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# Estimating South Dakota’s Capacity to Meet K-12 School Meal Fruit and Vegetable Requirements With State-Grown Produce

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# ESTIMATING SOUTH DAKOTA'S CAPACITY TO MEET K-12 SCHOOL MEAL FRUIT AND VEGETABLE REQUIREMENTS WITH STATE-GROWN PRODUCE

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This thesis is approved as a creditable and independent investigation by a candidate for the master's degree and is acceptable for meeting the thesis requirements for this degree. Acceptance of this does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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# ABSTRACT


ESTIMATING SOUTH DAKOTA'S CAPACITY TO MEET K-12 SCHOOL MEAL FRUIT AND VEGETABLE REQUIREMENTS WITH STATE-GROWN PRODUCE

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Objective: Quantify South Dakota (SD)'s capacity to procure locally-sourced fruit and vegetables (FVs) for K-12 school meals.

Methods: Secondary analysis of 2017 SD agricultural census and school meal data. Yields were converted to edible cups of FVs using school meal guidelines provided by the U.S. Department of Agriculture. Student enrollment and meal redemptions were used to estimate the number of FV cups needed.

Results: Estimated SD FV production met minimum total K-12 cup requirements, except for total fruit (66%) and dark green vegetables (80%). Legumes supplied 77% of the total cups of vegetables produced in 2017, whereas dark green vegetables were only 2%.

Conclusions & Implications: The FV procurement in SD is adequate to meet some, but not all, school meal requirements. Further research involving both nutrition and horticulture professionals is needed to determine the feasibility of sustainably providing and producing FVs for Farm to School and other local food needs.

# CHAPTER 1: INTRODUCTION

Children in the United States consume substantially fewer fruits and vegetables (FVs) than what is recommended for their age by the Dietary Guidelines for Americans.[1] By not consuming an adequate variety of FVs, the risk for vitamin and mineral deficiencies increases.[2] Potassium deficiencies could impact the efficiency of transporting electrical signals to cells, especially muscle cells of the heart.[3] Vitamin A deficiency, attributing to the highest risk of preventable blindness, affects 190 million pre-school aged children.[4] Scurvy can manifest in children from a vitamin C deficiency, which in severe cases, bone disease can form.[5] For vegan and vegetarian individuals, plant-based sources of vitamin B12 are important to help reduce their risk of developing a deficiency.[6] Spinach, peppers, oranges, mangos, peas, and many other FVs are good sources of these vitamins and minerals. Consumption of a variety of FVs is important in providing numerous vitamins and minerals; thus, reducing risks of developing deficiencies.

School meals are one opportunity for children to increase their consumption of various types of FVs. The National School Lunch (NSLP) and School Breakfast Program (SBP) provide nutritious meals at a free or reduced price for income-eligible families, thus improving child nutrition while simultaneously alleviating families' financial stress.[7] The Healthy, Hunger-Free Kids Act of 2010 set requirements for these programs to include a minimum serving size of FVs per meal.[7] These requirements vary by grade to comply with national dietary guidelines for FVs. Even though participating children are required to take at least one fruit or vegetable with each school meal, consumption is not guaranteed. Multiple plate waste studies conducted in school cafeterias have shown that roughly half of FVs taken by school-age children at school meals are wasted.[8-11]

The Farm to School (FTS) Program provides an opportunity for children to build connections with agriculture and encourages behavior change towards increasing FV consumption and reducing waste. This program was initiated through the authorization of the Farm to School Grant Program in the Richard B. Russell National School Lunch Act of 2010.[12] This authorized the USDA to provide the training and funding necessary for schools to implement three core FTS activities – local procurement, education, and school/youth gardens. Of particular note for this thesis, local procurement emphasizes locally sourced food items to be served in schools for meals, snacks, or samples. These items typically include FVs, meat products, and dairy products. The 2019 Farm to School Census results showed that the percent of school food authorities (SFAs) participating in FTS that use local foods during meal service in the NSLP and SBP was 71.4% and 68.4%, respectively.[12] In short, several studies conducted on various grade levels have shown that FV consumption improved during meal service when local FVs were offered.[13-16] Thus, implementation of local foods is a successful activity to increase FV consumption in school-aged children.

Although the success of FTS procurement of local FV for school meals has been shown through studies, an issue that affects FTS procurement is building new supply chains between local farmers and schools. Time constraints, labor demands, proximity, and supply demands are a few obstacles in partnering with local farmers. SFAs have reported that taking the time to build connections with local farmers is time consuming, and may result in lower reliability than partnerships with large distributors.[17] If there are not enough farmers in the area to provide sufficient amounts of FVs, partnerships may not even be a feasible option.[17] However, having large volumes of local FVs available for FTS procurement could also be an issue. With many schools having limited labor and equipment to properly prepare fresh FVs for meal service, some districts may not have the capacity to source many FTS products and may instead rely on ready-to-serve FVs from larger distributors.[18]

One factor that has not been well explored is the capacity of local food systems to meet the nutritional needs of school meals set forth by the Healthy, Hunger-Free Kids Act. For example, South Dakota (SD) is ranked 47th and 50th among the 50 states in market value of FVs sold in the United States, respectively.[19] SD not only faces limited acreage for FV production, but overall agricultural production is declining. According to the 2022 Census of Agriculture, the total number of farms in SD have decreased by roughly 1700 since 2017, reducing total farm acreage by ~940,000.[19] However, vegetable farms in South Dakota have increased by ~80 and fruit, tree nut, and berry farms by ~40 from the 2017 to the 2022 Agriculture Census.[19] For FVs specifically, 65.9% of SD producers surveyed reported using 1-5 acres for FV production, meaning that most FV production is taking place on small operations in SD.[20] Smaller farmers, especially those that operate in food deserts, utilize all of the land they own for FV production, while ≤ 2% of total land on large farms are used for these crops.[20] Overall, SD's FV yield in comparison to commodity crops such as soy and corn, and continual decrease in total farms and growing acres, has raised concerns among FTS advocates that SD's growing capacity cannot sufficiently provide locally-sourced FVs for all schools that wish to participate in FTS.

These concerns have not hindered FTS growth within SD. The FTS movement has expanded tremendously throughout the state over the past 14 years, resulting in increased interest in local food production. This movement started in 2010 when Dakota Rural Action joined the National FTS Network. From there, collaboration with South Dakota State University Extension in 2016 lead to the launch of the SD FTS Taskforce. A number of notable FTS procurement projects were implemented in the following years, including a Beef to School project in Wall District in 2018 and a partnership between Brandon Valley District and Cherry Rock Creek in 2022 to procure locally grown apples for school meals. The FTS Census found that 73% of SFAs participating in FTS within SD use local foods within their schools.[21] SDSU Extension produced a "South Dakota Farm to School Resource Guide" in 2019 and has since released a second edition in 2022 to serve as a tool for farmers and school programs regarding the application of FTS.[22] SDSU Extension collaborated with the SD Local Foods Coalition to form a FTS subcommittee in the summer of 2021. With increased growth and development, SDSU Extension branched out to form the "Farm to School Network", in spring of 2022. (A. Tvedt, personal communication, 2024) To this day, this platform is used for interested individuals to collaborate and connect to support FTS growth.[23] As FTS continues to be of growing interest and concern among SDSU Extension professionals and other organizations, understanding the state's FV production and the feasibility of implementing FTS procurement at schools is a pertinent topic and warrants further exploration.

Project Rationale:

Because SD ranks in the bottom 10% of market value for FV sales among the 50 states, it is vital to understand the yield of these products. However, this information is not collected at a commercial level for this state. Phone calls to farmers of both small and large production were contacted to inquire if yield information was reported to the USDA's State of Agriculture Census every 5 years, and whether personal records of total weight and acres for each crop grown each year were available. Almost all the farmers who were contacted stated they report every 5 years to the USDA Ag Census. Some of the farmers kept records of total crop acreage, but crop yields were not recorded. Thus, at best, estimations could be determined through sales. Others noted that their harvests varied greatly year-to-year with the weather, thus providing yield estimates would be challenging. Because of this, a method for modeling the amount of FV harvested into edible cups was needed to estimate SD's capacity for local FV procurement.

Thesis Aims:

The purpose of this thesis is to determine the capacity of SD to supply FVs to meet the nutritional requirements for K-12 school meal programs throughout the state. We hypothesized that the number of FV grown in SD was not sufficient to meet the minimum total servings per cup requirements needed by SD public schools.

# CHAPTER 2: LITERATURE REVIEW

This study's focus is to determine South Dakota's capacity to produce sufficient FVs to meet minimal nutritional requirements for K-12 meal programs, specifically for use in the FTS program. Topics explored in this literature provided necessary knowledge to further understand concepts connected to the aim of this thesis. These topics include defining local foods, identifying school meal programs, distinguishing Farm to School Program activities, reviewing current research of FV FTS procurement, and history of FTS in South Dakota.

