The Economic Viability of Expanding Fresh and Processed Fruit and Vegetable Production in Missouri – Fruit and Vegetable Processing

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Table of Contents

This report is the second of a three-part series on the economic viability of expanding fresh and processed fruit and vegetable production in Missouri. The other related parts include:

Part 1: The Economic Viability of Expanding Fresh and Processed Fruit and Vegetable Production in Missouri – Interview Summaries, Marketing, Outlook, Opportunities, and Next Steps

Part 3: Missouri Specialty Crop Marketing and Costs & Returns Budgets: A Commercial Growers Guide

Introduction

This report intends to inform how fruit and vegetable processing activities may support Missouri in expanding its fruit and vegetable production. Missouri fruit and vegetable producers and processors may use the report's contents to do the following:

- Understand the scope of U.S. and Missouri fruit and vegetable processing.
- Evaluate changes in fruit and vegetable product use.
- Examine processing methods that add value to fruits and vegetables.
- Gauge the operational factors and costs associated with processing foods and beverages, including those made from fruits and vegetables.
- Identify market opportunities for processed fruit and vegetable products.
- Learn from "case study" examples of fruit and vegetable processing ventures.

The report summarizes information collected from academic studies, government agencies, industry publications, market research reports and other stakeholder groups. Also, the report shares results from interviews conducted with individuals familiar with the fruit and vegetable processing business. It concludes by sharing recommendations for Missouri to consider to increase fruit and vegetable processing activity in the state.

1. The U.S. Food and Beverage Industry

In 2018, food and beverage manufacturers contributed 15% of all U.S. manufacturing shipments' value, and the fruit and vegetable processing industry represented 8% of food and beverage manufacturing's total shipment value. Value added by U.S. food and beverage manufacturers totaled nearly $360 billion in 2018, and fruits and vegetables contributed 10% of the total (Zeballos 2020).

In its 2018 benchmarking analysis of food and beverage companies, Deloitte analyzed financial data for 76 U.S. and Canadian firms from 2014 to 2016. Large companies tended to perform better with respect to profitability. Companies growing revenue most quickly during this period, however, were smaller than average. The analysis noted how startup firms that position their products as healthy, fresh, local and organic have the potential to grow further and capture a greater share of the market — possibly at the expense of legacy brands. The report also described the "highly competitive" nature of the U.S. food and beverage industry (McDonald et al. 2018).

New Jersey-based The Boyd Company Inc. has released several comparative analyses focused on defining food and beverage processing plant costs by region. Costs considered include labor, electric, natural gas, land and construction. The Boyd Company limited its analysis to show costs likely to differ significantly according to production location and excluded other operating costs. The report featuring data representative of first-quarter 2017 assessed how costs would vary for a 225,000-square-foot facility that had 350 employees. It evaluated costs in 11 markets; most were near the East Coast. Chicago was the market closest to Missouri. Relative to the 11 markets analyzed, Chicago ranked as the seventh most expensive. Long Island, New York, had the most expensive operating costs. Scranton/Wilkes Barre, Pennsylvania, had the least expensive operating costs. Labor was

the most significant operating cost in all markets — 82% of total operating costs in the Chicago analysis. Other costs considered and their share of a Chicago facility's total operating costs were electric power, 2.2%; natural gas power, 0.8%; amortization, 9.1%; and property and sales tax, 6.1%. The Chicago facility's investment costs would total an estimated $45.7 million — $4.1 million for land acquisition, $21.6 million for construction and $20 million for machinery and equipment (The Boyd Company Inc. B).

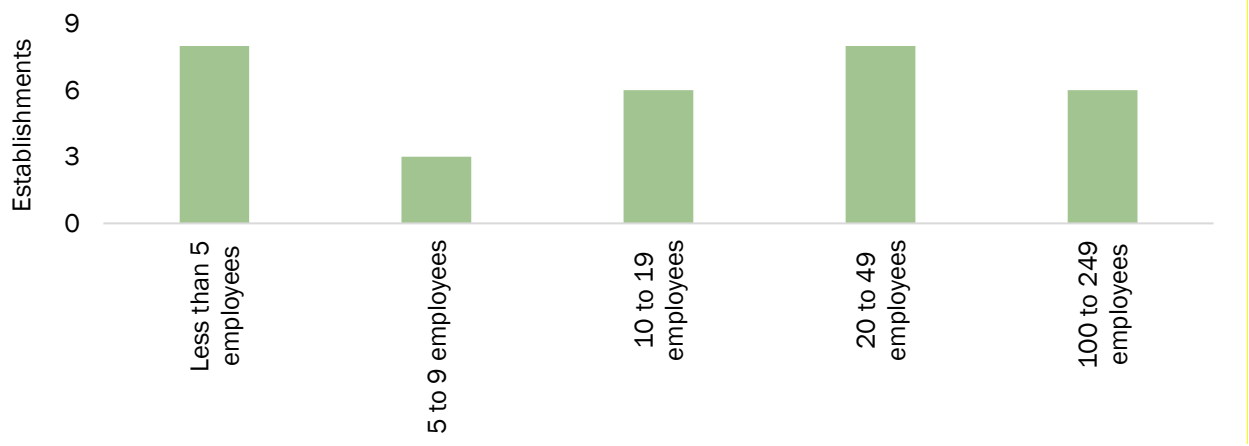
The Boyd Company Inc. produced an earlier report specific to data from second-quarter 2016. For it, the company evaluated how costs would vary in 24 markets, including those in the U.S. and Canada. Several of the observed markets were in or near the U.S. Heartland: Chicago; Omaha/Eastern Nebraska; Minneapolis/St. Paul; and Dallas/North Texas. The models assumed a 300,000-square-foot facility that had 500 employees. Of the Heartland region markets included in the analysis, costs were highest in Minneapolis/St. Paul and Chicago and lowest in Dallas/North Texas and Omaha/Eastern Nebraska. Like in the other analysis, labor served as the most expensive operating cost (The Boyd Company Inc. A).

2. Missouri's Processing Industry

According to the U.S. Census Bureau, Missouri had 90 establishments — including employer and nonemployer establishments — operating as part of the fruit and vegetable preserving and specialty food manufacturing industry in 2018. Employer firms, measured in the County Business Patterns dataset, accounted for 38% of total establishments. A majority of establishments — 62% — were nonemployer businesses (U.S. Census Bureau 2020a).

Annual payroll exceeded $156.6 million for the state's 34 employer establishments operating in the fruit and vegetable preserving and specialty food manufacturing industry in 2018. In terms of their business structures, 47% were organized as S-corporations, 26% were formed as C-corporations, and 26% were structured as partnerships. For 31 of these establishments, the U.S. Census Bureau shared their size according to employment. See Exhibit 2.1. Based on these data, employment count varied, but most establishments had fewer than 100 employees (U.S. Census Bureau 2020b).

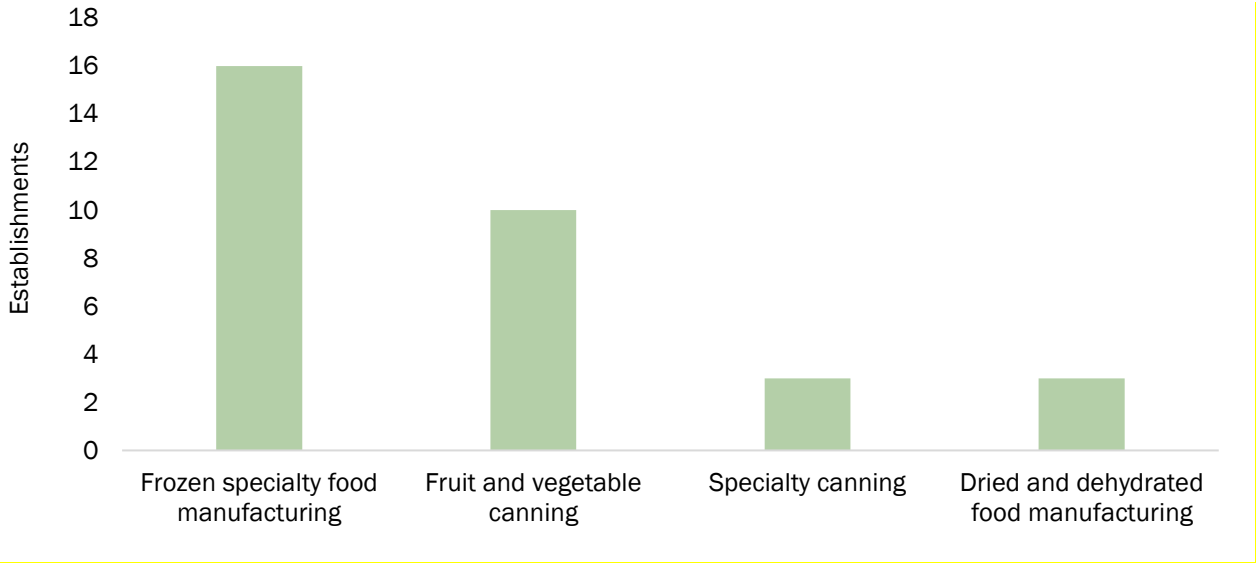
Exhibit 2.1. Employee Count by Missouri Employer Establishments in the Fruit and Vegetable Preserving and Specialty Food Manufacturing Industry, 2018



Source: U.S. Census Bureau (2020b)

During 2018, Missouri fruit and vegetable preserving and specialty food manufacturing employer establishments most commonly were classified as frozen specialty food manufacturers. Exhibit 2.2 presents the number of establishments by subindustry. Several firms participated in fruit and vegetable canning. Relatively few produced specialty canned products or dried and dehydrated foods (U.S. Census Bureau 2020b).

Exhibit 2.2. Missouri Fruit and Vegetable Preserving and Specialty Food Manufacturing Industry Employer Establishments by Subindustry, 2018



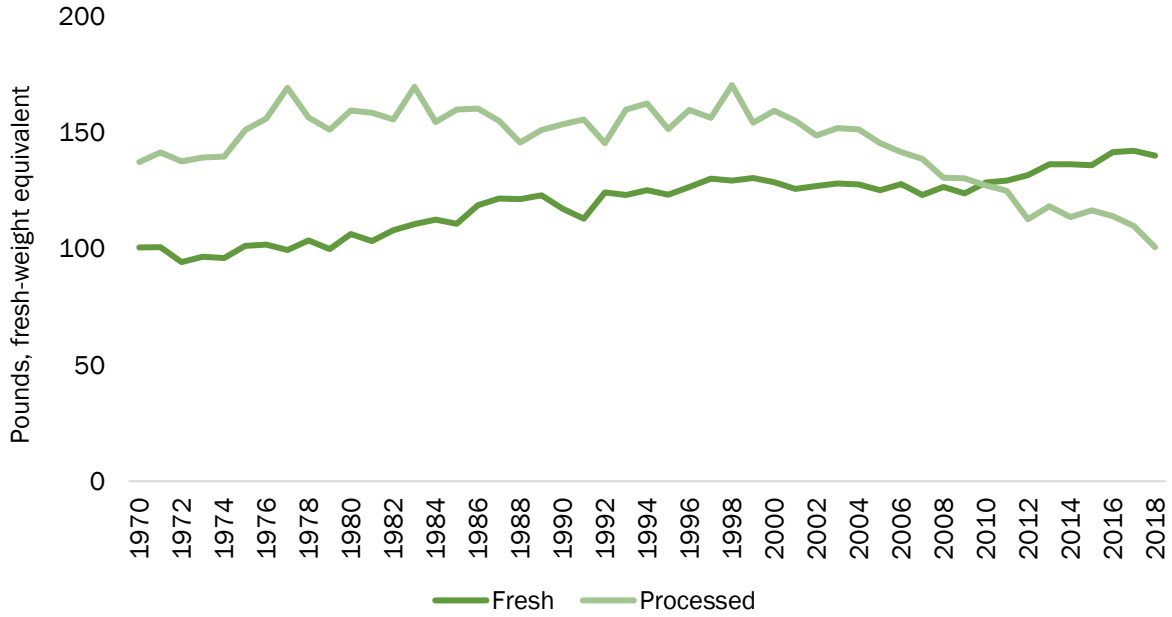
Source: U.S. Census Bureau (2020b)

With respect to Missouri nonemployer establishments in the fruit and vegetable preserving and specialty food manufacturing industry, 56 operated in 2018. Most of those were individual proprietorships. Sales, value of shipments or revenue for the industry's nonemployer establishments totaled nearly $2.2 million (U.S. Census Bureau 2020c).

3. Fruit and Vegetable Use Trends

In the past five decades, U.S. consumers changed how they used fresh and processed fruits and vegetables. Exhibit 3.1 shares fruit per capita availability data reported by the USDA Economic Research Service. Note, per capita availability may roughly approximate use. In 2018, fruit per capita availability totaled 240.9 pounds — as measured on a fresh-weight basis — and 58% was available as fresh product compared with 42% available as processed goods. Of fruit dedicated to processing in 2018, juice captured a nearly 80% share. Canned fruit represented 12% of total processed fruit available per capita followed by frozen, 5% of the total, and dried, 3% of the total (Kantor and Blazejczyk 2020).

