storage and preparation is important to changing people's behavior and eventually reaching any food loss reduction goals.

If conventional and alternative fresh markets are saturated, a third strategy could be for growers to export their crop. Providing growers with export and contract development assistance to profitably export any excess sweetpotatoes to another country's food market (which may have different aesthetic requirements) could keep these roots from being used for alternative (non-food) purposes or being dumped. Exporting processed (dehydrated or canned) sweetpotatoes may help decrease

transportation costs related to temperature control. In addition, helping small farmers get into processing contracts to market canners would make it profitable for them to harvest roots of this size in the first place.

In all cases, cost-benefit analyses can shed light on the effectiveness of these potential strategies to reduce food loss and waste.

Going Forward

Future studies and Extension initiatives could conduct surveys to better quantify the extent of food loss and waste in each of the sources identified here; ask for grower, packer, retailer, and consumer perspectives on potential strategies to address the most problematic sources; and conduct a more detailed cost-benefit analysis of those reduction strategies. Extension initiatives could also increase sellers' knowledge of potential export markets, export quality requirements, and contract development.

Consumer surveys and economic experiments could be conducted to test our assumption of consumer demand for sub-optimal produce in conventional and alternative fresh markets. Retailers' and consumers' appreciation for sub-optimal foods may be lower because they may associate aesthetic quality with food safety and nutritional value, so future studies could provide evidence of the safety and nutritional value of sub-optimal sweetpotatoes. Emerging technological innovations with applications in food supply chain management and smart contract design, such as blockchain technology, could also play a role in facilitating food safety verification and marketing sub-optimal fresh produce.

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