## Local Food

The word "local" has no universally accepted meaning, thus communities and countries are responsible for defining local food in their own terms.[22] For example, The Canadian Food Inspection Agency describes local food as anything produced in the same province or within 50 kilometers of the border.[24] Meanwhile, the Campaign for the Protection of Rural England proposed that local foods are any item grown and produced within 30 miles of the store in which it is sold.[25] In the United States, the 2008 Farm Act defined local or regionally produced food products as those that are transported within 400 miles of the location where they were grown.[26] However, other definitions of "local food" have been used to satisfy needs specific to particular communities, such as climate impacts and seasonality.[27]

Common characteristics for defining local foods, as reported by Martinez et al., include geographical, social, and supply chains.[28] Geographically, defining local foods can depend on region and population size.[28] Densely populated regions may define local foods using a smaller geographic radius than rural areas.[28] For example, King County, WA, is a populated urban county where 66% of 54 producers surveyed reported local markets as their own county or the surrounding area, whereas in the rural, sparsely populated Grant County, WA, only 21% of 62 producers surveyed defined local as their own or surrounding counties.[28] Social characteristics of local food are defined as the direct interactions from producer to consumer.[28] These interactions can be directly with the producer through producer co-ops or food hubs, or via a connection with third parties such as distributors.[27] With regard to supply chains, local foods utilize short food supply chains, and producers often label products with the grower's personal information, including the location of where the product originated from.[28]

Of the 50 states, 9 do not have a law to define local foods: Arizona, Delaware, Idaho, Kansas, Nebraska, Nevada, New Mexico, North Dakota, and South Dakota.[29] Thus, multiple definitions could be used in these states to define local foods. Figure 1 depicts three possible definitions of local food for Pierre, SD, South Dakota's capital city, reproduced from the South Dakota Farm to School Resource Guide. From left to right, "local" could be expressed by a specific radius, state-wide, or regionally.[22] The first graphic uses the 400-mile radius from the 2008 Farm Act definition. This radius includes areas from all 6 of South Dakota's neighboring states, which may not seem "local" to community members in Pierre. The state-wide area defines local food as any that is grown within the given state. This can be a convenient definition as the borders are clearly defined, but states vary greatly in size. The regional area displays a "hyperlocal" definition of local food. This area may only include a single county or even a singular city, which may be sufficient depending on the hyperlocal agricultural landscape.[27]

**Figure 1:** Three possible definitions of "local food" for Pierre, SD[22]

Defining local foods can also be affected by the amount of food produced within a certain area.[27] For example, if ample supplies of fruits and vegetables are produced in a county, then "local" may be defined at the county level for fruits and vegetables. However, if the production of dairy is minimal within that same county, then the definition of local dairy may be state-wide or multistate in nature.[27]

**Benefits of Local Foods**

Local foods positively impact the economy, environment, and human health when compared to global food systems.[28] Buying locally supports businesses directly while also reducing the amount of money spent to import items, thus, reducing transport time and supporting the local economy.[28,29] According to the 2020 Local Food Marketing Practice Survey by the USDA, a total of $9 billion of local food was sold nationally through sales to direct consumers, retailers, institutions, and intermediaries.[30] Of this,

$2.9 billion (32%) were direct-to-consumer sales, including at farmer's markets and farm stores.[30] A study theorized local food systems' potential economic impact on local communities through the retention of revenue locally.[31] They calculated that if every household in Virginia spent $10 per week on locally grown food items, $1.65 billion would be generated annually in direct economic impact.[31]

Although agricultural practices do release greenhouse gas emissions, the U.S. Environmental Protection Agency has reported that they are roughly 7 times less than those released from transportation, which is the largest contributor of these emissions.[32] Reducing "food miles," or the distance food has to travel from farm to retail, has the potential to reduce transportation emissions through shorter travel time and can be accomplished through short food supply chains (SFSC).[29] Compared to global food chains, SFSC have tended to produce a smaller carbon footprint and use less energy.[33] In fact, in a study by Pirog et al., local foods, containing a variety of food items, including chuck roast, vegetables, rice, and spices, were estimated on average to travel a total of about 3,445 miles, whereas conventionally grown and distributed foods traveled roughly 22,100 miles.[34] This change would result in saving 280-346 thousand gallons of fuel and reduction in $CO2$ emissions of 6.7-7.9 million pounds depending on the truck and system used.[34]

Local foods are typically less processed than conventional foods.[22,28] Juul et al. analyzed 2001-2018 National Health and Nutrition Examination Survey (NHANES) data to investigate changes in U.S. food intake by food processing level.[35] The NOVA system, which groups foods into 4 groups by processing level (Figure 2), was utilized for the analysis. The results showed that the U.S. adult population significantly increased its processed culinary (3.9 – 5.4% kcal) and ultra-processed food (53.5 – 57% kcal) intake over time, while significantly decreasing its minimally processed food (32.7 – 27.4% kcal) intake.[35] Processed food items averaged the same percent of caloric intake over time, at roughly 10% kcal.[35] This trend has been detrimental to human health; it has been inferred that the rising rates of obesity in the U.S. are parallel to the increase in ultra-processed food intake.[35] Moreover, Hall et al.'s randomized controlled trial comparing minimally- and ultra-processed foods suggested that ultra-processed foods encouraged overeating, weight gain, and poor metabolic health, despite both study diets being isocaloric.[36] Local food items are generally categorized as either minimally-processed (Group 1) or processed (Group 3) in the NOVA food system.[36] Thus, transitioning to locally grown foods at a population level would help curb the rising consumption of ultra-processed foods.[36]

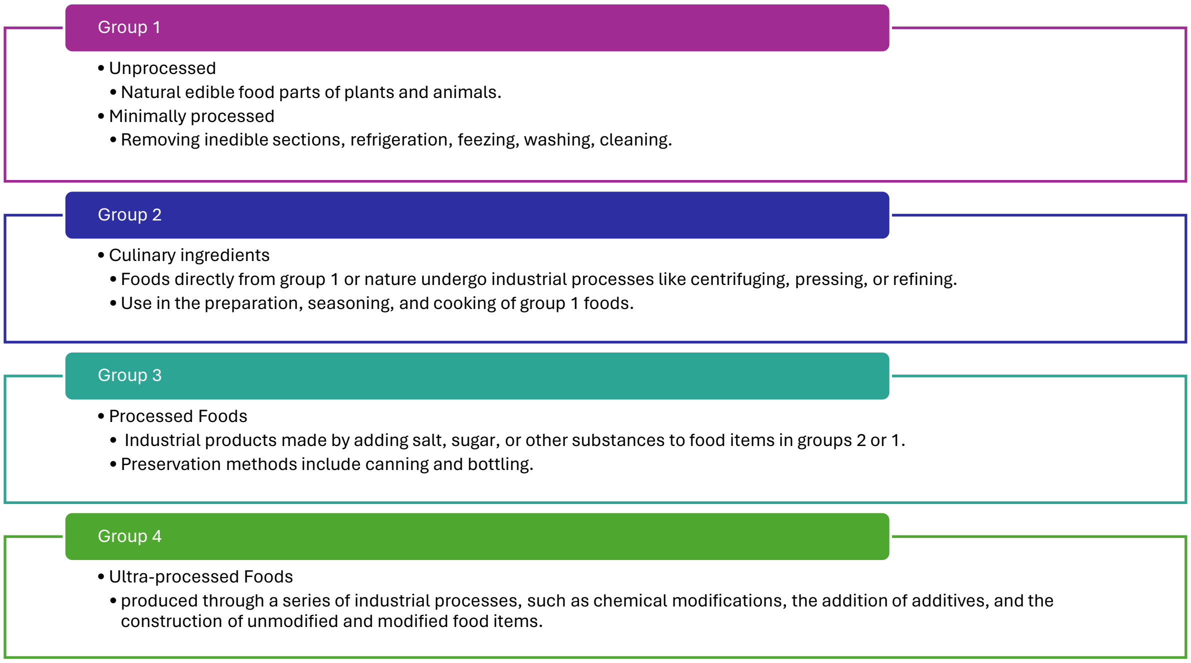


**Figure 2:** NOVA Food System Classification[37]

Local foods may also help mitigate food loss and food waste, which costs the United States over $160 billion each year.[38] Researchers from the USDA Economic Research Service identify several factors that influence food loss on the farm including: price volatility, labor costs and availability, supply-chain factors, standards and consumer expectations, contracts, and policy constraints.[39] Notably for this thesis, 40% of North America's total fruit and vegetable loss has been attributed to the supply chain.[40] This is due to losses that have happened within the long food supply chain (LFSC) shipping process, such as loss of quality through molding or bruising and the ripeness of the food item.[39] Fruits and vegetables with a longer travel time are picked under-ripe to try and avoid damage, leaving the ripe fruit behind to rot in the fields.[41] Purchasing local produce reduces its travel time through the short food supply chain (SFSC) systems, allowing for ready-to-eat produce to be harvested, and thus having the potential to reduce food loss.[39]