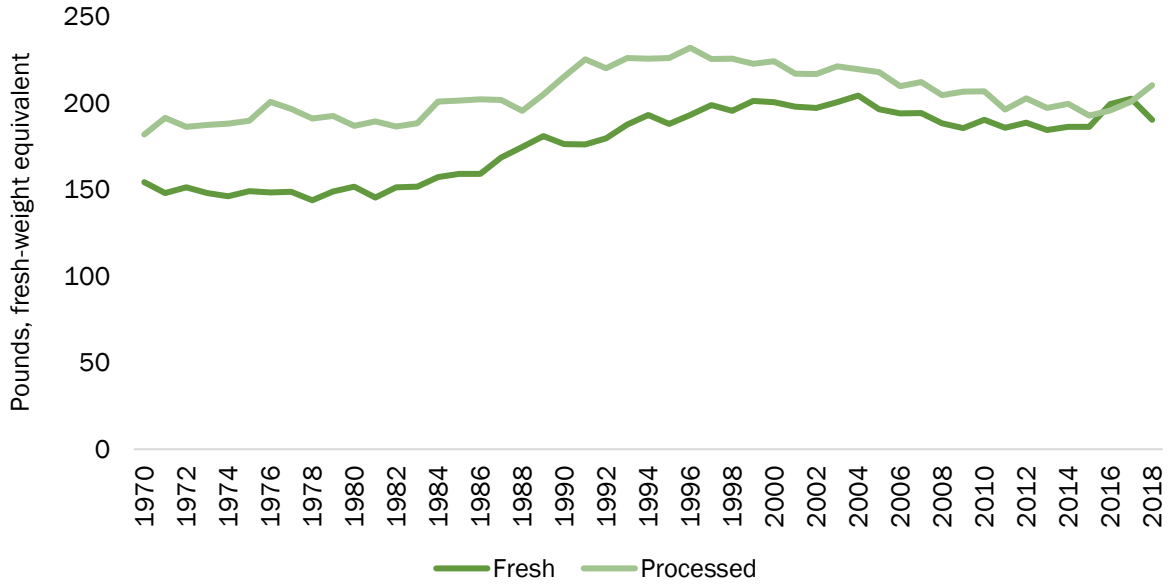
Exhibit 3.1. Fresh and Processed Fruit Per Capita Availability, 1970 to 2018



Source: USDA Economic Research Service (Kantor and Blazejczyk 2020)

With respect to vegetables, availability per capita totaled roughly 401 pounds in 2018 when considering fresh and processed forms. Processed product's per capita availability exceeded fresh availability for most of the past five decades — as measured on a fresh-weight basis — but the gap between the two narrowed until 2016 and 2017. During those two years, fresh vegetable per capita availability slightly surpassed processed vegetable per capita availability. See Exhibit 3.2. In 2018, fresh vegetables represented 48% of per capita availability compared with 52% for processed vegetables. Vegetables for canning and freezing captured 43% and 35%, respectively, of total processed vegetable availability per capita. Potatoes for chips, 9% of processed total; legumes, 7%; and dried, 6%, represented the balance of processed vegetable availability per capita (Kantor and Blazejczyk 2020).

Exhibit 3.2. Fresh and Processed Vegetable Per Capita Availability, 1970 to 2018



Source: USDA Economic Research Service (Kantor and Blazejczyk 2020)

4. Processing Methods

To add value to fruits and vegetables, firms may choose from several processing methods. The following discussion describes types of fresh-cut, frozen, canned and dried fruit and vegetable processing (Kadam 2020).

4.1. Fresh-Cut

The Postharvest Technology Center at the University of California defines fresh-cut as "fresh fruits and vegetables that have been prepared (cleaned, washed, sanitized, cut), packaged and held under refrigeration until consumption" (Postharvest Technology Center 2020).

4.1.1. Category Trends

Traditionally, the fresh-cut category included products such as carrot sticks, baby carrots and celery sticks, but it has grown to more widely refer to value-added produce (Gibbons 2017). In 2019, value-added produce sales represented roughly 10% of all produce dollar sales. Dollar sales of value-added vegetables were more than three times as much as value-added fruit sales. Exhibit 4.1.1.1 illustrates how dollar sales and volume sales growth varied for value-added fruits and vegetables in the year preceding Nov. 3, 2019. Value-added fruit sales grew faster than value-added vegetable sales (Karst 2020).

Exhibit 4.1.1.1. Value-Added Produce Sales Growth in Year Preceding Nov. 3, 2019

	Dollar Sales Change	Volume Sales Change
Value-added vegetables	3.1%	2.3%
Value-added fruit	4.7%	6.7%

Source: Power of Produce cited by The Packer (Karst 2020)

Fresh-cut fruit that tends to perform well includes melons (e.g., watermelon, cantaloupe, honeydew), mango, apples and pineapple. Berry cups have also gained popularity (Burt 2019). Between 2013 and 2018, fresh-cut berry, melon, mango, mix and pineapple sales increased most in dollar terms, based on IRI Fresh data (Strailey 2019).

With respect to vegetables, consumers have accepted spiralized options such as squash, beets, sweet potatoes and zucchini as substitutes for noodles, and cauliflower and broccoli rice have been popular. In some cases, varietal development has emphasized features that deliver on fresh-cut product expectations. For example, some carrot varieties have a sweeter flavor or grow long and thin to simplify making baby carrots. Also, some lettuce varieties are more resistant to browning that can happen after being cut (Gibbons 2017).

Other forms of value-added produce include bowls with produce and grains or proteins, ready-to-cook produce that has been washed and produce sold with seasonings (Gibbons 2017). Pairing fresh-cut product with complementary goods, such as dips, may increase sales potential (Burt 2019).

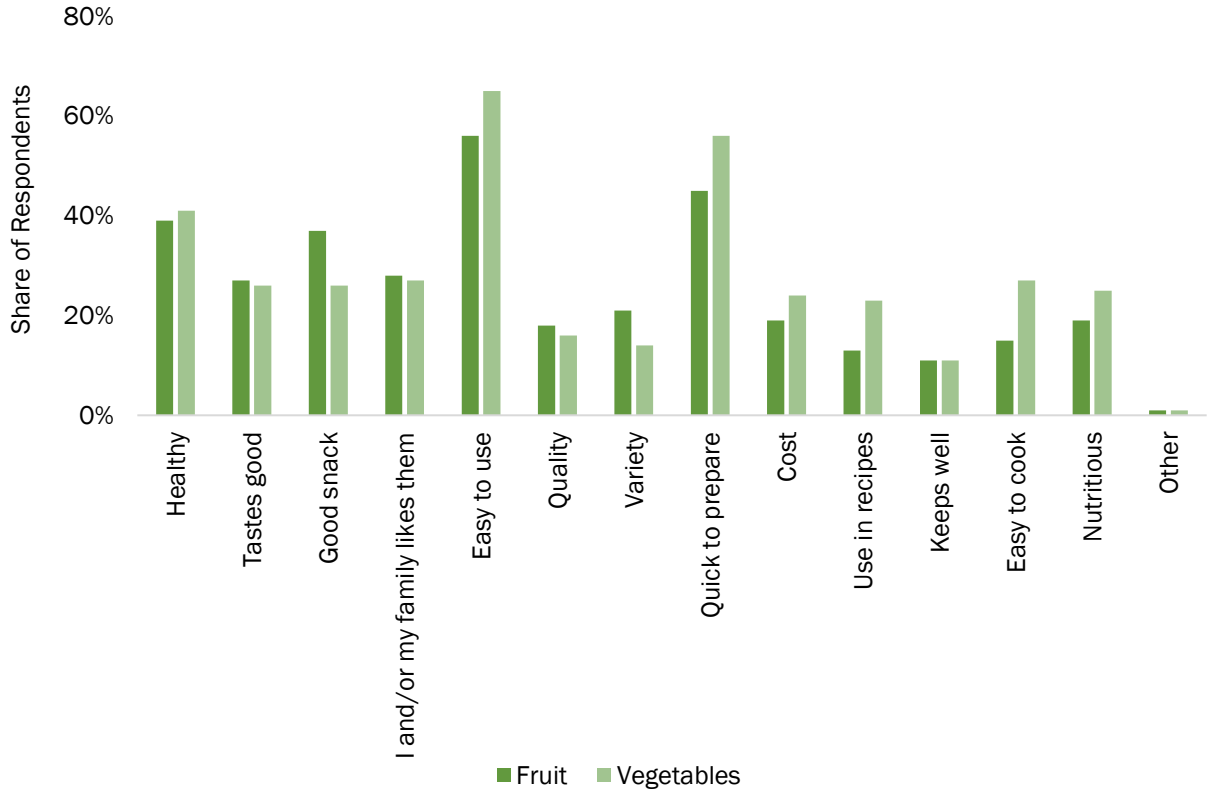
In some cases, consumers may hold a preference for organic products. However, organic fresh-cut or value-added options may command a premium some consumers are unwilling to pay because a product's total price would include the value attributed to the organic attribute and the value-added product's preparation (Gibbons 2017).

4.1.2. Target Audience

More than nine in 10 U.S. households have made value-added produce purchases, based on data reported in the Power of Produce 2020 (Stein 2020). To an extent, consumers have been more likely to frequently or sometimes purchase value-added vegetables than value-added fruits, according to the Power of Produce (Karst 2020). Two consumer segments that fit particularly well in the value-added produce target audience are those who are younger and care about their health and those who are moms and want to provide healthy, quick snacks for their kids (Burt 2019).

Data provided by the Produce for Better Health Foundation highlight further insights into why consumers tend to choose various fruit and vegetable products. To assess purchase motivations, adults who identified as their households' shoppers participated in an online survey. They ranked "easy to use" as the top factor motivating purchases of pre-cut, pre-washed fruits and vegetables. See Exhibit 4.1.2.1. Survey respondents relatively commonly noted how the "quick to prepare" and "healthy" attributes of pre-cut, pre-washed fruits and vegetables encouraged them to buy (Produce for Better Health Foundation 2017).

*Exhibit 4.1.2.1. Pre-Cut, Pre-Washed Fruit and Vegetables Purchase Motivations**



* n=239 for pre-cut, pre-washed fruit; n=225 for pre-cut, pre-washed vegetables
Source: Power for Better Health Foundation (2017)

With respect to healthfulness, some research has focused on assessing whether fresh-cut produce loses nutritional value post-processing. One review explained that the ethylene production induced by cutting produce causes some vitamin levels, such as vitamin C, to decline more quickly (Barrett, Beaulieu and Shewfelt 2010). A study published in 2006 evaluated fresh-cut fruit nutrient levels. The fresh-cut fruits studied — mango, strawberry, watermelon, pineapple, kiwifruit and cantaloupe — were stored at 5°C. Vitamin C and carotenoid levels after six days in storage varied by crop. The total phenolic content did not change significantly. The study provided this summary: "In general, fresh-cut fruits visually spoil before any significant nutrient loss occurs" (Gil, Aguayo and Kader 2006). Other potential quality problems for fresh-cut produce include browning and textural changes such as mushiness and wilt (Barrett, Beaulieu and Shewfelt 2010).

4.1.3. Operations

Fruits and vegetables grown for fresh-cut use undergo several preparation steps before they reach their end markets. Washing and trimming represent the first two stages following the harvest. Trimming removes unnecessary leaves, roots and peels. Next, processors use machines or hire hand labor to cut, core and prepare fruits and vegetables to sell as fresh-cut products. After making cuts, processors may wash the cut fruits and vegetables in a cold water-disinfectant solution. If it washes fresh-cut products, then the facility would dry the product before packaging it. Although shelf life varies according to factors such as storage

temperature, packaging type and product type, the typical shelf life for fresh-cut products ranges from six days to 21 days (USDA Agricultural Marketing Service 2016).

Retailers have shown interest in outsourcing fresh-cut preparation to local and regional processors. To prepare fresh-cut options on site, they would need the appropriate equipment, hire enough labor to cut product and train those workers. Additionally, they would need to adhere to protocol meant to minimize food safety risk — for example, testing wash water, monitoring for pathogen contamination and adopting microbial testing (Burt 2019). Missouri's cottage food laws do not qualify cutting produce as cottage food production (Missouri Grown 2018). The U.S. FDA released fresh-cut fruit and vegetable guidance in February 2008 (U.S. Food and Drug Administration 2008), and it later published draft guidance for fresh-cut produce in October 2018 (U.S. Food and Drug Administration 2018). Local and regional processors that specialize in creating controlled environments suitable for fresh-cut activities and maintaining a dedicated labor pipeline experienced at this work (Burt 2019) may carve a niche for themselves.

Traditionally, fresh-cut produce has been prepared using square cuts. However, some buyers — for example, chefs and caterers — have expressed interest in unique cuts, such as triangles, hearts, halfmoons and rosettes, according to a 2014 story from *Produce Processing*. These formats can add visual appeal to otherwise ordinary dishes served at buffets or events. However, cutting fresh produce into these unique shapes tends to require hand labor (Gibbons 2014).

4.1.4. Case Study

In January 2020, stakeholders in western Washington supported a feasibility analysis of operating a startup processing facility that could minimally process — peel, slice, cut, dice and chop — as much as 1,000 pounds per day. The facility could accommodate blanching, chilling and freezing with added investment. This study found a facility capable of producing individually quick-frozen products would not likely work for an initial investment because of the infrastructure required (Bramwell et al. 2020).

The study found a facility minimally processing fruits and vegetables could operate profitably as long as it had a suitable mix of crops processed, grower pricing and selling prices. The study identified that startup equipment and raw goods would represent two significant costs. However, specific costs would vary by crop. Carrots, summer squash and butternut squash would be relatively easy to process. Other crops that could share relatively basic processing equipment needed for carrots and reduce total equipment needs and costs include beets, potatoes, turnips and rutabagas. Ultimately, the profitability analysis found that processing summer squash, butternut squash and carrots yielded better profitability than processing broccoli and green beans — due to factors such as processing equipment needed. In addition to considering processing-related factors when selecting crops, the study also focused on choosing crops that could scale well in the field without significant labor investments, profit well per acre and align well with buyer demand (Bramwell et al. 2020).

Another consideration when choosing crops is seasonality. Summer crops, such as summer squash and green beans, require immediate post-harvest processing quickly post-harvest. Winter crops, including butternut squash and carrots, store better, so they can undergo

processing over an extended period if appropriate storage is available. This approach allows operations to use facility space more evenly over time (Bramwell et al. 2020).

This study estimated crop waste to range from 5% to 20% when processing. Minimizing the waste or diverting the waste to a value-added market, such as producing vegetable broth, can improve a processing facility's profitability (Bramwell et al. 2020).