Local food systems build community and resilience. O'Hara et al. analyzed the levels of community interaction between a chain supermarket and a farmers' market.[42] The results showed that 75% of shoppers at farmers' markets came in groups, while 84% of shoppers at the supermarket went alone.[42] At the chain supermarket, 9% of customers interacted with another customer and 14% interacted with an employee, while at the farmers market, these interactions were reported as 63% and 42%, respectively.[42] Transporting local foods through SFSC also allows producers to develop direct relationships with consumers, increasing recognition of local producers, and strengthening communities.[33,43,44] When market channels are disrupted, these relationships allow local farmers or food managers to supply food items locally while building community networks.[43] This is one example of how local food systems provide resilience in a community. Local food systems have remained resilient as stressors arise, such as climate change or pandemics.[44] For instance, during the COVID-19 pandemic, state-level initiatives were developed to increase local or fresh foods among the food insecure.[44] The USDA partnered with regional/local distributors at the federal level to supply products to food banks or organizations, such as through the Farmers to Families Box Program.[44]

## School Meal Programs

The National School Lunch Program (NSLP) is a federally assisted program that serves nutritionally balanced lunches to students in grades K-12 attending public or nonprofit private schools at low or no cost.[45] It originated in 1946 when President Harry Truman approved the Richard B. Russell National School Lunch Act.[45] This program is now governed by the United States Department of Agriculture (USDA) Food and Nutrition Service (FNS) at the federal level and State Agencies at the state level.[45] The School Breakfast Program (SBP) is another federally administered program governed by the same agencies; its purpose is to provide free and reduced breakfasts to eligible students.[46] The SBP began in 1966 as a pilot program and was later established as a permanent program by Congress in 1975.[46]

A student's eligibility to participate in the NSLP and SBP program is based on their family's household income:

- Students from households ≤ 130% of the Federal Poverty Line qualify for free breakfasts and lunches.
- Students from households > 130% and < 185% of the Federal Poverty Line qualify for reduced-price breakfasts and lunches.
- Students from households >185% of the Federal Poverty Line must pay full price for breakfasts and lunches.[47]

Students can also be "categorically eligible" for free or reduced-price NSLP and SBP meals if anyone in their household participates in certain federal assistance programs, such as the Supplemental Nutrition Assistance Program or Head Start.[45] Moreover, schools can apply for free school meals for all their students through the Community Eligibility Provision (CEP).[48] The CEP provides school-wide free meals in high-poverty areas where ≥ 40% of students are income or categorically eligible for free or reduced-price meals.[48] In the 2021-2022 school year (SY), 33,300 schools from 49 states and the District of Columbia adopted the CEP (74.3% of all eligible schools).[48,49]

Schools that implement school meal programs receive reimbursements from the federal government for meals that meet NSLP and SBP guidelines.[50] The Federal Register published a national estimated reimbursement rate in effect from July 1, 2023 to June 30, 2024.[50] For the 48 contiguous states, the maximum estimated NSLP reimbursement projections for each full price, reduced-price, and free lunch were $0.48, $4.02, and $4.42, respectively.[50] SBP reimbursements were based on whether schools have a "non-severe need" or a "severe need," in terms of low-income students.[50] For a school to be classified as "severe need," > 40% of meals served through NSLP lunches must have been reduced-price or free two SYs prior.[51] This means that eligibility for SY 2024-2025 is determined by the percent operation of NSLP and SBP during SY 2022-2023.[51] For "non-severe need" schools, SBP reimbursements were $0.38, $1.98, and $2.28 for each full price, reduced-price, and free breakfast, respectively.[50] For "severe need" schools, the reimbursements were $0.38, $2.43, and $2.73, respectively.[50]

In Fiscal Year (FY) 2022 (July 1, 2021 – June 30, 2022), 4.9 billion lunches and 2.5 billion breakfasts were provided by these programs, with a total of 95.1% of lunches and 97.1% of breakfasts being free or reduced-price.[47,52] At the time of writing, FY 2022 data were the most recent available. These percentages are similar to pre-pandemic years, as FY 2020 and 2021free and reduced-price meal redemption were inflated due to temporary changes in NSLP and SBP administration enacted by the American Rescue Plan in response to COVID-19.[53] In FY 2019 (July 1, 2018 – June 30, 2019), pre-pandemic, 74.1% of lunches and 85.1% of breakfasts were served for free or at a reduced price.[54]

Every school that implements NSLP/SBP must abide by the *Dietary Guidelines for Americans*[55] and follow the nutrition guidelines set by the Healthy, Hunger-Free Kids Act of 2010.[47,56] Table 1 indicates the specific meal patterns required for different age groups.[57,58]

**Table 1:** Nutrition Requirements for the National School Lunch Program and School Breakfast Program During a Typical School Week (5 days)

| | National School Lunch Program | | | School Breakfast Program | | |
|---|---|---|---|---|---|---|
| Grade Level | Grades K-5 | Grades 6-8 | Grades 9-12 | Grades K-5 | Grades 6-8 | Grades 9-12 |
| Fruits (cups) | 2 ½ | 2 ½ | 5 | 5 | 5 | 5 |
| Vegetables (cups) | 3 ¾ | 3 ¾ | 5 | 0 | 0 | 0 |
| Grains (oz eq) | 8-9 | 8-10 | 10-12 | 7-10 | 8-10 | 9-10 |
| Meat/Meat alternatives (oz eq) | 8-10 | 9-10 | 10-12 | 0 | 0 | 0 |
| Fluid Milk (cups) | 5 | 5 | 5 | 5 | 5 | 5 |
| Min-max calories (kcal) | 550-650 | 600-700 | 750-850 | 350-500 | 400-550 | 450-600 |
| Saturated fat (% of total calories) | <10 | <10 | <10 | <10 | <10 | <10 |
| Sodium Interim Target 1 (mg)[a] | ≤ 1,230 | ≤ 1,360 | ≤1,420 | ≤540 | ≤600 | ≤640 |
| Trans Fat | Nutrition label or manufacturer specifications must indicate zero grams of trans fat per serving. | | | | | |

*a:* Sodium limit for school lunches implemented in the final rule of Transitional Standards for Milk, Whole Grains, and Sodium by the U.S. Department of Agriculture.[59]

## Farm to School

The Farm to School (FTS) program is a school-based initiative that implements various activities to expose students to local foods and agricultural educational experiences[60]. The Richard B. Russell National School Lunch Act of 2010 authorized the Farm to School Grant Program, allowing the USDA to provide funding and training necessary for schools to implement FTS activities.[60] Figure 3 displays the 3 main FTS components.[22] Schools that implement FTS may incorporate 1, 2, or all 3 of the following components:[22]

1. **Local Food Procurement:** schools purchase locally grown foods to serve for school meals, snacks, or classroom samples.
2. **Education:** students receive classroom education on healthy eating, nutrition, agriculture, and food production.
3. **School/Youth Gardens:** students receive hands-on experience with growing food, either onsite, via a community garden, or by partnering with local farms.

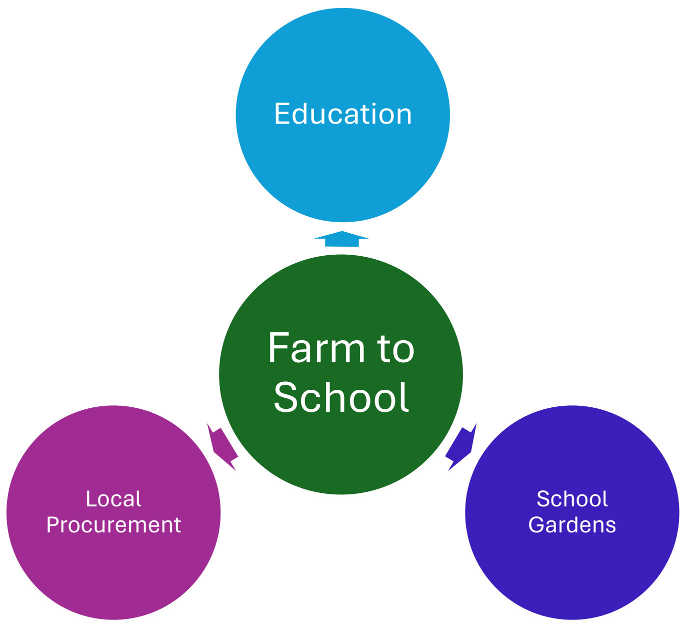


**Figure 3:** Farm to School Components[22]

The USDA Farm to School Census is a compilation of data from school food authorities (SFAs, i.e., school food service operators[60]) participating in the NSLP, to gauge FTS involvement.[12] Nationwide data is collected from all 50 states, Guam, American Samoa, Northern Mariana Islands, U.S. Virgin Islands, Puerto Rico, and Washington D.C.[61] The SY 2019 census questionnaire was sent to 18,832 SFAs who were implementing or planned to implement FTS activities, of which 12,634 were completed (response rate =

65.4%).[60] The information collected by the census from schools who implemented FTS included the length of FTS participation by SFAs, the percentage of SFAs serving local foods, the percentage of SFAs who provide FTS education, the teaching strategies utilized, the Child Nutrition Programs used, and the percentage by state of SFAs which reported operating a school garden.[61]

Results from the 2019 Farm to School Census indicated that 88.1% of SFAs participated in local food procurement, 59.9% participated in education, and 34.3% had a school garden.[60] In total, these FTS activities reached a total of 42.8 million students.[61] Despite the high percentage of local food procurement, 30% of respondents did not utilize a set definition of "local." The most common definition of local food used, at 23%, was "produce [grown] within the State."[60] Yet, the service of local foods in NSLP is the most common FTS activity. [60] Educational strategies used in FTS education included cooking demonstrations and taste tests (33.5%), holding school field trips to farms (30.7%), having farmers visit classrooms (15.3%), and using USDA National team Materials (11.8%). Although roughly one-third of census respondents reported utilizing school gardens, the percentage varied greatly by state. Guam and Vermont lead in reported participation, totaling 100% and 85%, respectively, and Texas placed last in participation with a total of 20%.[61] Twenty-nine percent of South Dakota SFAs reported having school gardens.[61]

Regarding the number of years participating in FTS, 56.7% of schools had participated in FTS for ≤ 3 years, 24.7% for 3-5 years, 11.2% for 6-10 years, and 7.2% for ≥ 10 years.[60] Schools that had participated in FTS for ≤ 3 years were more likely to be smaller, more rural, and display high levels of free or reduced-price eligibility (≥ 86% of students eligible). Additionally, these schools were more likely to implement procurement only (30.5%) compared to schools participating in FTS ≥ 3 years (11.0%).[60] For SFAs who participated in FTS for ≥ 3 years, schools were larger in size, rural, but had less students eligible for free or reduced-price lunch.[60] The prevalence of FTS local food service was higher among participants in the NSLP (72%) and SBP (68%) in comparison to other federal school meal programs.[60]

USDA has claimed that FTS provides "wins" to 4 stakeholder groups:[62]

1. **Kids:** are provided hands-on experience through school gardens and education.[62]
2. **Schools:** can provide nutritious meals resulting in higher participation in school lunches and reduced plate waste.[22]
3. **Farmers:** obtain financial support, as the 2019 Census reported operators of this program purchasing $1.26 billion worth of local food items during the SY 2018-2019.[62]
4. **Communities:** participate in strengthening their local economy through networking with local farmers and supporting a sustainable food system..[22,62]

## The Impact of Fruit and Vegetable Farm to School Procurement

**Search Strategy**

A systematic review was conducted to determine the impacts of fruit and vegetable (FV) procurement in farm-to-school (FTS) programs. Three databases (ERIC, PubMed, and Web of Science) were searched for full articles published between 2012 – 2022, using the keywords “farm to school” AND (fruit OR vegetable). Moreover, articles cited in a previously published, related FTS review[63] were also searched. To be included in the review, a study must have been conducted in the United States and investigated procurement FTS strategies (as opposed to education and/or school gardens without procurement) that included FV. A total of 127 articles were found; after removing duplicates and articles that did not meet inclusion criteria, 18 articles were included.

**Local Food in School Lunches**

Three studies investigated if serving local produce in school lunches would result in students’ increased FV consumption.[13-15] Despite differences in the interventions, all 3 studies found an improvement in FV intake when local FV were served. This effect was demonstrated across different populations, including high schoolers in Missouri[13] and 5th graders in rural Mississippi.[14] Avuwadah et al. found an increase in total meals served in 15 low-income schools in the Alachua County Public Schools district in Florida in the 2015-2016 academic year when local produce was offered.[15] However, the amount of local FV served in salad meals and total meals served were no longer statistically significant after school fixed characteristics were accounted for, like race/ethnicity and the type of meal served.[15] The authors concluded that this may have been due to the fact the schools in the study used the Community Eligibility Provision for school meals, and thus NSLP participation was already high pre-intervention.

**Promotion and Education of Local Food Items**

Promotional signage was used to advertise locally sourced FV in 4 of the studies analyzed.[13-15,64] In 2 of these studies, schools also promoted local FV through morning announcements or by serving samples.[13,14] Chiero et al. provided hands-on, food-based education in addition to signage, where results showed an increase in the selection of locally grown zucchini in low-income elementary schools in Connecticut.[64] Promotional signage was also used in Avuwadah et al.'s study conducted in Florida; although, as previously noted, FTS FV consumption did not increase after accounting for school-fixed characteristics.[15]

**Knowledge and Attitudes of Local FV**

The knowledge, attitudes, and consumption of FV increased in 3rd-5th graders in Wisconsin schools during the 2010-2011 academic year after the implementation of a FTS program. Consumption of FV was most impacted in individuals who consumed inadequate fruit (< 0.95 cups/1000kcal) at baseline.[65] Chiero et al. found that children who received FTS interventions in low-income, diverse elementary schools over the 2017-2018 school year had significantly higher attitude scores, preference scores, and overall scores on a locally grown vegetable knowledge and attitude survey versus the control schools.[64] The results of these 2 studies present similar trends across diverse backgrounds. The Bontrager et al. sample population was predominantly Caucasian (81%),[65] and the Chiero et al. sample population was mainly Hispanic/Latino (50%).[64] However, a study by Landry et al. observed the knowledge and attitudes towards FV of 5th-grade students at an elementary school in Mississippi after receiving a month-long pilot FTS intervention. Results showed no significant nutrition knowledge change from pre-and post-test. The authors suggested that since pre-test scores were almost half the highest score (7), a longer FTS intervention may be necessary to see more significant changes in the students' nutrition knowledge.[14]

**Plate Waste of Local FV**

Four studies conducted plate waste analyses using the quarter plate waste method to determine how much FV were consumed and wasted.[16,65-67] After implementing a FTS program and offering locally-grown FV, consumption of FV increased among 1st -5th graders attending treatment elementary schools in the Alachua County Public Schools district, Florida, compared to control schools.[16] A study in Wisconsin elementary schools found that FV consumption in 3rd-5th graders was higher among schools with more extended FTS implementation.[65] Within the same setting and location, another study conducted one year later showed that locally sourced FV were wasted more than conventionally sourced FV.[66] However, it is important to note that the average serving size for locally sourced FV was almost twice as large as what was served for conventionally sourced FV (0.61 cups vs 0.35 cups).[66] Elementary and middle schools in South Carolina with FTS programs also experienced an increase in vegetable consumption, but not fruit, compared to control schools.[67] The authors found fruit consumption increased when a la carte items were not served as lunch snacks.[67] Of the 4 studies, Jones et al. was the only one that investigated middle schools instead of elementary schools. Jones et al. also had a much smaller sample size (528 vs 1117, 1877, and 3726). These differences may have influenced the null results for fruit consumption.

**Purchasing Patterns and Projections of Locally Sourced FV**

Two studies identified purchasing patterns of locally sourced items in various FTS programs.[68,69] From July 7, 2014 – May 20, 2015, Title 1 public schools in the Sarasota County School District spent less of their FV budget (29.6%) on local produce versus more affluent schools (34.1%).[68] A study involving 9 states across the US concluded that the size of the school could also affect local produce purchasing habits, as larger schools purchased local foods daily more frequently than medium and small schools.[69]

Two studies used modeling techniques to predict how local FV procurement would change under different circumstances.[70,71] Based on how much produce was being served in two school districts in Mississippi, it was predicted that roughly 30,000 lbs of local FV would need to be purchased to provide 500 students with at least one locally sourced fruit or vegetable per week.[70] Another study predicted how local FV procurement would have changed for 3 Northern Colorado school districts if reimbursement rates under CO HB 19-1132 were modified in August-December 2017 and 2018. Increasing the reimbursement rate resulted in an increased prediction of local FV procurement, however, the models were different depending on the season. When 100% reimbursement for local produce was modeled, FV purchases from August – October in 2017 and 2018 increased by 11% and 12%, respectively, while from November - December of 2017 and 2018, the expected increase would be by 1% and 0%, respectively.[71]

**<u>Increasing FV Procurement in Schools</u>**

Two studies looked at other factors affecting local FV procurement. FTS programs more than tripled from 2006 – 2007 (5.1%) to 2008 – 2009 (18.0%) in U.S public elementary schools, coinciding with a similar increase in the number of those schools in a state with a FTS program law (7.7% to 20.8% in the same period).[72] The researchers concluded that this increase was correlated with increased FV availability at these schools, and could have led to a parallel rise in FV consumption.[72] One qualitative study explored the barriers preventing Indiana school food service directors from procuring local FV. The results showed that factors such as the schools' proximity to local farms, dependability of local producers, and the total number of produce farmers in the area were all factors preventing local FV procurement. Notably, the authors noted that almost 96% of Indiana's crop production includes row crops, like corn and soybeans, and < 2% includes FV.[73] This is a similar situation to South Dakota: < 0.1% of crop sales in the South Dakota came from FV in 2017.[74]