Exhibit 4.1.4.1 summarizes costs for three models. The basic model assumes a facility would peel and cut carrots, summer squash and butternut squash. With the mid model, a facility could accommodate green beans by adding a bean snipper and a different processor for cutting. To process broccoli, the full model requires a broccoli floretter. Supplemental equipment includes two walk-in coolers, washing tubs, tables, packing equipment and other miscellaneous items. The study added 10% for other costs. The facility's daily throughput would range from 650 pounds to 1,000 pounds (Bramwell et al. 2020).

Exhibit 4.1.4.1. Capital Costs of Three Processing Equipment Setups in Western Washington

	Basic	Mid	Full
Supplementary equipment	$30,760	$30,760	$30,760
Processing equipment	$28,500	$95,000	$116,000
Total (+10% buffer)	$65,200	$138,300	$161,400

Source: Bramwell et al. 2020

4.2. Frozen

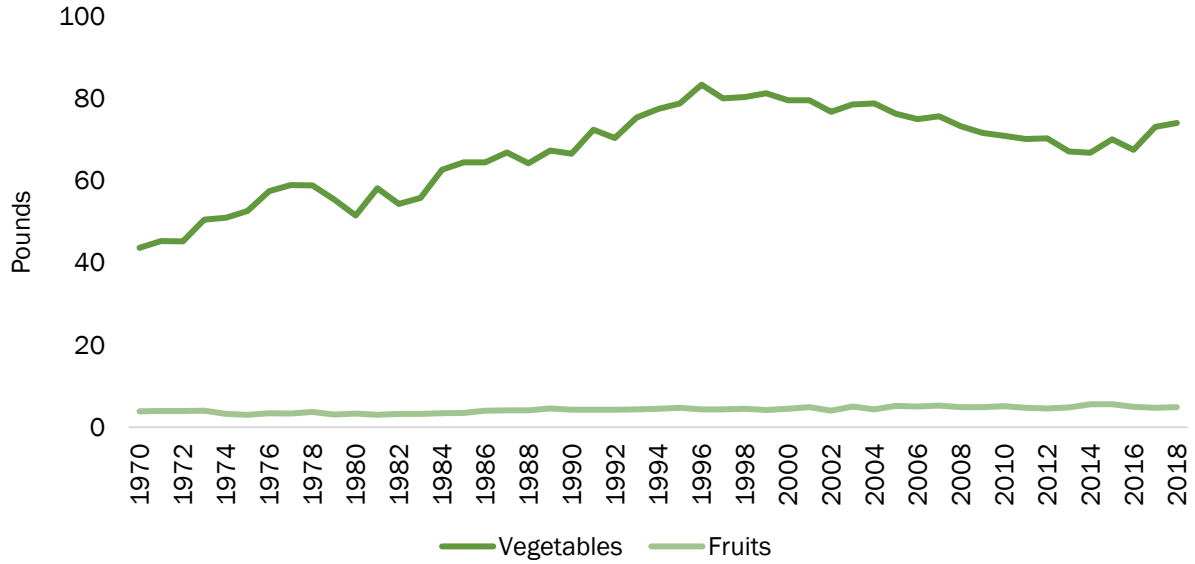
Consumers may use frozen fruits and vegetables in varying applications — those from smoothies to side dishes. Their versatility, convenience and easy-to-use characteristics lead to a significant share of U.S. households choosing frozen food products (Buch 2020).

4.2.1. Category Trends

In the past five decades, frozen fruit per capita availability grew subtly. During the 1970s, annual availability per capita averaged 3.6 pounds for frozen fruit. It grew to average 5 pounds annually from 2010 to 2018. Note, these measures are communicated on a fresh-weight basis (Kantor and Blazejczyk 2020).

Relative to frozen fruit, frozen vegetables have had much higher per capita availability. See Exhibit 4.2.1.1. From the 1970s to the 1990s, per capita availability of frozen vegetables increased before it began to decline. In recent years, frozen vegetable per capita availability resumed its growth, though this measure was about 10 pounds lower on a fresh-weight basis in 2018 than its peak in the mid-1990s (Kantor and Blazejczyk 2020).

*Exhibit 4.2.1.1. Fruit and Vegetable Per Capita Availability for Freezing, 1970 to 2018**

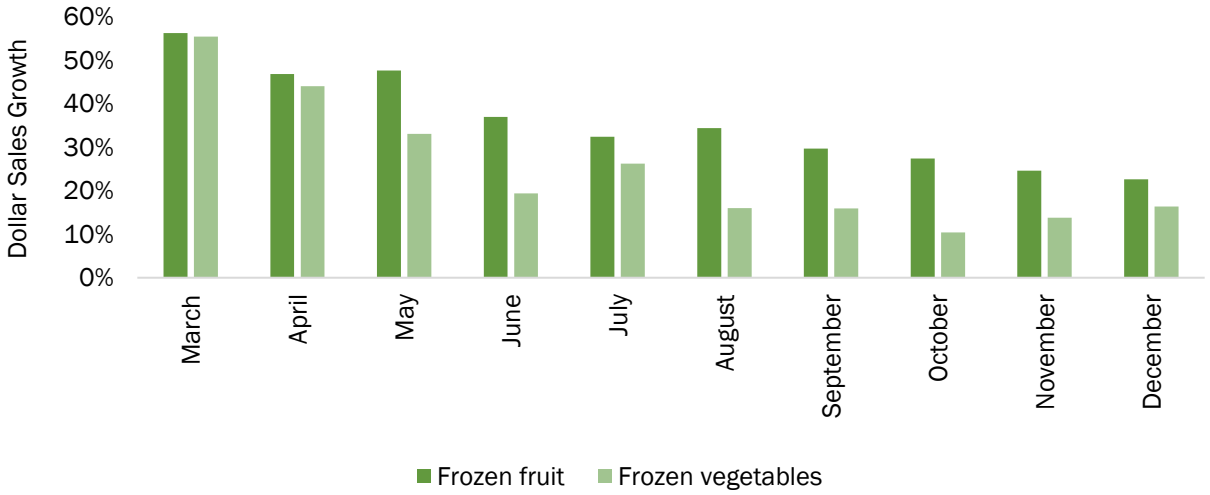


* Fresh-weight equivalent
Source: USDA Economic Research Service (Kantor and Blazejczyk 2020)

A 2020 report from IBISWorld shared that nearly half of the U.S. frozen food production industry's sales focused on prepared food and entrees. The report estimated that the frozen vegetable and the frozen fruit and juice concentrate segments captured 28% and 9.5% of industry revenue, respectively (Ristoff 2020). The COVID-19 pandemic that began in 2020 supported the frozen food sector's growth, even as it was already showing strength (Baltazar 2020). In March 2018, frozen food's performance began to take a positive turn (Fusaro 2020). A story from Winsight Grocery Business attributed the frozen category's performance to innovation, product quality, emerging diet trends and frozen products' convenience and health benefits (Baltazar 2020).

During 2020, frozen fruit and vegetable sales posted strong growth relative to 2019. Sales growth was particularly high during the pandemic's initial stages, but it continued later into the year, too. Exhibit 4.2.1.2 shares the monthly change in frozen fruit and vegetable dollar sales by comparing 2019 and 2020 sales data reported by IRI. From March to December, 2020 monthly dollar sales surpassed 2019 monthly dollar sales. In each month observed, frozen fruit dollar sales increased more than frozen vegetable dollar sales (Roerink).

*Exhibit 4.2.1.2. Change in Monthly Frozen Fruit and Vegetable Dollar Sales, 2019 to 2020**



* Monthly periods analyzed were March 8 to 29, April 5 to 26, May 3 to 31, June 7 to 14, July 5 to 26, Aug. 2 to 30, Sept. 6 to 27, Oct. 4 to Nov. 1, Nov. 8 to 29 and Dec. 6 to 27
Source: 210 Analytics and IRI (Roerink)

With respect to frozen fruit, ready-to-blend smoothie kits have opened opportunities to use frozen berries and tropical fruits. Consumers have also had interest in juicing their own frozen fruit and mixing frozen fruit in oatmeal and yogurt. They've also tended to accept premium juice blends, as interest in juice made from frozen concentrate has declined. Within the frozen fruit and juice production industry, strawberries represented the largest whole-fruit segment, according to a March 2020 report from IBISWorld. Frozen orange juice concentrate garnered more sales than other frozen concentrates (Zheng 2020).

4.2.2. Target Audience

Research from the National Frozen & Refrigerated Foods Association described 35- to 44-year-olds as having particularly strong frozen food demand, and some frozen items appeal to consumers who are younger (Hamstra 2020). Young consumers have been a key target for frozen fruit, for example (Zheng 2020).

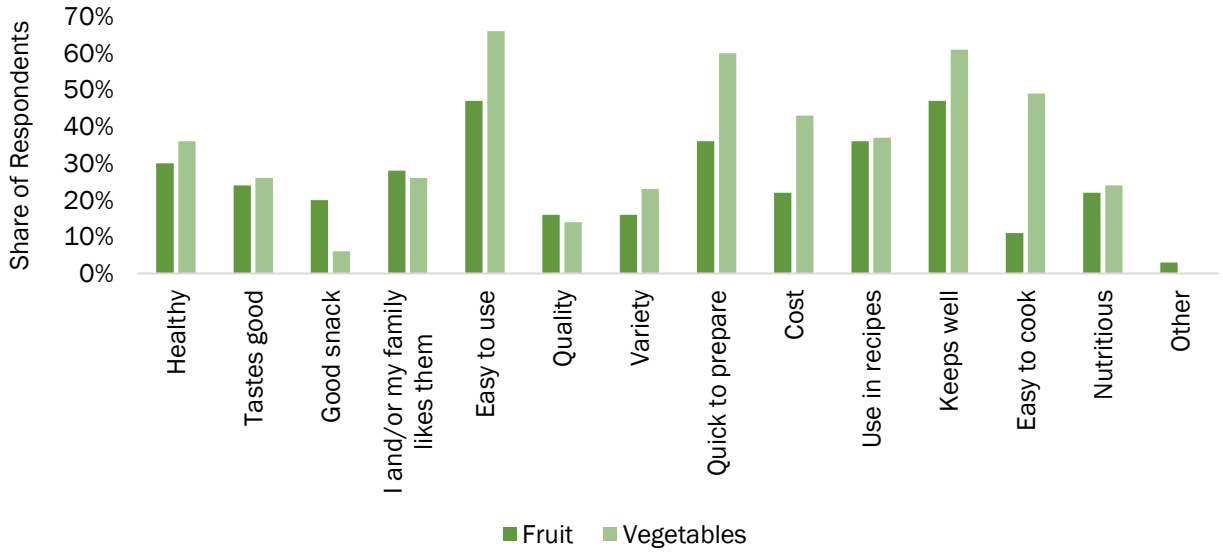
The COVID-19 pandemic led to an uptick in activity for frozen food products as consumers wanted to stock up on foods and limit trips to retail stores. To study frozen food behaviors, the American Frozen Food Institute supported a survey of 1,200 U.S. adults from April 10 to April 14, 2020. Participants ranged in age from 18 to 75 years old and had purchased frozen foods at least once since the pandemic began. The research found 70% of responding consumers reported buying more frozen food in the five weeks since early March than they otherwise normally would. Millennials, households with children, urban and suburban households, middle- to high-income households, larger households and households with relatively little freezer space in particular noted purchasing more frozen food early in the pandemic. Additionally, 68% of respondents said they had tried different frozen food items, and 7% indicated they had not purchased or had infrequently purchased frozen foods before the pandemic but bought frozen food early in the pandemic. These are important "new shoppers" (American Frozen Food Institute and 210 Analytics 2020).

In the first five weeks of the pandemic, nine in 10 respondents said they had purchased frozen vegetables compared with 78% of respondents saying they had purchased frozen fruit. Nearly one in five respondents said they purchased frozen fruit for the first time during the pandemic — a relatively high level of first-time trial. One-third of respondents said they bought more frozen vegetables than usual compared with one-quarter who said they had purchased more frozen fruit than usual (American Frozen Food Institute and 210 Analytics 2020). Behaviors acquired during the COVID-19 pandemic may continue post-pandemic. Considering that half of U.S. households use more than one freezer, many Americas have storage space to accommodate frozen food purchases (Fusaro 2020). The American Frozen Food Institute survey research found a positive relationship between freezer capacity and frozen food purchase likelihood (American Frozen Food Institute and 210 Analytics 2020).

Consumers use frozen fruit and vegetables for different purposes. From December 2013 to November 2014, the Produce for Better Health Foundation surveyed 600 adults who shop for groceries, and it found that 82% of the frozen vegetable consumers used those products as side dishes. Other significant uses were soups/stews, 55%; stir-fry, 48%; and casseroles, 41%. Frozen fruit consumers were most likely to use frozen fruit products in smoothies; 70% said they use frozen fruit for this purpose. One-third said they use frozen fruit in desserts (Produce for Better Health Foundation 2017).

The Produce for Better Health Foundation's 2016 survey measured reasons why consumers purchase frozen fruits and vegetables. Exhibit 4.2.2.1 shares the percentage of respondents who selected various reasons for purchase. The top reasons motivating frozen fruit use were "easy to use," "keeps well," "quick to prepare" and "use in recipes." Respondents were most likely to identify "easy to use," "keeps well" and "quick to prepare" as frozen vegetable purchase motivators (Produce for Better Health Foundation 2017).

*Exhibit 4.2.2.1. Frozen Fruit and Vegetables Purchase Motivations**



* n=221 for frozen fruit; n=235 for frozen vegetables
Source: Produce for Better Health Foundation (2017)

With respect to frozen produce nutrition, research from the University of California, Davis found freezing largely yielded fruit and vegetable products with nutritional content that was similar to that in refrigerated fresh products. The study measured ascorbic acid, riboflavin, alpha-tocopherol and beta-carotene levels in eight crops — corn, carrots, broccoli, spinach, peas, green beans, strawberries and blueberries — that had been stored for different times. In some cases, frozen goods had higher nutrient levels. Levels of beta-carotene notably dropped during freezing for some products (Bouzari, Holstege and Barrett 2014).

To reach end consumers, frozen food marketers rely on foodservice establishments, grocery wholesalers and retailers. Wholesalers can serve as gatekeepers to reaching retailers and foodservice buyers. Some large-scale retailers now bypass wholesalers because they pay less if buying direct from manufacturers. “Wholesale bypass” has also opened opportunities for manufacturers and small-scale retailers to transact directly (Ristoff 2020).

4.2.3. Operations

To freeze fruits or vegetables, processors tend to procure ripe raw product. Freezing is known for effectively preserving nutrient content (Kadam 2020), though blanching or steaming steps can reduce some nutrient levels (Aubrey 2018). Processors blanch product to preserve its color, prevent browning and promote a longer shelf life, but they tend to avoid blanching “delicate” crops, including berries and zucchini. Post-blanching, they use an ice water bath to “shock” the product and then drain (Berkenkamp, Mader and Kastler 2012).

Next, the system used for freezing will ideally quickly decrease the temperature (Berkenkamp, Mader and Kastler 2012). A slower freezing process may lead to more ice crystals developing and an unpleasant texture and flavor (Ristoff 2020). Oxygen may degrade certain nutrients. To protect frozen products’ nutritional integrity, processors often pack the frozen fruits or vegetables in a nitrogen environment (Kadam 2020). To maintain product quality during storage, processors typically find a storage environment with a -10 degrees Fahrenheit temperature (Berkenkamp, Mader and Kastler 2012).

Raw material purchases, including ingredients and packaging, represent significant costs for firms that process food through freezing. To procure raw commodities, frozen food manufacturers generally form contracts with suppliers. Large companies also tend to form contracts with buyers. Over time, processors have sought to automate their work. This mechanization has allowed firms to operate more efficiently (Ristoff 2020).

Firms in the frozen food production industry tend to invest $0.21 in capital for each dollar spent on wages (Ristoff 2020). For frozen fruit and juice processors, spending on capital is slightly higher — $0.25 for every dollar in labor expense. Investments have focused on automating processes for sorting, processing, flash freezing and packaging (Zheng 2020).

Firms operating in the U.S. frozen food production industry must invest in facilities, equipment, warehouses and distribution (Ristoff 2020). The freezing system a facility chooses to use will affect operating costs and performance. Cryogenic freezers quickly freeze products; however, because they’re fueled by liquid nitrogen or carbon dioxide, their operating costs tend to be relatively high (Berkenkamp, Mader and Kastler 2012). Setup costs for a cryogenic system tend to be relatively low, and such systems may also require

less cleaning and maintenance relative to mechanical systems (Ristoff 2020). Blast freezers provide an economical option. Using forced air, they freeze product, but the freezing process can take time. Recognized as the industry standard, individual quick freeze (IQF) systems freeze product as individual pieces (Berkenkamp, Mader and Kastler 2012).

To assess IQF's advantages and disadvantages, consider the Western Massachusetts Food Processing Center's experience. In 2011, the nonprofit center began freezing five-pound bags of produce into blocks using walk-in freezers. This approach meant thawing the bags took time, buyers would need to thaw all five pounds, and the slow freezing process produced ice crystals. Conversely, IQF exposes produce to temperatures near -180 degrees C. The extreme cold leads to fast freezing and individually frozen pieces. The center bought a used IQF system that could process 500 pounds per hour for $20,000. It invested roughly $110,000 in total after accounting for system repairs, installation, piping and other costs and had the system ready to use in fall 2014. To use the system, costs averaged about $0.10 per pound, according to a 2017 report. Liquid nitrogen represented a notable expense. Because of costs, the center required using the system in at least four-hour increments. After implementing the IQF technology, the center learned several lessons. For example, it tended to succeed with products if farm suppliers would do basic processing (e.g., snipping, chopping). For the center to do this work, it would possibly need crop-specific prep equipment, which would be expensive if processing multiple crops. Other lessons included the importance of minimizing unit costs by operating equipment at full capacity and optimizing upstream and downstream activities to prevent bottlenecks (Brooks 2017).

A handful of large-scale firms operate in the frozen food production industry; however, other firms operate on a small or medium scale. Small-scale operations may compete by innovating products with niche characteristics, including certified organic. Some large firms have purchased smaller firms in recent years as a strategy to add to their product diversity and boost market share. To compete in this industry, firms need to set reasonable prices, offer good quality and provide something different (Ristoff 2020). Within the frozen fruit and juice production industry more specifically, IBISWorld describes local firms entering the industry to serve local areas as a key trend. Firms in this industry tend to compete based on price, taste, quality, freshness, packaging and marketing (Zheng 2020).

4.2.4. Case Study

Developed by The Institute for Agriculture and Trade Policy, a report titled "Frozen Local: Strategies for Freezing Locally Grown Produce" highlighted multiple considerations for using frozen produce in schools — particularly those in Minnesota. Growers in Minnesota and Wisconsin produce large volumes of sweet corn, snap beans, green peas, carrots and potatoes intended for processing, and they typically grow these crops under contract for Upper Midwest processors. For growers, the contracted price may be lower than the fresh-market price, but they often can sell more to processors than they could in the fresh market. To ensure consistent crop quality, processors tend to stipulate production standards. When choosing varieties, taste and nutrition do not often rank as the top considerations. Instead, growers tend to plant those that perform well agronomically and yield the most usable product. Although contracts help processors plan, they may at times have too much harvested volume to move through their facilities. In such cases, product never leaves the field, or it is converted into silage (Berkenkamp, Mader and Kastler 2012).

For zucchini, broccoli and winter squash, the study assessed the cost-effectiveness of schools freezing these products and using them in their menus. The criteria guiding crop selection included product palatability, usefulness in school menus, local availability, preparation requirements and compatibility with school lunch nutrition standards — somewhat different criteria from the agronomic and yield factors mentioned earlier. Cost-effectiveness varied according to the crops being processed, the process used, price paid for raw material and labor rates commercially (Berkenkamp, Mader and Kastler 2012).

The study also evaluated various processing configurations, including mobile units and multiuse facilities. Mobile processing units allow users to clean, cut, blanch, freeze, package and otherwise process produce from a vehicle or trailer, and they can move to a crop's production location. The study evaluated the experience of Vermont and North Dakota state agriculture departments in offering mobile processing services. The states learned several similar lessons from these experiences. For example, farms did not as openly accept the mobile units as hoped, and they would need storage space for frozen produce and an understanding of how to reach markets with frozen product. Mobile units also typically offer limited processing capacity, and they require someone to manage scheduling and coordination as many farmers have similar harvest times. Other challenges include needs for water and electricity hookups at farm locations and food handling training among all individuals who use the units (Berkenkamp, Mader and Kastler 2012).

Multiuse facilities refer to entities such as commercial kitchens, business incubators, nonprofits and small businesses that offer freezing services to clients. The Institute for Agriculture and Trade Policy profiled multiple facilities in its report, and it identified key points learned by these processors. First, the capital required to prepare and freeze food can be expensive. Small-scale processors often choose low-tech models that don't cost as much but may take more time to freeze and yield a lower quality product. When talking with groups that freeze produce, several indicated that finding an appropriately sized freezing system has presented challenges — many are too big or too small. An equipment manufacturer cited a similar sentiment and noted investments in developing mid-sized systems that could handle 15,000 pounds per day (Berkenkamp, Mader and Kastler 2012).

Other lessons learned from multiuse facilities include managing fixed costs by using capital investments year-round. If a business' operations concentrate during a particular time, then sharing or leasing facilities and equipment can spread costs over more units. Purchasing used equipment or equipment that can accommodate multiple crops are other possibilities to control costs. Processing seconds or offering higher value, specialty items may add value to raw materials. Facilities that map their processes to minimize bottlenecks, ensure they have adequate receiving and storage space and deliver on customer needs may support processing feasibility (Berkenkamp, Mader and Kastler 2012).

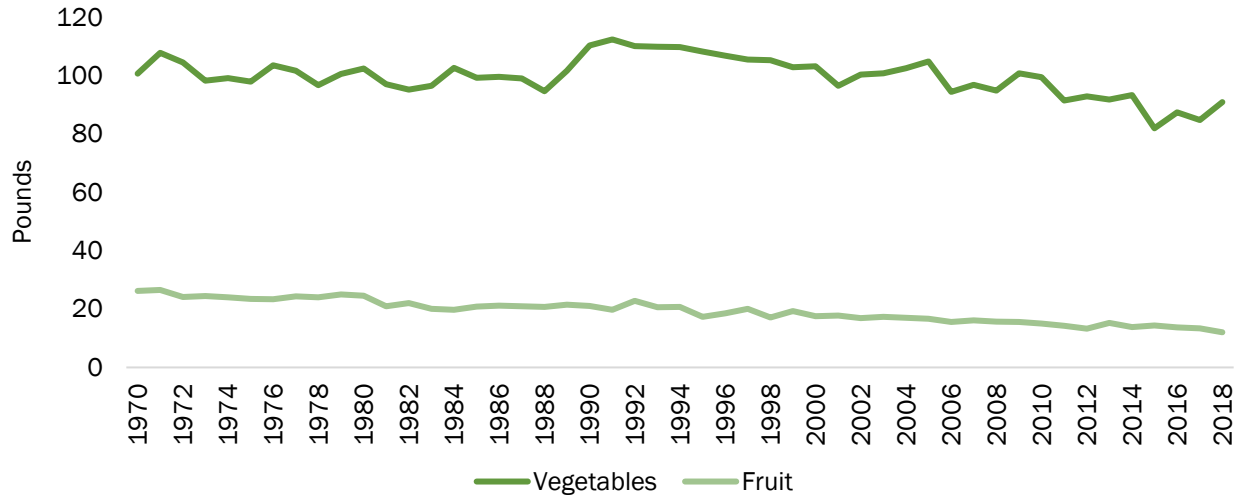
4.3. Canned

In the early 1800s, the U.S. saw its first canning facility open, and canneries use a similar process today to preserve fruits, vegetables and other foods (Canned Food Alliance B).

4.3.1. Category Trends

Canning fruit and vegetable availability per capita declined in the past five decades, as illustrated in Exhibit 4.3.1.1. In 2018, per capita availability of canning vegetables was more than seven times higher than per capita availability of canning fruit. Canning vegetable availability totaled nearly 91 pounds per capita in 2018 compared with 12 pounds per capita for canning fruit availability. Note, these measures are communicated on a fresh-weight basis (Kantor and Blazejczyk 2020).

*Exhibit 4.3.1.1. Fruit and Vegetable Per Capita Availability for Canning, 1970 to 2018**



* Fresh weight equivalent
Source: USDA Economic Research Service (Kantor and Blazejczyk 2020)

Within the canned fruit and vegetable industry described by IBISWorld, products generating the most sales in 2020 were canned fruits and vegetables. Other top sales categories during 2020, according to IBISWorld, were fruit and vegetable juices, ketchup and tomato-based sauce and dried and dehydrated product (Kennedy 2020).

Fruits and vegetables often preserved through canning include beans, corn, tomatoes, peaches, pears and apricots (Midwest Research Institute 1995). With respect to juices, most have sugar added, which concerns some buyers (Kennedy 2020). Traditionally, juices have included orange, pineapple, tomato and cranberry options (Midwest Research Institute 1995). Consumers have increasingly adopted cold-pressed juices and bottled smoothies. With respect to ketchup and tomato sauces, processors have prioritized flavor innovation and premium options to coincide with demand (Kennedy 2020). To supply canned fruit, the U.S. has increasingly relied on imports (Cook et al. 2007). Contributing to imports has been strong demand for fruits and vegetables not grown in the U.S. (Kennedy 2020).

Innovation in canned fruit has included delivering multiple product formats, including types of fruit, types of cuts, container sizes and ingredients. The industry has also innovated its packaging, such as pull-top cans, plastic containers and single-serving units (Cook et al. 2007). The stand-up, shelf-stable pouches Libby's introduced in 2016 provide a specific

example. Stocked with canned goods in stores, these pouches can be microwaved for just 60 seconds to provide a convenient vegetable dish (Hartman 2016a).

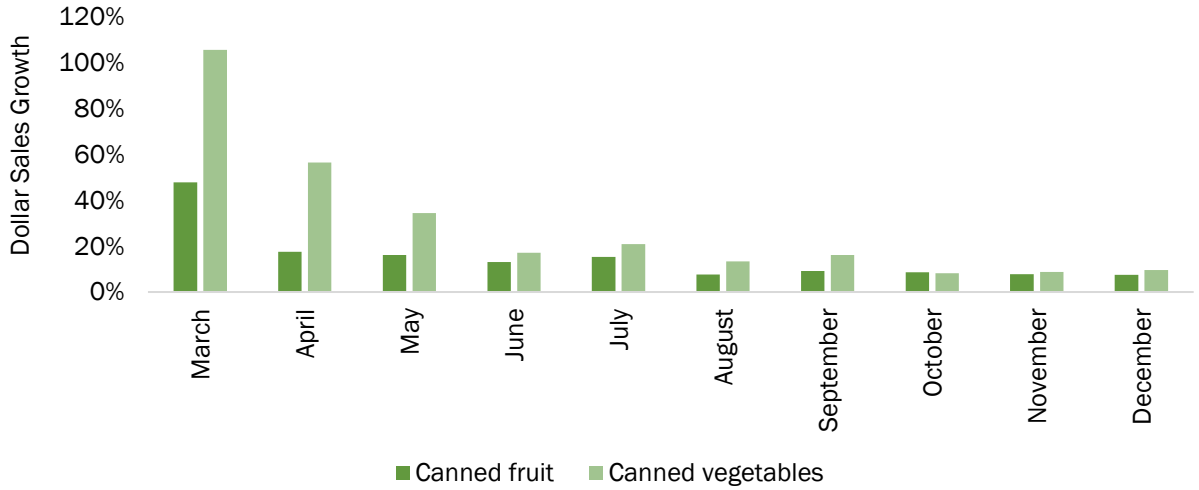
4.3.2. Target Audience

Opportunities to sell canned fruits and vegetables weakened in recent years as consumers changed their preferences. Overall, consumers tend to associate fresh fruits and vegetables with better healthfulness than canned goods (Kennedy 2020). In some cases, however, canning may enhance nutritional content. Canned tomatoes provide an example. Consuming canned tomatoes relative to fresh product may provide more B vitamins, vitamin E and carotenoids (Kadam 2020).