## South Dakota and Farm to School

**<u>SD Farm to School History</u>**

South Dakota's FTS history began in 2010 when Dakota Rural Action (DRA) joined the National Farm to School Network. DRA is a nonprofit organization that focuses on local food and farm initiatives, including the SD Local Foods Directory and Dakota Rural Action Farmers Network.[75] In 2016, DRA helped launch the SD Farm to School Taskforce, which has aided in statewide FTS efforts by connecting FTS implementers to resources, training, federal and state agencies, and other networking opportunities.[76]

One of the first instances of FTS procurement in South Dakota was the Beef to School Program at Wall School District in 2018. In 2019, a local rancher provided six cows to the school per semester through their partnerships with Wall Meat Processing and Lynn Dunker, the food service director of Wall School District..[22,77] Brandon Valley School District in Brandon, SD was one of the first school districts in the state to implement procurement of local produce. From 2018-2020, the district collaborated with DRA, Homegrown Chapter, and Cherry Rock Creek to procure produce for its summer meal programs and school salad bars year-round. As of 2022, Brandon Valley School District procured local produce from Cherry Rock and Hoversten Orchard (personal communication, Andrea Kruse, Brandon Valley Child Nutrition Director, 2022). More FTS expansion took place in 2021 as Laura B. Anderson Elementary School in Sioux Falls implemented its own school garden in the Riverside neighborhood. Four planter boxes on the school's front lawn encouraged school and community involvement in producing fruits and vegetables, such as rhubarb and tomatoes.[78] To spread more local produce awareness across South Dakota and the other "Mountain Plain" states, the Mountain Plains Crunch Off was initiated in 2019. The Crunch Off is a social media competition among the states in the region, encouraging schoolchildren and FTS partners to "crunch" into local produce, like apples. The South Dakota Crunch Off has been organized by SDSU Extension and the South Dakota Department of Education.[79]

## Farm to School Grants

The most recent summary of grant awards (FY2013 – FY2018) reported that SD requested 15 FTS grants ($846,884) and was awarded 4 ($184,414), ranking them 48th in the United States for dollars distributed.[80] Since then, 5 grants have been awarded, totaling $406,194.[81] The details of these grants are outlined in Table 2.

**Table 2:** Farm to School Grants Awarded to South Dakota[81]

| Fiscal Year | Amount | Awardee | Partners | Type | Purpose |
|---|---|---|---|---|---|
| 2013 | $39,463 | Bureau of Indian Affairs-Flandreau Indian School | N/A | Planning Grant | Implement local produce and meat within school meals, provide education of these products, and construct a school garden. |
| 2015 | $99,189 | Inter Tribal Buffalo Council | N/A | Support Service | Assist schools on Tribal Reservations by increasing local food access, especially bison, and develop garden programs. |

| | | | | | |
|---|---|---|---|---|---|
| 2017 | $24,158 | South Dakota Department of Education | South Dakota State University Extension and Dakota Rural Action | Training | To bring forth state-wide training opportunities on farm to school procurement and develop the "South Dakota Farm to School Procurement Training Handbook." |
| 2019 | $50,000 | Brookings School District: | Brookings School District, South Dakota State University Extension, the Fishback Center for Early Childhood Education, and the Local Foods Education Center | Planning | Develop an action plan to increase local procurement and education in early care setting. |
| 2020 | $98,250 | SD Department of Agriculture | South Dakota Department of Education, South Dakota Department of Health, Dakota Rural Action, South Dakota State University Extension Service, | State Agency | From the South Dakota Farm to School Network to provide a space for producers and schools interested in Farm to School implementation. |
| 2022 | $91,554 | Cheyenne River Sioux Tribe (CRST) | CRST Buffalo Authority Corporation, School administrations and Boards on | Implementation | Implement local beef and buffalo to school lunch programs. |

| | | | | | |
|---|---|---|---|---|---|
| | | | the Reservation, Bureau of Indian Education, SD Beef Industry Council, InterTribal Buffalo and Agriculture Councils. | | |
| 2022 | $23,474 | Gayville-Volin School District | N/A | Planning | Increase exposure to local foods through meal service and cooking demonstrations. |
| 2022 | $100,000 | Lower Brule Schools | South Dakota State University, Lower Brule Sioux Tribe and South Dakota University Pierre Regional Extension Center. | Implementation | Develop a facility for year-round growth of fruits and vegetables and implement produce within the school salad bar. |
| 2022 | $92,916 | SD Department of Education | South Dakota State University Extension and Dakota Rural Action | State Agency | To achieve four objectives concerning farm to school stakeholder networking and branding. |

**<u>Farm to School Practices in South Dakota</u>**

Sixty-nine percent of SFAs in South Dakota, a total of 133 SFAs representing 433 schools, responded to the 2019 FTS Census. Of those who responded, 81 SFAs (61%)

reported implementing a FTS program for less than three years, while 7 (5%) have implemented FTS for >10 years.[82] Of these SFAs, 73 South Dakota school districts were implementing FTS or interested in doing so, as reported by South Dakota Specialty Producers Association.[83] The FTS census numbers may be higher than what was reported by the South Dakota Specialty Producers Association because there may be >1 reporting SFA per school district.

According to the FTS Census, 44% of SD SFAs use at least one FTS activity, 52.5% provide food, nutrition, or agricultural education, and 28.8% have an edible garden. Regarding local food procurement, reports show that 61% of SD SFAs procure local food for the NSLP, and 42% of SFAs procure them for the SBP. South Dakota SFAs reported different definitions of what they constituted "local" foods for their FTS activities (Figure 4). Notably, 44% reported having no set definition of local foods; a further 17% are not sure.[60]

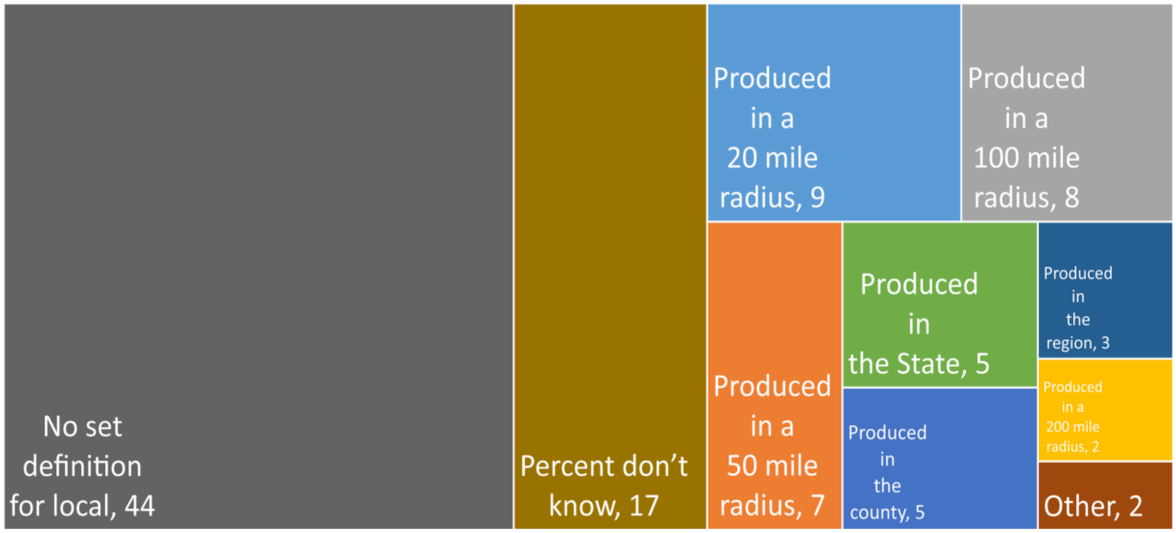


**Figure 4:** Definitions of Local Food used by South Dakota School Food Authorities Who Implement Farm to School.[82]

To better understand topics related to the aim of this thesis, exploration of current literature was conducted. The word "local" can possess multiple meanings; thus, it is important to identify how this word is interpreted. School program minimum requirements were identified. FTS activities and practices were determined. A systematic review of current literature highlighted involvement of FTS activities. The history of FTS utilization within South Dakota was reviewed. With this information, understanding of critical topics of concern can now be applied to the current research conducted.