Another consumer concern that has likely affected canned fruit and vegetable consumption is bisphenol A (BPA) exposure. Used in food can linings and jar lids, BPA qualifies as a hormone disruptor (Hartman 2016b). The compound may affect reproductive, neurological and immune functions, and it may leach from packaging into the packaged contents (Pierce 2018). Some research suggests canned soups and pastas have contained more BPA than canned vegetables or fruits (Hartman 2016b). Because of consumer concerns about BPA exposure after consuming canned goods, food companies have largely displaced BPA use in packaging. An estimate from the Can Manufacturers Institute published in 2018 suggested that at least 90% of food can packages used linings without BPA (Pierce 2018).

Recently, the COVID-19 pandemic shifted consumer behavior related to food products packaged in cans. By buying canned fruits and vegetables, consumers could make economical choices and purchase enough to keep their pantries full and avoid frequent grocery store trips (Kennedy 2020). By month, Exhibit 4.3.2.1 communicates the change in canned fruit and vegetable dollar sales between March to December 2019 and March to December 2020, according to IRI data. Early in the pandemic, monthly dollar sales were notably higher than corresponding monthly dollar sales in 2019. Canned vegetables recorded particularly strong dollar sales growth. For most of the months observed, canned vegetables outperformed canned fruit in terms of dollar sales growth; October was an exception. During summer and fall 2020, monthly canned fruit and vegetable dollar sales continued to post growth relative to their corresponding months in 2019. However, growth was subtler than early in the pandemic (Roerink).

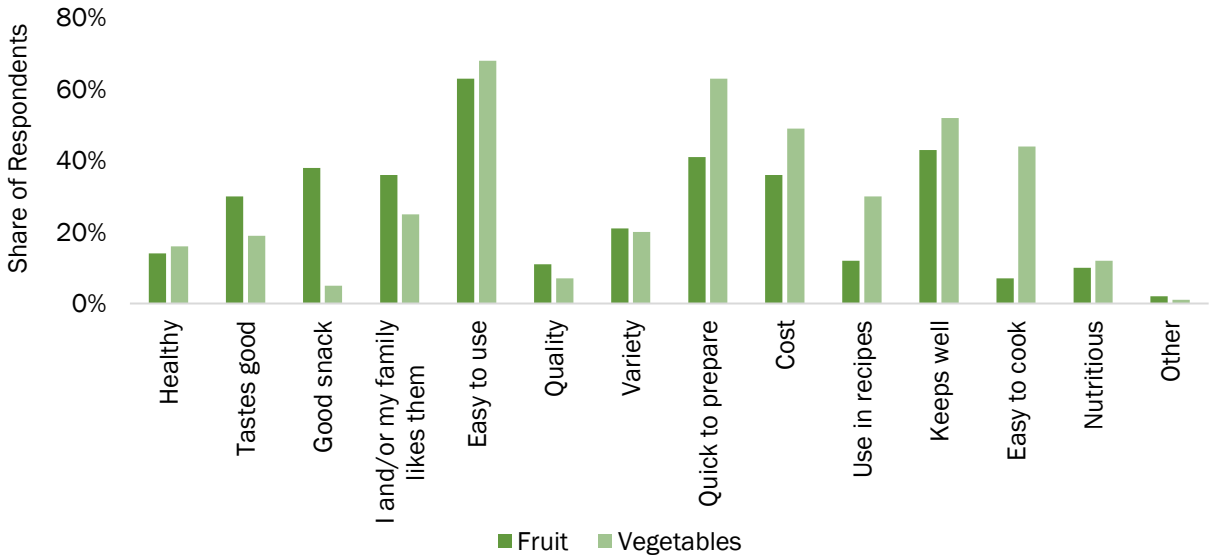
*Exhibit 4.3.2.1. Change in Monthly Canned Fruit and Vegetable Dollar Sales, 2019 to 2020**



* Monthly periods analyzed were March 8 to 29, April 5 to 26, May 3 to 31, June 7 to 14, July 5 to 26, Aug. 2 to 30, Sept. 6 to 27, Oct. 4 to Nov. 1, Nov. 8 to 29 and Dec. 6 to 27
Source: 210 Analytics and IRI (Roerink)

Consumers purchase canned fruit and vegetables for several reasons. Exhibit 4.3.2.2 presents data from the Produce for Better Health Foundation's 2016 survey, which asked participating consumers why they purchased certain types of fruits and vegetables. Top reasons contributing to canned fruit purchases among the responding consumers were "easy to use," "keeps well," "quick to prepare" and "cost." The reasons cited for canned vegetable purchases are similar — with the addition of "easy to cook" (Produce for Better Health Foundation 2017).

*Exhibit 4.3.2.2. Canned Fruit and Vegetables Purchase Motivations**



* n=233 for canned fruit; n=250 for canned vegetables
Source: Produce for Better Health Foundation (2017)

In terms of how consumers use canned fruits and vegetables, the 2014 survey data reported by the Produce for Better Health Foundation provide insights. Canned fruit consumers most commonly noted using canned fruit as is; roughly two-thirds said such. Nearly half of participating consumers said they used canned fruit for snacks and desserts. Of the canned vegetable consumers, nearly 90% said they used such products as side dishes. Half included canned vegetables in soups and stews, and 45% indicated they add canned vegetables to casseroles (Produce for Better Health Foundation 2017).

4.3.3. Operations

Producing canned fruits and vegetables typically begins with procuring fresh, ripe product that offers good flavor and nutrition (Kadam 2020). Following procurement, the canning process requires washing raw commodities. Then, processors prepare raw materials by peeling, trimming, coring, slicing, chopping and blanching (Canned Food Alliance A). The specific processes depend on the commodity. For example, the choice of peeling process — mechanical, steam or lye — varies by crop (Midwest Research Institute 1995). Acidic products may require a sterilization treatment (Canned Food Alliance B). Also, fruits, unlike many vegetables, often don't undergo blanching (Midwest Research Institute 1995).

Next, processors pack the prepared commodities into cans, add juice or water and season the mixture (Canned Food Alliance A). Cans should then have an airtight seal (Canned Food Alliance B). After sealing the can with a lid, processors cook the material in the can and follow the cooking process with a fast-cooling process (Canned Food Alliance A). The temperature used for heating must kill microorganisms. Typically, heating to 240 degrees F to 250 degrees F via steam pressure will properly cook canned product. The cooking time varies by a crop's acidity, density and heat transfer abilities (Canned Food Alliance B). If canning vegetables, then the process may require more cooking to remove heat-resistant organisms and produce a palatable end product. Cooling cans quickly ensures that the canned product doesn't overcook (Midwest Research Institute 1995). Processors should have a hazard analysis and critical control point plan in place to ensure the manufacturing process yields a safe product (Canned Food Alliance B). The U.S. FDA provides guidance about hazard analysis critical control point systems (U.S. Food and Drug Administration B). It also provides guidance about current good manufacturing practice, and special guidance pertains to low-acid canned foods (U.S. Food and Drug Administration A).

IBISWorld predicts weaking sales potential for canned goods in the next few years yet a subtle increase in the number of firms. New entrants tend to capitalize on low entry barriers; local and regional markets tend to feature particularly low barriers. Barriers that do exist include warehouse space, expensive equipment and distribution channel relationships. Additionally, firms entering this industry will need to manage input costs (Kennedy 2020).

Firms that can fruit tend to locate near growing areas — for example, peaches in California; pears in California, Washington and Oregon; and fruit mixes in California (Cook et al. 2007). Larger firms have recorded weak sales, but they tend to capture economies of scale, which are important given canned goods' relatively low unit value. By offering organic or specialty options and acquiring small-scale firms, large-scale firms may have an opportunity to grow their market share (Kennedy 2020). Relative to many canned fruit industries abroad, the

U.S. industry is more concentrated (Cook et al. 2007). Still, it tends to be known as an industry with relatively low concentration (Kennedy 2020).

For firms canning fruits and vegetables, raw materials represent a significant cost; such material purchases include fruits, vegetables, flavorings and packaging. Within the competitive landscape, however, an increase in raw material costs tends to affect fresh produce more and make canned product an economical choice. Labor also ranks as a top cost for canned fruit and vegetable processors, despite processors incorporating some automation into their operations. The average processor in 2020, according to IBISWorld projections, would spend $0.29 in capital for each dollar invested in labor. Small-scale firms that lack capital tend to use more labor (Kennedy 2020). Large-scale firms that can fruit use modern technology (Cook et al. 2007).

The U.S. International Trade Commission in 2007 stressed how managing production costs greatly affects profitability potential and competitiveness for fruit canneries. Exhibit 4.3.3.1 presents the cost structure for an average U.S. canning operation that produced canned peaches in 2007. In this analysis, raw fruit represented the most significant expense followed by packaging — cans. Costs included in the "other" category include utilities, capital, storage, inventory and shipping (Cook et al. 2007). Peaches serve as an example here of canning facility costs.

Exhibit 4.3.3.1. Cost Structure for Canning Peaches in the U.S.

	$/kg	%
Raw fruit	0.29	31
Cans	0.23	25
Labor	0.14	15
Other	0.26	28
Total	0.93	100

Source: U.S. International Trade Commission (Cook et al. 2007)

To source raw materials, canned goods manufacturers and suppliers tend to form contracts, which minimize inputs risk (Kennedy 2020). The contracts that fruit canneries form with growers often dictate multiyear commitments, which have price updates made each year. For growers, such contracts are particularly beneficial if the commodity they grow is suitable only for processing. Cling peaches, for example, tend to lack market opportunities other than canning. Contracts often articulate quality expectations, and they may outline technical and financial assistance that the canner will provide to growers (Cook et al. 2007).

To distribute final goods, processors rely heavily on grocery wholesalers and retailers, including mass merchandisers that tend to purchase from manufacturers. Wholesalers connect canneries to supermarkets, convenience stores and other customers. Large-scale firms with diversified products may more easily arrange prime stocking locations and adequate shelf space. Small-scale firms tend to compete by offering differentiated, high-quality products. Canneries may enter into contracts with buyers (Kennedy 2020). Institutional buyers represent an important market for canned fruit (Cook et al. 2007). Additionally, large firms may package private-label products on contract (Kennedy 2020).

Because U.S. fruit production is seasonal, many canneries operate during a relatively short period — perhaps as few as three months — and idle plants for the rest of the year. Idle time allows facilities to conduct maintenance and prepare for the following year, but it also means facility capacity is not used consistently throughout the year (Cook et al. 2007).

4.3.4. Case Study

Nonprofit organization Virginia Food Works describes that it "guides food producers in taking their product from recipe to retail." It offers co-packing and product development services (Virginia Food Works) and formed in 2012 (VA Foodie 2021).

Virginia Food Works operates from Virginia's Prince Edward County Cannery. The cannery first opened in 1975 to serve home canners. Grant funding from the Virginia Tobacco Indemnification and Community Revitalization Commission allowed the cannery to convert into a commercial kitchen in 2010. Equipment available at the facility includes sinks, 20- to 60-gallon kettles, can seamers, retorts, food processors, apple corer/choppers, pulper/juicers, produce washer, onion chopper and potato peeler (Prince Edward County). For three days per week throughout the year, Virginia Food Works offers its services at the cannery, and the products canned on those day are directed to resale. It primarily serves clients from central and northern Virginia. However, it also attracts out-of-state clients that need equipment with greater capacity than their own commercial kitchens provide. Its client base has been roughly 40% farmers and 60% food businesses. Nearly all products made at the facility are acid or acidified foods (VA Foodie 2021). In September 2019, Virginia Farm Bureau reported that Virginia Food Works worked with 30 commercial canners in the previous year, and output for them totaled 28,000 units (Virginia Farm Bureau 2019).

The hands-on go-to-market assistance and education provided by Virginia Food Works helps clients to navigate developing their products (VA Foodie 2021). On its website, the organization lists that it offers services such as recipe development, pH testing, label design and outreach to a process authority for product approval. Additionally, the organization's personnel can provide consultation related to topics such as sanitation guidelines, food processing regulations and equipment use (Virginia Food Works). For its clients, Virginia Food Works will share recipes for products such as applesauce, apple butter, jam, salsa, pizza sauce and pickles. Alternatively, clients may develop their own recipes, which Virginia Food Works tests before producing large volumes. It sets no batch minimums for its clients, and it packages products in glass jars and metal lids. Clients may do basic preprocessing (e.g., washing, prep, freezing) as initial steps. They can then store frozen ingredients on their own operations or at the cannery, and when the timing works well, they can schedule a time with the cannery to further process the ingredients into final products (VA Foodie 2021).

The rate co-packers pay depends on the number of Virginia Food Works employees assisting. Hourly rates range from $65 if one employee is processing to $125 if four employees are involved. To reduce paid labor needs, the client can bring helpers of its own, but at least one Virginia Food Works employee must be engaged. The nonprofit reduces the hourly rate by $5 if a client incorporates Virginia-raised ingredients (Virginia Food Works). Clients can also rent freezer space at the Virginia Food Works facility. In addition to these revenue streams, Virginia Food Works receives support from Prince Edward County, which provides facility maintenance, equipment repairs and operating funds (VA Foodie 2021).

Home canners represent a second audience for the cannery. From June to December, home canners can use the facility three days a week to can produce they grow themselves or seconds they purchase elsewhere. Users prep their produce before canning, but they may use prep equipment available at the cannery. They package the processed goods in metal cans, and the cannery's staff provides assistance during the process (VA Foodie 2021).