# CHAPTER 3: MANUSCRIPT

## Introduction

Diet quality among U.S. children is substandard, as Healthy Eating Indices for this life stage range from 51-61 out of 100, decreasing from early childhood into adolescence.[55] Particularly, fewer than 10% of school-aged children adhere to fruit recommendations while fewer than 5% adhere to vegetable recommendations.[1] Inadequate intake of fruits and vegetables (FV) can result in insufficient calcium, vitamin D, potassium, and fiber, among other nutrients that are vital to the growth and overall health of an individual.[55] Many factors along the socio-ecological model influence FV intake among children, including physical and social environments, as well as individual and interpersonal factors.[84-86]

Child Nutrition programs, particularly the National School Lunch Program[47] and School Breakfast Program[52], have been shown to improve diet quality among school-aged children by providing nutritious meals that meet the Dietary Guidelines for Americans.[87-90] Students in grades K-12 whose families have an income under 185% of the Federal Poverty Line are eligible for free or reduced-price meals through these programs.[47] Nationally, in Fiscal Year (FY) 2023, 70.8% of lunches and 79.5% of breakfasts provided by these programs were free or reduced-price.[54] Meal nutrition standards are required of school breakfast and lunch providers by the U.S. Department of Agriculture (USDA) in order to receive reimbursement for program-eligible meals. One requirement set via the

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Healthy Hunger-Free Kids Act of 2010 is the provision of minimum daily servings of fruits and vegetables. These daily requirements include:

- Breakfast: 1 cup of fruit for grades K-12[58]
- Lunch: ¾ cup of vegetables and ½ cup of fruit for grades K-8, 1 cup of both fruits and vegetables for grades 9-12[57]

However, FV consumption at school meals remains low. According to national data, 96% of participating schools offer vegetables and 94% of schools offer fruit, yet only 51% and 45% of all students consumed vegetables and fruits for lunch, respectively.[8] Many of the FVs not eaten are wasted by schoolchildren. Studies have shown an increase in FV plate waste when a lower variety of FVs are offered at meals, [9,10,91] when whole fruits are offered instead of canned or cut fresh fruit,[10] when potato products were offered (competing with raw vegetables), [10] and among middle schoolers when compared to elementary schoolers.[11]

Farm to School (FTS) is one initiative that has been designed to increase school-aged children's FV intake through leveraging partnerships with local agriculture. FTS programs typically consist of ≥1 of 3 activities: procurement of locally-sourced foods for school meals, food and nutrition education with an emphasis on local foods, and hands-on school or youth gardening.[60] Implementing FTS activities has been shown to positively affect the knowledge and attitudes of school-aged children towards increased FV consumption, especially when repeated exposures to and tastings of local foods are used.[14,64,65] FTS has been shown to reduce FV food waste as offering local FVs at school meals has increased consumption.[13-16]

According to the 2019 Farm to School Census, 65% of the reporting school food authorities (SFA) participated in one or more FTS activities during the 2018-2019 school year.[60] Local procurement was reported as the most implemented activity (88%), with fruits and vegetables being the most common locally purchased food item.[60] However, local FV procurement likely varies greatly by state. For instance, South Dakota, a rural state in the Northern Great Plains highly susceptible to drought, high winds, low wind chill temperatures, and periods of heavy snow, does not grow a substantial amount of FV.[92] Of the 50 states, South Dakota was ranked 47$^{th}$ in fruit, tree nuts, and berries sales ($2.26 million in 2022) and 50$^{th}$ in sales of vegetables, melons, potatoes, and sweet potatoes ($7.02 million in 2022); yet, the state sold ~$7.4 billion in grains, oilseeds, dry beans, and dry peas in 2022, ranking it 9$^{th}$.[19]

As the FTS movement continues to grow, a question that has remained unanswered in the literature is whether certain states that grow low quantities of FV, such as South Dakota, have the capacity to meet the nutritional standards of the School Breakfast and National School Lunch Programs through local FV procurement. While school meal programs implementing FTS are by no means required to only procure local foods (and in most cases, it would be impossible to do so), defining the gaps in local food systems at the state level can help inform policies and programs to help support local FV producers in increasing either their operation sizes or their yields. This, in turn, would help schools procure more local produce for school meals, which in combination with FTS educational activities, could spur K-12 students to consume more FV and improve their diet quality. Thus, the purpose of this study is to determine the capacity of the state of South Dakota to supply FVs to meet the nutritional requirements for K-12 school meal programs throughout the state. We hypothesized that the number of FV grown in South Dakota was not sufficient to meet the minimum total servings per cup requirements needed by South Dakota public schools.

## Methods

### **Data Sets Used**

This study is a secondary data analysis of 2017 data from the U.S. Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) and the South Dakota Department of Education (SD DOE). Publicly available information from the NASS 2017 Census of Agriculture[93] was used for the collection of South Dakota FV production data. The NASS 2022 Census of Agriculture[94] was released prior to publication; however, data collection and analysis were conducted before these data were available. School enrollment data for the 2016-2017 and 2017-2018 school years were collected from public records on the SD DOE website,[95] and a data set including the number of reimbursable school breakfasts and lunches from each school district for the same years was provided to the researchers from the SD DOE upon request. This research study was considered exempt by the Institutional Review Board at South Dakota State University.

## Measures

***Agricultural Production.*** The harvested or "bearing" area was reported, in acres, for each FV listed in the 2017 Census of Agriculture (except for "tomatoes under protection," i.e., greenhouse-grown tomatoes, which were measured in sq ft and were converted to acres by the researchers). All FV acreages for the state of South Dakota were assessed. The FVs were excluded from analysis if the reported acreage was marked as "z" or "d", which denoted that the data collected was less than half of the reference unit (i.e., 1 acre) or that the information was withheld to avoid disclosing data from individual farms, respectively. Moreover, FVs were excluded from the analysis if they could not feasibly be served in their whole form for a school meal (e.g., rhubarb, or vegetables used as herbs, like garlic). Split peas were also excluded from the analysis, as most split peas grown in South Dakota undergo fractionation to produce pea protein, as opposed to being consumed as a whole legume.[96]

Yields for each crop, in hundredweight (cwt) per acre, were collected to estimate the total number of pounds of each harvested crop. Due to South Dakota's relatively low production of FVs compared to other states, it is exempt from reporting yield estimates for FV crops to NASS; thus, state-level yield estimates were unavailable from this data set. National yield estimates from the 2017 NASS Census, averaged from states that were required to report yield data for each crop were used when possible. However, certain crops have not had national yield estimates reported in NASS databases for decades; thus, when needed, online resources from Cooperative Extension were consulted and used instead.[97-111]

***Meal Data.*** Public and private schools were included in the analysis if they participated in the NSLP at any point in the 2017 school year. Schools with no available data for calendar year 2017 were excluded, as well as facilities that were classified as Community Support Providers (i.e., organizations that deliver meal services and support to individuals with disabilities and their families).[112]

As school breakfast and lunch meal requirements differ by grade groups (K-5, 6-8, and 9-12), and the SD DOE did not collect information from school districts on the grade level of each meal recipient, enrollment data from the 2016-2017 and 2017-2018 school years were used to estimate the number of meals per grade. One school district did not have enrollment data available and was excluded from the analysis.

## Analysis

Analyses were conducted with Microsoft Excel. The number of edible cups of each FV was determined by multiplying the total number of pounds (determined from multiplying the acreage by the yield, then converting cwt to pounds) by the number of servings per pound stated by the USDA Food Buying Guides,[113,114] then adjusting for the serving size (e.g., if the serving size was ¼ cup, the number of servings was multiplied by 4 to convert to the number of cups). The servings per pound in the Food Buying Guides accounted for the yield loss in the conversion of each food from its As Purchased (A.P.) to Edible Portion (E.P.) state. For foods that could feasibly be served multiple ways in school meals (e.g., apples could be served fresh or made into apple sauce), the researchers determined what would be the most commonly served form of the produce, and that form was used for the A.P. to E.P. conversion estimates.

To estimate the number of meals served to students in each grade group (K-5, 6-8, and 9-12), the researchers assumed that for each school district, the number of students per grade who received school meals was directly proportional to that school district's enrollment. Thus, the 2016-2017 school year enrollments provided grade group estimates for school meals from January-July 2017, and the 2017-2018 school year enrollments provided grade group estimates for school meals from August-December 2017.

Estimates were found for total cups of fruits, vegetables, and vegetable subgroups (dark greens, red/orange, starchy, legumes, and others) for each grade group by multiplying the total number of breakfasts or lunches served to a grade group by the USDA's minimum serving size requirement.[57,58] To determine if the total cup requirements within SD schools were met, the total cups of FV or vegetable subgroup produced were divided by the total cups needed.

## Results

After the application of the inclusion criteria and aggregating information from the two data sets, a total of 13 fruits and 36 vegetables were included in the analysis. A total of 19,525 acres (492 acres for fruits and 19,033 for vegetables) were utilized for FV production in 2017. One hundred eighty-three school districts state-wide were included in this analysis. Across these districts over the SY 2017, 4,396,834 breakfasts and 16,676,559 lunches were served. The total school enrollment was 144,388 in 2016-2017 and 145,643 in 2017-2018.