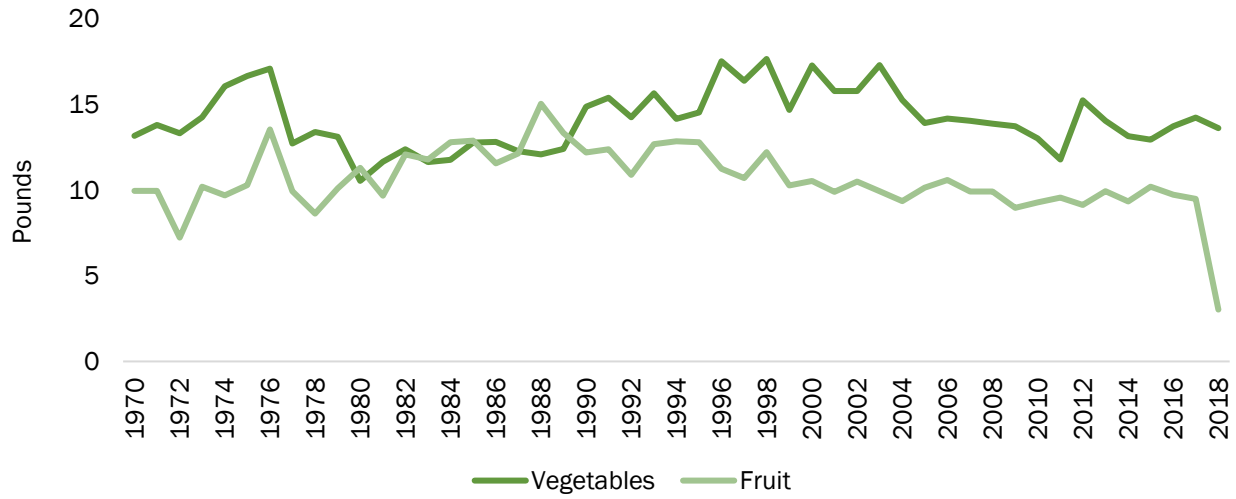
4.4. Dried

Drying and dehydration removes moisture as a preservation practice. The specific process dictates the end product's moisture content and characteristics.

4.4.1. Category Trends

Per capita availability of fruits and vegetables for drying has had some volatility in the previous five decades. Exhibit 4.4.1.1 shows how dried vegetable per capita availability has most often exceeded dried fruit per capita availability, including in recent years. 2018 per capita availability for dried vegetables totaled 13.6 pounds relative to 3 pounds for dried fruit (Kantor and Blazejczyk 2020).

*Exhibit 4.4.1.1. Fruit and Vegetable Per Capita Availability for Drying, 1970 to 2018**



* Fresh weight equivalent
Source: USDA Economic Research Service (Kantor and Blazejczyk 2020)

Processors may choose to dry or dehydrate fruits and vegetables and position the end products as healthy snacks or add them to salads and other dishes (Hinder 2020). Marketing messages for dried and dehydrated goods have focused on using these products in various dayparts, including lunch and snacks (Riell 2019).

Firms operating in this industry recorded the most sales in 2020 from raisins and dried prunes (Hiner 2020). However, consumers have shown interest in other snacks made from dried or dehydrated fruit, including strawberries and blueberries (Kennedy 2020). Other types of fruits processed through drying include apples, peaches, cantaloupe and plums (Kadam 2020). Chips made by baking vegetables have gained popularity. Vegetables such as potatoes, peppers, tomatoes (Hiner 2020), snap peas and green beans have been dried

or dehydrated (Kennedy 2020). Some dried vegetables serve as standalone products, but others have application as ingredients or spices added to other foods. For example, dried peppers may be added as a spice to certain dishes (Hiner 2020). Freeze-drying technologies have processed fruits and vegetables such as apples, strawberries, blackberries, pumpkin, tomatoes and asparagus. These freeze-dried ingredients are added to products including cereal, soup and confectionary goods (Bhatta, Stevanovic Janezic and Ratti 2020).

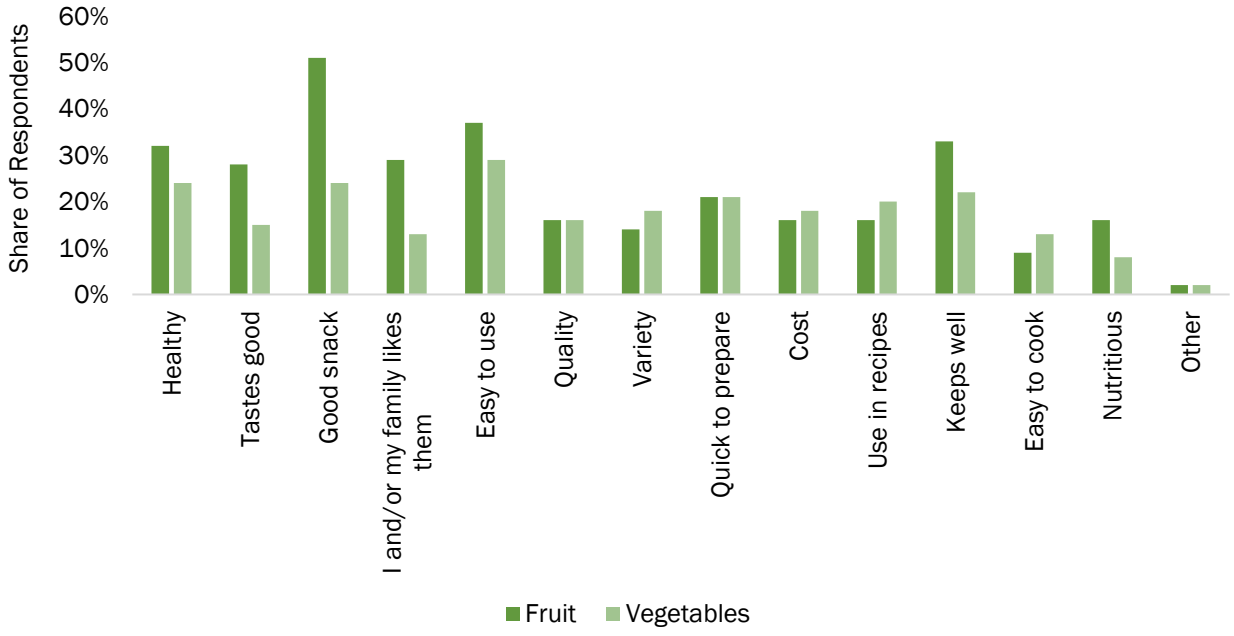
4.4.2. Target Audience

Consumers most likely to consider dried fruits and vegetables as snacks show interest in nutrition and product quality. Parents represent a key segment as they look to source snacks for their kids (Hiner 2020). Groups interested in dried fruits include young professionals and families looking for convenient snacks (Riell 2019).

Snacks made from dried fruits and vegetables may carry price premiums, so industry performance tends to trend with consumer purchasing power (Hiner 2020). When dried fruits lack sugar, they command higher prices (Stiffler-Meyer 2007). However, to offer more indulgent dried options, some firms cover dried fruit with candy or yogurt (Hiner 2020).

Dried and dehydrated options offer benefits such as convenience and shelf life (Hiner 2020). A 2016 survey of U.S. adults who buy groceries for their households assessed reasons why consumers buy dried fruits and vegetables. Exhibit 4.4.2.1 presents the results. Dried fruit consumers most commonly selected “good snack” as a reason for purchasing; half identified dried fruit as a good snack. At least one-third of respondents also described dried fruit as “easy to use,” “keeps well” and “healthy.” The most popular reason driving dried vegetable purchases was “easy to use” (Produce for Better Health Foundation 2017).

*Exhibit 4.4.2.1. Dried Fruit and Vegetables Purchase Motivations**



* n=228 for dried fruit; n=201 for dried vegetables
Source: Produce for Better Health Foundation (2017)

Buyers may use dried fruits and vegetables as standalone snacks or ingredients in granola bars, baked goods, cereal bars, salads (Hiner 2020), trail mixes, flaked cereals (Stiffler-Meyer 2007), fruit leather and other final goods (Fusaro 2012). Bites represent a new snack product category that may add dried goods and offer something different from more typical bar products. Incorporating dried fruit in yogurt and smoothie products are other possible uses (Riell 2019). The 2014 survey data reported by the Produce for Better Health Foundation reinforces dried fruit's popularity as a snack. Of the responding dried fruit consumers, 79% said they use dried fruit as a snack. Just more than 40% reported using dried fruit on cereal, in salads and for baking (Produce for Better Health Foundation 2017).

To successfully market dried fruits and vegetables, processors must capture the attention of grocery wholesalers and retailers because they most frequently buy dried fruits and vegetables to then distribute to customers, including final consumers and manufacturers that would add the dried product as ingredients in other foods. Manufacturers must work with retail outlets to secure adequate shelf space (Hiner 2020). Foodservice buyers also tend to show interest in some dried goods, including apricots and tomatoes (Riell 2019).

4.4.3. Operations

Through drying or dehydrating, processors remove water from fruits and vegetables to preserve the end product. Nutritional content changes to a minimal extent during drying, but the changes vary by processing method (Kadam 2020). To dry fruits and vegetables, firms often rely on sunlight or heat from large ovens. Raisins often dry on the vine (Hiner 2020).

If mechanizing the process, then freeze-drying is an option to produce high-quality finished products. Freeze-drying has three phases: freezing, primary drying and secondary drying. Temperature and pressure facilitate the process (Bhatta, Stevanovic Janezic and Ratti 2020). Water content will often drop from 90% to between 1% and 3% (Fusaro 2012). Ultimately, the end product has a crunchy texture (Watson 2017), and the process preserves the product's color, flavor and shape (Stiffler-Meyer 2007). Freeze-drying is particularly fitting for processing foods with thermally and oxidatively sensitive compounds (Bhatta, Stevanovic Janezic and Ratti 2020). Through freeze-drying, products tend to retain nutrients (Gore-Langton 2016). For example, one study illustrated that five freeze-dried and fresh tropical fruits — starfruit, mango, papaya, muskmelon and watermelon — had similar ascorbic acid content. Total phenolic compounds and beta-carotene levels may differ in fresh and freeze-dried fruit, however, according to the study (Mohamad Shofian et al. 2011). Fruits and vegetables processed through freeze-drying don't need added preservatives or sugar (Gore-Langton 2016). The process tends to require quite a lot of cost and energy (Stiffler-Meyer 2007). Energy requirements may be four to 10 times more than those typical of hot-air drying (Bhatta, Stevanovic Janezic and Ratti 2020). Additionally, the end product requires a moisture-free storage environment (Stiffler-Meyer 2007).

A drum dryer will expose puree to heated cylinders that rotate. The dried product resembles fine flakes or powder to add to snacks, soups, chips and some baked goods and cereals. Operating the drum dryer involves less cost than freeze-drying (Fusaro 2012), but it may also negatively affect nutritional content (Stiffler-Meyer 2007). Fruits and vegetables

processed using a drum dryer contain little moisture — often less than 5% (Fusaro 2012) — and they may need a carrier in final goods (Stiffler-Meyer 2007).

Infusion represents another drying option. To infuse fruit, firms often soak it in sugar or another medium and add heat. This process pulls out moisture to make the end product shelf-stable (Stiffler-Meyer 2007), but it also can reduce nutrients and increase sugar content — if sugar is the medium used. In some cases, processors may choose a cold infusion process. An infused product may contain roughly 30% moisture (Fusaro 2012).

The preferred process may vary by raw material and its cellular structure. Air-drying, for example, works well for apples, but freeze-drying is a better option when processing peaches (Stiffler-Meyer 2007). Also, the specific process used can create products with different characteristics. For example, if processing apples, then drying would make a crunchy snack, but dehydrating would create a gummy product (Hiner 2020). Drying fruit in the sun creates a chewy product. Adding moisture to a freeze-dried product can reconstitute it (Stiffler-Meyer 2007). To use freeze-dried fruits, possible applications include cereals, snacks and trail mixes, and freeze-dried vegetables tend to work well in dried soups and seasoning mixes. Uses for semidried infused fruits and vegetables include snack mixes, trail mixes, baked goods and cereals (Fusaro 2012).

The number of firms operating in this industry has increased in recent years, and market share concentration is low. Many businesses serve local or regional markets. Going forward, IBISWorld projects that new entrants will focus on making small batches of niche, premium products. Typically, firms entering this industry are startups operating on a small scale. To meet consumer needs, firms may consider offering innovative flavors or developing products that meet organic, fair-trade or natural standards (Hiner 2020). Minimizing use of preservatives has also benefited the dried fruit category as retailers have been more open to stocking such items in their produce areas (Riell 2019). Other innovation opportunities include fortifying dried goods with probiotics, adding herbs and spices and developing new types of environmentally conscious packaging that promotes shelf life (Hiner 2020). Most current packaging offers dried or dehydrated goods in convenient pouches (Riell 2019).

Relative to other forms of processing, drying and dehydrating may yield better profitability. IBISWorld reporting shows higher profit margins for dried fruit and vegetable snacks compared with canned fruit and vegetable processing, frozen food production and frozen fruit and juice production (Hiner 2020, Kennedy 2020, Ristoff 2020 and Zheng 2020). Products capturing premium prices may support the industry's profitability. Costs incurred to dry and pack fruits and vegetables also tend to be relatively low (Hiner 2020). For example, processors that dry or dehydrate product tend to use less energy than those that freeze or can fruit and vegetables. Dried goods also tend to store more efficiently (Kadam 2020). However, to operate on a large scale, firms typically need expensive capital that adds efficiencies. Equipment used for drying and dehydrating can be costly. Other costs to consider include the facility, transportation system and storage space (Hiner 2020).

As firms in this industry grow, they benefit from economies of scale; however, most firms operating in this industry are relatively small. Labor represents one expense that large processors can often better control. Small-scale firms tend to rely on hand labor, whereas

large firms are more likely to have added mechanization to their systems. Raw commodity costs are significant for firms that dry and dehydrate fruits and vegetables, and they affect profitability. IBISWorld projects an increase in commodity prices. By participating in harvesting fruits and vegetables on their own — many firms in this industry do — companies that dry or dehydrate fruits and vegetables may control raw material costs (Hiner 2020).