Regarding fruit production in South Dakota, apples were the most harvested at 33% of the total acreage of fruit, grapes were second at 25%, and watermelon third at 18% (Table 3). Almost 10 million cups of edible fruit were produced in 2017; per capita based on 2017 Census estimates,[93] this equates to roughly 11 cups per capita, or 0.03 cups per capita per day. Watermelon comprised the most edible cups of fruit at 5,019,095, approximately 50%. Cantaloupes were the second highest at 1,778,200 cups (18%), and aronia berries were third at 1,749,300 cups (17.6%) (Table 3).

Of the total vegetables grown in South Dakota, legumes made up roughly 77% of the total harvested acres, thus, Table 3 presents the vegetable results both with and without legumes. When legumes are not accounted for, the total acres of vegetable production equals 695 acres, with pumpkin production utilizing 23% of these acres. The subcategory of dark green vegetables only accounts for nearly 2% of total acres for vegetable production when legumes were excluded, with romaine lettuce contributing 1 acre and kale contributing 6. “Red/orange” vegetables were the highest category of edible cups at 13.9 million cups making up roughly 40% of the total cups produced when legumes were not accounted for. However, with legumes having 121.5 million edible cups, “red/orange” vegetables dropped to roughly 9% of the total cups of vegetables produced (Table 3).

**Table 3:** 2017 Fruit and Vegetable Production in South Dakota: Estimated Acres, Yield, Hundredweight, Edible Portion (EP) Available per pound, and Total Cups Produced

| ***Produce*** | **Acres[a]** | **Yield (cwt/acre)[b]** | **Total Hundredweight** | **EP Cups per Pound[c]** | **Total Number of Cups[d]** |
|---|---|---|---|---|---|
| ***Fruit*** | 492 | 112.6[e] | 55,377 | 1.8 | 9,954,853 |
| Apples | 162 | 17.6 | 2,851 | 3.6 | 1,037,837 |
| Aronia Berries | 42 | 140.0[f] | 5,880 | 2.9 | 1,749,300 |
| Cherries, Tart | 4 | 3.7 | 15 | 1.6 | 2,355 |
| Elderberries | 1 | 33.9[f] | 34 | 2.9 | 10,100 |
| Grapes | 123 | 7.4 | 910 | 2.9 | 265,323 |
| Melons, Cantaloupe | 51 | 243.4 | 12,413 | 1.4 | 1,778,220 |
| Melons, Watermelon | 87 | 378.3 | 32,912 | 1.5 | 5,019,095 |
| Pears | 2 | 16.0 | 32 | 2.1 | 6,560 |
| Pears (excluding Bartlett) | 1 | 16.0 | 16 | 1.0 | 1,640 |
| Pears, Bartlett | 2 | 16.0 | 32 | 2.9 | 9,160 |
| Plums | 3 | 7.9 | 24 | 2.7 | 6,308 |
| Raspberries | 5 | 5.7 | 28 | 3.0 | 8,546 |
| Strawberries | 9 | 25.6 | 230 | 2.6 | 60,409 |
| ***Vegetables (Excluding Legumes)*** | 674 | 253.6[e] | 170,947 | 2.1 | 36,276,233 |
| *Dark Green* | *13* | *197.9[e]* | *2,573* | *5.2* | *1,336,964* |
| Broccoli | 4 | 158.5 | 634 | 2.9 | 182,275 |
| Greens, Kale | 6 | 230.0[f] | 1,380 | 6.1 | 841800 |
| Lettuce, Romaine | 1 | 309.0 | 309 | 3.9 | 121,013 |
| Spinach | 2 | 125.0 | 250 | 7.8 | 191,875 |
| *Red/orange* | *207* | *363.0[e]* | *75,145* | *1.9* | *13,948,639* |

| | | | | | |
|---|---|---|---|---|---|
| Carrots | 11 | 408.4 | 4,492 | 4.9 | 2,234,969 |
| Pumpkins | 158 | 220.2 | 34,792 | 1.2 | 4,088,013 |
| Sweet Potatoes | 2 | 224.0 | 448 | 1.7 | 73,920 |
| Tomatoes, in the Open | 33 | 791.2 | 26,110 | 2.1 | 5,567,872 |
| Tomatoes, Under Protection | 3 | 3,101.0 | 9,303 | 2.1 | 1,983,864 |
| *Starchy* | *240* | *236.2*[e] | *56,681* | *1.8* | *10,169,048* |
| Peas, green (excl Southern) | 4 | 22.0 | 88 | 6.4 | 56,320 |
| Potatoes | 97 | 350.0 | 33,950 | 2.1 | 7,129,500 |
| Sweet Corn | 139 | 162.9 | 22,643 | 1.3 | 2,983,228 |
| *Other* | *193* | *189.4*[e] | *36,548* | *2.4* | *8,803,800* |
| Asparagus | 12 | 32.0 | 384 | 1.2 | 46,080 |
| Beans, Snap | 14 | 85.2 | 1193 | 3.1 | 369,768 |
| Beets | 8 | 31.7 | 254 | 1.9 | 48,818 |
| Brussels Sprouts | 1 | 140.0[f] | 140 | 3.4 | 46,900 |
| Cabbage, Chinese | 1 | 450.0[f] | 450 | 1.8 | 81,000 |
| Cabbage, Head | 11 | 392.3[f] | 4,315 | 2.8 | 1,208,284 |
| Cauliflower | 2 | 198.1 | 396 | 3.1 | 121,831 |
| Celery | 1 | 505.9 | 506 | 3.1 | 158,094 |
| Cucumbers | 25 | 161.4 | 4,035 | 3.1 | 1,250,850 |
| Eggplant | 2 | 165.0[f] | 330 | 1.7 | 55,275 |
| Lettuce, Head | 2 | 351.1 | 702 | 2.6 | 182,572 |
| Lettuce, Leaf | 6 | 203.5 | 1,221 | 2.7 | 331,196 |
| Okra | 1 | 90.0[f] | 90 | 2.4 | 21,825 |
| Onions, Dry | 14 | 543.8 | 7613 | 1.9 | 1,503,607 |
| Onions, Green | 1 | 99.0[f] | 99 | 1.7 | 16,583 |
| Peppers, Bell | 11 | 341.0 | 3,751 | 2.4 | 909,618 |

| | | | | | |
|---|---|---|---|---|---|
| Pepper, Chile | 7 | 208.5 | 1,460 | 3.9 | 569,205 |
| Radishes | 4 | 96.0[f] | 384 | 3.8 | 146,880 |
| Squash, Summer | 10 | 24.9 | 249 | 2.1 | 52,415 |
| Squash, Winter | 60 | 149.6 | 8,976 | 1.9 | 1,683,000 |
| *Unidentified[g]* | *21* | *289.5[e]* | *6,080* | *3.3* | *2,017,781* |
| ***Vegetables (Including Legumes)*** | 19,033 | 19.2[e] | 365,633 | 4.3 | 157,700,970 |
| *Legumes* | *18,359* | *10.6[e]* | *194,681* | *6.2* | *121,460,737* |
| Beans, dry edible (excl chickpeas/lima) | 5,619 | 22.1[f] | 124,180 | 6.2 | 76,991,538 |
| Chickpeas | 4,992 | 12.4[f] | 61,901 | 6.2 | 38,068,992 |
| Lentils | 7,748 | 1.1[f] | 8,600 | 7.4 | 6,364,207 |

a = data obtained from the 2017 National Agricultural Statistics Service reflecting total acres harvested.

b = Measured in hundredweight (100 lbs.) per acre. Data was obtained from the National Agricultural Statistics Service 2017 Census of Agriculture, unless otherwise noted.

c = data collected from the Food and Nutrition Service Food Buying Guide

d = The total cups were calculated by multiplying the hundredweight by the E.P. Cups per Pound. The product was multiplied by 100.

e = Denotes a weighted average yield of all produce in that category or subcategory.

f = Denotes a yield estimate sourced from Cooperative Extension. See sources 3-17 for more information.

g = “Unidentified” relates to vegetables that did not have a specific code on the census, as defined by the General Explanation and Census of Agriculture Report Form.

Of the total number of students enrolled in a K-12 school participating in the School Breakfast and/or National School Lunch Program, roughly 50% were in grades K-5, 30% in grades 9-12, and 20% in grades 6-8 (Table 4). Over 21 million meals were redeemed in South Dakota during 2017, or about 145 meals per student. The minimum fruit requirements were greater than that for vegetables by roughly 1.4 million, as fruit requirements were applied for both breakfasts and lunches. Minimum fruit and vegetable requirements for 9th-12th graders made up 40% and 34% of the total minimum serving requirements, respectively. Although this grade group only made up 30% of the student population, the minimum fruit and vegetable requirements are greater for these grades compared to the others.