5. Processor Interview Findings

To learn more about the processing business, the project team conducted a series of interviews with U.S. fruit and vegetable processors during late 2020 and early 2021. In total, 12 respondents agreed to participate, and 10 completed their phone interviews. The participants had fruit and vegetable processing experience. Some grew and processed fruits and vegetables, and others exclusively focused their businesses on processing. Some operated within Missouri, but others processed fruits or vegetables in other states. Additionally, the project team interviewed one food scientist.

The following points summarize key findings provided during these interviews.

5.1. Production and Ingredient Supply

- Climate may narrow the options for specialty crop production in Missouri's hot, humid weather. For example, green beans may grow better than peas.
- The biological lag — the time between deciding to produce an item and harvesting it — can challenge matching supply and demand. When possible, look to shorten the lag. For example, choose high-density fruit production practices to produce a crop in less time than more traditional production practices would allow.
- To extend availability of locally produced ingredients, stagger production during the growing season when possible (e.g., plant annual crops to harvest in waves), or consider how to store or process (e.g., freeze) some ingredients that can then be available to use in a further value-added form later. Protected agriculture (e.g., greenhouses, high tunnels) could allow for producing fruit and vegetable crops more consistently throughout the year. The sales prices for these goods would need to cover the added costs of protected environment production.
- A few processors noted difficulty in accessing local ingredients. Local producers seem focused on growing for farmers markets or grocery store sales. To preserve their margins, processors can't afford to pay retail prices.
- Purchasing surplus ingredients from farmers may give an opportunity to buy more locally grown product — for example, buying from farmers' market vendors to liquidate their inventory at the end of market days.
- Local product can be more inconsistent than product sourced from large-scale operations throughout the country. Investing time and energy into educating suppliers about product quality standards can improve consistency.
- If growing under contract for a processor, then the producer often supplies the land, and the processor often retains control of all other decisions and work, including planting, seed choice, input applications and harvesting. In this case, processors may schedule work in sets, and a set of acreage is scheduled for harvest in advance to

manage throughput at the processing facility. Contracts may also outline good agricultural practices to follow and the price.

- For farms that do their own processing, rightsizing the operation can free up time and make the operation function more efficiently. For example, limiting production to the most highly productive soils would allow the farm to focus production on higher-yielding areas and provide time and labor hours needed for processing activities.
- Harvesting equipment needed for some crops might be in short supply or cost-prohibitive for producers to buy. In such cases, processors that own the necessary machinery and harvest the crop themselves would remove a production barrier.

5.2. Operations

- Labor availability can present a problem, particularly given the processing business' short-term, seasonal nature.
- Access to supplies or crop varieties can vary by location. If you're not located near suppliers — for example, firms that manufacture packaging — then you incur shipping costs, which add to total production costs. The COVID-19 pandemic has complicated access to some supplies, such as glass jars. With respect to varieties, some are exclusively available to growers in certain states where groups funded a particular variety's development. This provision limits the varieties available — potentially highly demanded varieties — to growers more broadly.
- Used equipment availability can vary by processing scale. If processing fruit, then medium-scale equipment is scarce in the used market. Equipment used on a very small scale tends to be more readily available. Some large-scale equipment also tends to be available in the used market.
- Value chain actors should have Food Safety Modernization Act certification to ensure they have broad food safety knowledge needed to prevent food safety problems. Additionally, they should have a hazard analysis critical control point plan to map the critical control points in their systems and anticipate how to manage food safety problems should they arise. Processors that control more of the value chain may more easily have access to documentation needed to satisfy regulatory provisions.
- A food process authority can advise processors about the appropriate food safety procedures and processes to adopt. The Association of Food and Drug Officials lists food process authority contacts at afdo.org/foodprocessing. One respondent mentioned a need for an in-state program that could offer services such as pH testing and nutritional panel information at a reasonable price.
- To monitor ingredients and products through the value chain, processors should consider best practices for traceability. Those include recording lot numbers for inputs and creating batch sheets to track product activities.
- Local resources, such as community kitchens, may provide needed processing infrastructure and allow processors to cost-share with other tenants.
- Working with a co-packer may provide access to infrastructure and expertise; however, the costs may be extensive and pressure margins.

5.3. Marketing

- In terms of what buyers want, one respondent shared buyers want the most "frills and chills" you can offer at the lowest price point.

- To wholesale fresh product, you need washing and packing lines, so those minimal processes would be a minimum investment.
- When processing crops for private label, buyers place orders months in advance, and those orders dictate all other decision-making.
- Accessing distributors can present a challenge. Distributors seem to work with one supplier for each product, and because most have established rosters of products, it can be hard to break into working with a new distributor. Developing a new product not offered by other firms is one possibility. Working collectively is another.
- Securing distribution in small-town stores as a strategy may help to move product as those small shops get to know their suppliers.
- Large companies selling private-label product often want to introduce new products periodically, and they typically have long lead times for developing those products and may request research and development assistance.
- If you have a novel product, then try selling it on the farm first. When visiting a farm, consumers tend to have a greater interest in unique varieties or new options.
- Strategically price your products to open markets. If you keep your prices consistent — even as average market prices increase in a given year — then you may attract interest from new buyers and grow your business with them.
- Expanding distribution takes work, particularly if you're selling your product to different store locations in different geographic markets. However, taking it slow gives you the time to scale in a measured fashion and troubleshoot growing pains more easily than if you were to attempt abrupt increases in sales volume.
- Platforms such as RangeMe offer small-scale processors an opportunity to have their products prequalified — ensure they meet label standards, regulations and liability insurance coverage requirements and so forth — and viewable by retailers, which use these platforms to screen and scout for new suppliers.
- The COVID-19 pandemic has made it harder to reach buyers and introduce new products to them in stores because of safety concerns, but this is an essential step to building awareness and encouraging product trial.
- Finding a market for seconds can be a challenge. If seconds don't sell in a retail farm store, then they may not have a market. Processors may direct some seconds to processing if they can innovate products that can use seconds as ingredients. In some cases, processors may prefer not to source seconds if they're too hard to use because they take too much time to process or may not reflect a high-quality image.
- When marketing a product, think about alternative applications for it, so it's not as narrowly targeted for one specific use. Buyers like products that can do more than just one thing because it moves the product more quickly.

6. Strategies for Missouri to Consider

The primary and secondary research conducted for this project contributed to forming the following strategies that Missouri stakeholders may consider to increase fruit and vegetable processing activity in the state.

- **Innovate practices to shrink the biological lag period.** Shortening the lag between planting a crop and seeing it mature may match supply and demand more quickly.

- **Locate near production locations**. Processing facilities located near production locations improve logistics and enable facilities to access ripe product.
- **Seek out contracts to manage risk**. For fruit and vegetable processors, supply-side contracts can reduce supply-side risk and ensure that incoming product meets certain standards. Contracts with distributors and other buyers may help to secure limited shelf space in highly competitive retail operations.
- **Address pricing**. Many processors have margins too thin to pay retail prices, and producers have shown a preference for selling in channels, such as grocery stores or farmers markets, that may allow them to earn higher prices than processors are willing to pay. Closing this gap may allow local producers and processors to transact.
- **Maximize facility utilization by finding year-round uses for processing space**. To use a facility year-round, operators may consider the seasonality of production and processing and equip a facility to process crops that store well. Those storable crops could then be processed during off-peak times. Winter crops, including butternut squash and carrots, may store well if provided the right environment.
- **Identify crops that use similar processing equipment**. The minimal processing case study from western Washington described how carrots, summer squash, butternut squash, beets, potatoes, turnips and rutabaga are relatively easy to process and demand similar basic processing equipment. Broccoli and green beans were less profitable to process, according to the Washington study's analysis. Processors may focus on offering more profitable items, assuming they have strong demand.
- **Consider mobile processing**. Mobile processing units can handle basic processing activities from a vehicle or trailer. Because they're mobile, they can travel to a crop's location, but multiple groups must commit to using them, creating on-farm frozen storage space, developing a system to reach markets and securing food safety training. These units also require managing scheduling and coordination.
- **Minimize bottlenecks**. Facilities must have adequate receiving and storage space and procure volumes that can be processed realistically in a timely manner.
- **Specialize in fresh-cut preparation to save time for buyers**. Retailers and chefs appear interested in sourcing fresh-cut items from processors that have appropriate facilities and a trained workforce.
- **If freezing product, then choose a system that allows for quick freezing**. Slow freezing may lead to ice crystals developing and an unpleasant texture and flavor.
- **Offer food process authority services**. An in-state process authority would provide Missouri processors with more ready access to product development and testing services at a cost potentially lower than what out-of-state groups charge.
- **Compete by offering niche products**. Small-scale firms will likely struggle to compete with large-scale firms based on cost alone. Providing products positioned to serve a niche audience (e.g., organic, gluten-free) may give small-scale firms an advantage.
- **Find markets for seconds**. Some processors may choose to not buy seconds or lack awareness of seconds options. A prefeasibility study focused on "first processed" opportunities in central Kentucky cited that restaurants may not know about seconds availability, though some purchase seconds to include in menu items. Research conducted for the study found seconds commonly were directed to food banks (Brislen, Rossi and Stancil). Investing in product development may open new markets and possible uses for seconds. For example, in January 2021, the Upcycled Food

Association announced it would soon launch a certification program that would validate food and beverage products contributing to food waste reduction. The U.S. has more than 400 upcycled products (Nunes 2021).

- **Encourage supporting industries.** Processors not only need access to raw commodities, but they also use other ingredients, packaging and supplies. If a local supply of these materials existed, then processors could possibly capture savings by not paying as much for shipping.
- **Connect processors to distributors.** Because processors may face roadblocks to accessing distributors, collaborating to find and work with distributors and offering the products distributors want to add to their portfolios may open new sales opportunities and distribution channels.

7. References

American Frozen Food Institute and 210 Analytics. 2020. "Frozen Food Sales Amid COVID-19." *American Frozen Food Institute*. Accessed Dec. 14, 2020, at https://affi.org/wp-content/uploads/2020/documents/Frozen%20Food%20Sales%20Amid%20COVID-19%20Consumer%20Research%20-%20FINAL.pdf.

Aubrey, Allison. 2018. "Frozen Food Fan? As Sales Rise, Studies Show Frozen Produce Is As Healthy As Fresh." *NPR*. Accessed Dec. 23, 2020, at https://www.npr.org/sections/thesalt/2018/05/17/611693137/frozen-food-fan-as-sales-rise-studies-show-frozen-produce-is-as-healthy-as-fresh.

Baltazar, Amanda. 2020. "Sales of Frozen Foods Soar." Winsight Grocery Business. Accessed Dec. 23, 2020, at https://www.winsightgrocerybusiness.com/center-store/sales-frozen-foods-soar.

Barrett, Diane M., John C. Beaulieu and Rob Shewfelt. 2010. "Color, Flavor, Texture and Nutritional Quality of Fresh-Cut Fruits and Vegetables: Desirable Levels, Instrumental and Sensory Measurement, and the Effects of Processing." *Critical Reviews in Food Science and Nutrition*. Accessed March 15, 2021, at http://www.fruitandvegetable.ucdavis.edu/files/217117.pdf.

Berkenkamp, JoAnne, Lynn Mader and Madeline Kastler. 2012. "Frozen Local: Strategies for Freezing Locally Grown Produce for the K-12 Marketplace." *Institute for Agriculture and Trade Policy*. Accessed Oct. 2, 2020, at https://www.iatp.org/sites/default/files/2012_12_11_FreezingReport_JB_web.pdf.

Bhatta, Sagar, Tatjana Stevanovic Janezic and Cristina Ratti. 2020. "Freeze-Drying of Plant-Based Foods." *Foods*. Accessed March 16, 2021, at https://www.mdpi.com/2304-8158/9/1/87/pdf.

Bouzari, Ali, Dirk Holstege and Diane M. Barrett. 2014. "Vitamin Retention in Eight Fruits and Vegetables: A Comparison of Refrigerated and Frozen Storage." *Journal of Agricultural*

and Food Chemistry. Accessed March 16, 2021, at https://pubs.acs.org/doi/10.1021/jf5058793.

Bramwell, Stephen G., Sydney Debien, Jennifer Post and Marilyn Sitaker. 2020. "Feasibility of a Value-Added Processing Facility for Minimally Processed Vegetables and Fruit in South Puget Sound." *Washington State University Extension, Olympia Farmers Market, South Sound Food System Network, Port of Olympia and Thurston County EDC.* Accessed Oct. 2, 2020, at https://s3.wp.wsu.edu/uploads/sites/2056/2020/01/Final-Report_20.1.27.pdf.

Brislen, Lilian, Jairus Rossi and Kenny Stancil. "First Processed Produce in Central Kentucky." *The Food Connection*. Accessed March, 18, 2021, at https://foodconnection.ca.uky.edu/files/first_processed_produce_in_central_kentucky.pdf.

Brooks, Nathaniel. 2017. "Individually Quick-Frozen (IQF) Machine Serves up the Local Produce Institutions Want. Featured Facility: Western Massachusetts Food Processing Center." *Farm to Institution New England*. Accessed Jan. 21, 2021, at https://www.farmtoinstitution.org/sites/default/files/imce/uploads/Western%20Mass%20FPC%20Case%20Study.pdf.

Buch, Karen. 2020. "Navigating the Frozen Food Aisles." *Progressive Grocer*. Accessed Feb. 9, 2021, at https://progressivegrocer.com/navigating-frozen-food-aisles.

Burt, Chris. 2019. "Managing Processing Pitfalls." *Produce Business*. Accessed Dec. 14, 2020, at https://www.producebusiness.com/managing-processing-pitfalls/.

Canned Food Alliance. A. "Serving Up Nutrition: The Simple Process that Delivers Canned Food from the Farm to Your Table." *Canned Food Alliance*. Accessed Dec. 21, 2020, at https://www.mealtime.org/wp-content/uploads/2020/07/CFA_Canning-Process_4-1-15_FINAL.pdf.

Canned Food Alliance. B. "The Canning Process." C*anned Food Alliance*. Accessed Dec. 21, 2020, at https://www.mealtime.org/the-canning-process/.

Cook, Daniel, Roger Corey, Brendan Lynch and Mark Simone. 2007. "Canned Peaches, Pears and Fruit Mixtures: Conditions of Competition Between U.S. and Principal Foreign Supplier Industries." *U.S. International Trade Commission*. Accessed Dec. 22, 2020, at https://usitc.gov/publications/332/pub3972.pdf.

Fusaro, Dave. 2012. "What's the Best Way to Dehydrate Fruits and Vegetables?" *Food Processing*. Accessed Dec. 17, 2020, at https://www.foodprocessing.com/articles/2012/best-way-to-dehydrate-fruits-and-vegetables/.

Fusaro, Dave. 2020. "Why Frozen Foods Are Hot Right Now." *Food Processing*. Accessed Dec. 23, 2020, at https://www.foodprocessing.com/articles/2020/frozen-foods/.

Gibbons, Kathy. 2014. “Shifting Shapes: Demand rises for unusual cuts of produce.” *Produce Processing*. Accessed Dec. 17, 2020, at https://produceprocessing.net/article/shifting-shapes-demand-rises-for-unusual-cuts-of-produce/.

Gibbons, Kathy. 2017. “Fresh-cut sector diversifies in response to new consumer trends.” *Produce Processing.* Accessed Dec. 17, 2020, at https://produceprocessing.net/article/fresh-cut-sector-diversifies-response-new-consumer-trends/.

Gil, Maria I., Encarna Aguayo and Adel A. Kader. 2006. “Quality Changes and Nutrient Retention in Fresh-Cut versus Whole Fruits during Storage.” *Journal of Agricultural and Food Chemistry*. Accessed March 15, 2021, at https://ucanr.edu/datastoreFiles/608-375.pdf.

Gore-Langton, Louis. 2016. “Freeze-drying fruit is top technique for retaining nutrients: Study.” *FoodNavigator-USA.* Accessed Dec. 17, 2020, at https://www.foodnavigator-usa.com/Article/2016/11/14/Freeze-drying-fruit-is-top-technique-for-retaining-nutrients-Study.

Hamstra, Mark. 2020. “Pandemic Fuels the Upscale Makeover of Frozen foods.” *U.S. Chamber of Commerce.* Accessed Dec. 23, 2020, at https://www.uschamber.com/co/good-company/launch-pad/frozen-food-industry-gets-upscale-makeover.

Hartman, Lauren R. 2016a. “Libby’s Launches Microwavable Pouch for Vegetables.” *Food Processing*. Accessed Dec. 18, 2020, at https://www.foodprocessing.com/industrynews/2016/libbys-launches-microwavable-pouch-for-vegetables/.

Hartman, Lauren R. 2016b. “Research Confirms Link Between Food Can Linings and BPA Exposure.” *Food Processing*. Accessed Dec. 18, 2020, at https://www.foodprocessing.com/industrynews/2016/research-confirms-link-between-food-can-linings-and-bpa-exposure/.

Hiner, Jacqueline. 2020. “Dried Fruit and Vegetable Snack Production.” *IBISWorld*. Accessed Nov. 25, 2020, from MU Libraries at https://library.missouri.edu/.

Kadam, Hrishikesh. 2020. “Convenience driving demand for $392 billion processed fruits, vegetables sector.” *Food & Beverage Insider*. Accessed Dec. 15, 2020, at https://www.foodbeverageinsider.com/fruits-vegetables-nuts-seeds/convenience-driving-demand-392-billion-processed-fruits-vegetables-0.

Kantor, Linda and Andrzej Blazejczyk. 2020. “Food Availability (Per Capita) Data System.” *USDA Economic Research Service*. Accessed Dec. 17, 2020, at https://www.ers.usda.gov/data-products/food-availability-per-capita-data-system/.

Karst, Tom. 2020. “Power of Produce shows growth in value-added.” *The Packer*. Accessed Dec. 17, 2020, at https://www.thepacker.com/markets/marketing-news/retail-news/value-added/power-produce-shows-growth-value-added.

Kennedy, Kevin. 2020. “Canned Fruit and Vegetable Processing in the U.S.” *IBISWorld*. Accessed Nov. 25, 2020, from MU Libraries at https://library.missouri.edu/.

McDonald, Doug, David Lam, Paul Hamam, Stephen J. Brown and Jim Kilpatrick. 2018. “Benchmarking for success 2018: Financial performance and trends within the North American food and beverage processing industry.” *Deloitte*. Accessed Nov. 24, 2020, at https://www2.deloitte.com/content/dam/Deloitte/ca/Documents/consumer-business/ca-benchmarking-for-success-en-aoda.pdf.

Midwest Research Institute. 1995. “Emission Factor Documentation – Canned Fruits and Vegetables Final Report.” *Environmental Protection Agency*. Accessed at Dec. 22, 2020, at https://www.epa.gov/sites/production/files/2020-10/documents/b9s08-1.pdf.

Missouri Grown. 2018. “Farmers’ Market Handbook.” *Missouri Grown*. Accessed March 15, 2021, at https://agrimissouri.com/pdf/fmhandbook.pdf.

Mohamad Shofian, Norshahida, Azizah Abdul Hamid, Azizah Osman, Nazamid Saari, Farooq Anwar, Mohd Sabri Pak Dek and Muhammad Redzuan Hairuddin. 2011. “Effect of Freeze-Drying on the Antioxidant Compounds and Antioxidant Activity of Selected Tropical Fruits.” *International Journal of Molecular Sciences*. Accessed March 17, 2021, at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3155377/.

Nielsen. 2020. “Pantries Padded with Produce as North Americans Prepare for the COVID-19 Long Haul.” *Nielsen*. Accessed Dec. 18, 2020, at https://www.nielsen.com/us/en/insights/article/2020/pantries-padded-with-produce-as-north-americans-prepare-for-the-covid-19-long-haul/.

Nunes, Keith. 2021. “Upcycled Certification Standard gets the go ahead.” *Food Business News*. Accessed Jan. 27, 2021, at https://www.foodbusinessnews.net/articles/17692-upcycled-certification-standard-gets-the-go-ahead.

Pierce, Lisa McTigue. 2018. “Most food cans no longer use BPA in their linings.” *Packaging Digest*. Accessed Dec. 22, 2020, at https://www.packagingdigest.com/food-packaging/most-food-cans-no-longer-use-bpa-their-linings.

Postharvest Technology Center. 2020. “2020 Fresh Cut Products: Maintaining Quality & Safety Workshop.” University of California. Accessed Dec. 17, 2020, at http://postharvest.ucdavis.edu/Workshops/Fresh-cut_Products_Workshop__Maintaining_Quality_-_Safety/.

Prince Edward County. “Cannery.” *Prince Edward County, Virginia*. Accessed March 17, 2021, at https://www.co.prince-edward.va.us/departments/cannery.

Produce for Better Health Foundation. 2017. “Primary Shoppers’ Attitudes and Beliefs Related to Fruit and Vegetable Consumption, 2012-2016.” *Produce for Better Health Foundation*. Accessed Jan. 28, 2021, at https://fruitsandveggies.org/wp-content/uploads/2020/08/PrimaryShopperReport_2016_WEB.pdf.

Riell, Howard. 2019. “Increased shelf space helps capture young, health-driven consumers: ‘It’s no longer Grandma eating prune.’” *Produce Business*. Accessed Jan. 26, 2021, at https://www.producebusiness.com/dehydrated-fruits-and-veg-preservation-is-back/.

Ristoff, Jared. 2020. “Frozen Food Production in the U.S.” *IBISWorld*. Accessed Nov. 25, 2020, from MU Libraries at https://library.missouri.edu/.

Roerink, Anne-Marie. “2020: A Year Like No Other for the Produce Department.” *210 Analytics and Information Resources Inc.* Accessed Feb. 9, 2021, at https://agfstorage.blob.core.windows.net/misc/FP_com/2021/01/13/Dec_2020_210Analytics_IRI_Produce_update.pdf.

Roerink, Anne-Marie. 2020. “Fresh Produce Continues Surge; Frozen and Canned Varieties Also Soar.” *Winsight Grocery Business*. Accessed Dec. 22, 2020, at https://www.winsightgrocerybusiness.com/fresh-food/fresh-produce-continues-surge-frozen-canned-varieties-also-soar.

Stein, Rick. 2020. “What Value-Added Really Means for Fresh Categories.” *PerishableNews.com*. Accessed Dec. 17, 2020, at https://www.perishablenews.com/retailfoodservice/what-value-added-really-means-for-fresh-categories/.

Stiffler-Meyer, Lee. 2007. ”How Are Your Fruits Dried?” *Food Processing*. Accessed Dec. 17, 2020, at https://www.foodprocessing.com/articles/2007/137/.

Strailey, Jennifer. 2019. “How to Capture Consumers With Fresh-Cut Fruit.” Winsight Grocery Business. Accessed Dec. 17, 2020, at https://www.winsightgrocerybusiness.com/fresh-food/how-capture-consumers-fresh-cut-fruit.

The Boyd Company Inc. A. “Comparative Food & Beverage Processing Industry Operating Costs.” *The Boyd Company Inc.* Accessed Oct. 14, 2020, at https://www.investnorthumberland.ca/assets/competitiveness/7330652c8e/Boyd-research-Food-Processing.pdf.

The Boyd Company Inc. B. “Comparative Food & Beverage Processing Industry Operating Costs.” *The Boyd Company Inc.* Accessed Oct. 14, 2020, at https://pennsnortheast.com/images/uploads/PNE_Boyd_Food_Processing_Industry_Cost_Report_060617.pdf.

U.S. Census Bureau. 2020a. “2018 County Business Patterns & Nonemployer Statistics Combined Report.” *U.S. Census Bureau*. Accessed Jan. 12, 2021, at https://www.census.gov/data/tables/2018/econ/cbp/2018-combined-report.html.

U.S. Census Bureau. 2020b. “County Business Patterns by Legal Form of Organization and Employment Size Class for U.S., States, and Selected Geographies: 2018.” *U.S. Census Bureau*. Accessed Jan. 12, 2021, at https://data.census.gov/cedsci/table?d=ANN%20Business%20Patterns%20County%20Business%20Patterns&tid=CBP2018.CB1800CBP&hidePreview=true.

U.S. Census Bureau. 2020c. “Nonemployer Statistics for the U.S., States, Counties, Metropolitan Areas, and Combined Statistical Areas; and by Legal Form of Organization and Sales, Value of Shipments, or Revenue Size for Selected Geographies: 2018.” *U.S. Census Bureau*. Accessed Jan. 12, 2021, at https://data.census.gov/cedsci/table?d=ANN%20Nonemployer%20Statistics&tid=NONEMP2018.NS1800NONEMP&hidePreview=false.

U.S. Food and Drug Administration. A. “Current Good Manufacturing Practices (CGMPs) for Food and Dietary Supplements.” *U.S. Food and Drug Administration*. Accessed March 16, 2021, at https://www.fda.gov/food/guidance-regulation-food-and-dietary-supplements/current-good-manufacturing-practices-cgmps-food-and-dietary-supplements.

U.S. Food and Drug Administration. B. “Hazard Analysis Critical Control Point (HACCP).” *U.S. Food and Drug Administration*. Accessed March 16, 2021, at https://www.fda.gov/food/guidance-regulation-food-and-dietary-supplements/hazard-analysis-critical-control-point-haccp.

U.S. Food and Drug Administration. 2008. “Guidance for Industry: Guide to Minimize Microbial Food Safety Hazards of Fresh-cut Fruits and Vegetables.” *U.S. Food and Drug Administration*. Accessed March 15, 2021, https://www.fda.gov/regulatory-information/search-fda-guidance-documents/guidance-industry-guide-minimize-microbial-food-safety-hazards-fresh-cut-fruits-and-vegetables.

U.S. Food and Drug Administration. 2018. “Draft Guidance for Industry: Guide to Minimize Food Safety Hazards of Fresh-cut Produce.” *U.S. Food and Drug Administration*. Accessed March 15, 2021, at https://www.fda.gov/regulatory-information/search-fda-guidance-documents/draft-guidance-industry-guide-minimize-food-safety-hazards-fresh-cut-produce.

USDA Agricultural Marketing Service. 2016. “Fresh-Cut Produce: Shipping Point and Market Inspection Instructions.” *USDA Agricultural Marketing Service*. Accessed Feb. 11, 2021, at https://www.ams.usda.gov/sites/default/files/media/FreshCutProduceInstructions.pdf.

VA Foodie. 2021. “From Recipe to Retail with Virginia Food Works.” *VA Foodie*. Accessed March 17, 2021, at https://www.vafoodie.com/featured-interviews/guiding-food-producers-from-recipe-to-retail-with-virginia-food-works.

Virginia Food Works. Accessed March 17, 2021, at https://virginiafoodworks.org/.

Virginia Farm Bureau. 2019. “Canneries cater to consumers who want to preserve fresh foods.” *Virginia Farm Bureau*. Accessed March 17, 2021, at

https://vfbarticles.personifycloud.com/news-and-features/categories/canneries-cater-to-consumers-who-want-to-preserve-fresh-foods.

Watson, Elaine. 2017. “Crunchies targets Millennial moms as fruit and veggie snacking gathers pace.” *FoodNavigator-USA.* Accessed Dec. 17, 2020, from https://www.foodnavigator-usa.com/Article/2017/03/22/Crunchies-targets-Millennial-moms-with-freeze-dried-fruits.

Zeballos, Eliana. 2020. “Food and beverage manufacturing.” *USDA Economic Research Service*. Accessed Dec. 17, 2020, at https://www.ers.usda.gov/topics/food-markets-prices/processing-marketing/manufacturing/.

Zheng, Gordon. 2020. “Frozen Fruit and Juice Production.” *IBISWorld*. Accessed Nov. 25, 2020, from MU Libraries at https://library.missouri.edu/.