**Table 4:** 2017 Enrollment and Redeemed Meals of K-12 South Dakota Schools, With Estimated Meals Distributed in Each Grade and Minimum Fruit and Vegetable Serving Size Requirement in Cups

| | K-5 | 6-8 | 9-12 | Total |
|---|---|---|---|---|
| **Enrollment** | | | | |
| **January – July 2017**[a] | 70,414 | 32,924 | 41,050 | 144,388 |
| **August-December 2017**[b] | 70,399 | 33,827 | 41,417 | 145,643 |
| **Redeemed Meals**[c] | | | | |
| **Breakfast** | 2,161,763 | 1,023,365 | 1,213,080 | 4,398,208 |
| **Lunch** | 8,120,162 | 3,836,674 | 4,719,723 | 16,676,559 |
| **Total** | 10,281,925 | 4,860,039 | 5,932,803 | 21,074,767 |
| **Minimum Cup Requirements**[d] | | | | |
| **Fruits** | | | | |
| **Breakfast** | 2,161,763 | 1,023,365 | 1,213,080 | 4,398,208 |
| **Lunch** | 4,060,081 | 1,918,337 | 4,719,723 | 10,698,141 |
| **Total** | 6,221,844 | 2,941,702 | 5,932,803 | 15,096,349 |
| **Vegetables** | | | | |
| **Lunch** | 6,090,121 | 2,877,506 | 4,719,723 | 13,687,350 |

**SY = School Year**

a = Data from the 2016-2017 school year, reflecting students enrolled on the last day of September 2016.

b = Data from the 2017-2018 school year, reflecting students enrolled on the last day of September 2017.

c = Data from the South Dakota Department of Education proportional to enrollment estimates for redeemed meals in 2017, due to not having individual grade redemption.

d = Calculated based on the minimum cup requirements of fruits and vegetables for each age group. BREAKFAST: Grades K-5, 1 cup fruit; 6-8, 1 cup fruit; 9-12, 1 cup fruit. LUNCH: Grades K-5, ½ cup fruit, ¾ cup vegetable; Grades 6-8, ½ cup fruit, ¾ cup vegetable; Grades 9-12 1 cup fruit, 1 cup vegetable. Data from the USDA Breakfast Program and the National School Lunch Program

The amount of FVs grown in South Dakota in 2017 was able to meet most serving size requirements for the number of K-12 school meals served (Table 5). However, dark green vegetables and total fruit production were not sufficient, with 80% and 66% of all schools' minimum serving requirements being met, respectively. Notably, South Dakota legume production (excluding split peas) was able to meet school meal needs 72 times over, with over 121 million edible cups grown in 2017.

**Table 5**: Fruit and Vegetable Serving Size Requirements Met by South Dakota Production in K-12 Schools in 2017

| *Produce Category* | Total Cups Produced in SD | Total Cups Needed in K-12 Schools | Percent School Needs Met by SD Production |
|---|---|---|---|
| *Fruits*[a] | 9,954,853 | 15,096,349 | 66 |
| *Vegetables*[a] | 157,612,173 | 13,687,350 | 1152 |
| *Dark Green*[b] | 1,336,964 | 1,667,656 | 80 |
| *Legumes*[b] | 121,424,737 | 1,667,656 | 7281 |
| *Red/orange*[b] | 13,948,639 | 2,973,456 | 469 |
| *Starchy*[b] | 10,169,048 | 1,667,656 | 610 |
| *Other*[b] | 8,803,800 | 1,903,642 | 462 |

*a* = Based on the daily serving size minimum requirements: BREAKFAST: Grades K-5, 1 cup fruit; 6-8, 1 cup fruit; 9-12, 1 cup fruit. LUNCH: Grades K-5, ½ cup fruit, ¾ cup vegetable; Grades 6-8, ½ cup fruit, ¾ cup vegetable; Grades 9-12 1 cup fruit, 1 cup vegetable. Data from the USDA School Breakfast Program and the National School Lunch Program.

*b* = Based on the weekly serving size minimum requirements. Dark green: ½ cup (K-12); Legumes: ½ cup (K-12); Red/Orange: ¾ cup (K-8), 1¼ cup (9-12); Starchy: ½ cup (K-12); Other: ½ cup (K-8), ¾ cup (9-12). Data from the USDA National School Lunch Program.

## Discussion

The results of this study found that South Dakota's fruit production was not adequate to meet the minimum serving size requirements for K-12 school meals in the state, but vegetable production was sufficient, except for dark green vegetables. Production fell short of reaching minimum school meal needs by 34% and 20% for fruits and dark green vegetables, respectively.

According to the World Health Organization, global total FV yield is 22% lower than that needed to reach nutrition recommendations for the world's population.[115] However, geospatial and food systems models reveal at a national level, the United States has the potential to grow enough FVs to meet the recommended intake for Americans.[116] Regionally, McCarthy et al. observed through geospatial models that each U.S. region has the biophysical potential to meet FV needs; however, land requirements, crop production, and population all factor between regions. For example, in the West North Central States of Montana, Wyoming, North and South Dakota, and Nebraska, less than 1% of current crop land would be needed exclusively for fruit and vegetable production to meet both the current and recommended intake.[116] Overall, modeling estimated that 12.2 million hectares (~30.5 million acres) or 7.5% of all crop land would be needed specifically for FVs to produce enough to meet the recommended nutritional intake levels according to the 2015 Dietary Guidelines for Americans.[116] This means that cropland for FVs would nationally need to increase by 7.5 million hectares (~18.7 million acres) to meet nutritional needs.[116]

Although increasing FV production in low-producing states like South Dakota would help FTS implementers in those states procure local FVs, Huang et al. noted that national FV production in the U.S. is declining, while imports, particularly through trade with Mexico, are increasing.[117] Several factors, including the implementation of the North American Free Trade Agreement, the depreciation of the Mexican peso, and improved economy and employment opportunities in Mexico versus the U.S., have been speculated to contribute to this trend.[117] The U.S. labor shortfall due to the COVID-19 pandemic has resulted in major crop losses of $16 million in lettuce, $5 million in apples, and $4 million in grapes, among others, particularly in states like California, Florida, and Arizona.[118] The high losses in these states may directly correlate to the increase in imports, as Huang et al. indicated these states are greatly affected by imports of FV from Mexico.[117] With the increased competition between imports, domestic production of FVs may decline resulting in less local produce available for FTS implementation.

Processing and statistical models have been developed by other researchers to help predict crop growth and yield. Processing tools include The Decision Support System for Agrotechnology Transfer[119] and LINTUL-POTATO-DSS,[120] which use physical information such as soil-plant-atmosphere and water efficiency to estimate growth, development, and yield. Statistical tools, such as one created by Schlenker and Roberts, take historical yields and weather patterns to predict yield under specific weather conditions.[121] However, these methods require a large number of parameters and primarily observe commodity crops rather than FVs. A SIMPLE model was developed by Zhao et al., which uses fewer parameters to predict the growth of non-specific crops. Therefore, a wider variety of crops could be analyzed, including FVs and legumes.[122] Parameters included weather, soil characteristics, crop management data, and initial variables (biomass, temperatures, light). From this analysis, simulated outcomes were relatively similar to the observed outcomes for biomass and yield, with a relative root mean square error of 25.7% and 25.4%, respectively.[122] The above models were not used in the current analysis, as the focal point of interest was most current yields of FVs specifically rather than predicted yields incorporating external factors.

Although South Dakota accounts for roughly 2% of total vegetables grown (excluding legumes) in the U.S.,[123] enough vegetables were grown in 2017 to meet all vegetable subcategory requirements for South Dakota school meal programs except dark green vegetables. A trend of lower acreage dedicated to vegetables in the dark green category seems to be prevalent in the Midwest, as observed in romaine lettuce. According to 2017 NASS Census data, Minnesota grew 22 acres of romaine lettuce (0.02% of the national output) whereas Michigan's harvested acres were too small of a number to be quantified in the Census. Conversely, California recorded a total of 90,200 acres harvested for romaine lettuce alone.[93] This suggests that geographic location plays a role in the type of specialty crop produced and the amount which can be harvested. A variable that is impacted by location is temperature. Lettuce prefers to grow in temperatures of 65–70°F during the day and 45–55°F at night, with soil temperatures between 55 – 65ºF.[124,125] In states that experience only 3 seasons, such as those on the West Coast, temperatures may not be as much of a concern compared to states that experience winter, like those in the Midwest. Weather permitting, The University of Illinois Extension reports that romaine lettuce can be planted in late summer and harvested by late fall, as this type of lettuce is fairly heat tolerant.[125] On the other hand, romaine lettuce can be planted in California midsummer and harvested 65 – 80 days later, or planted in late fall to winter and be harvested up to 130 days later. Thus, other methods for growing dark green vegetables may be necessary to increase production in states affected by location and temperature.[126]

One factor not assessed in this study is whether the growing seasons of the FVs studied lined up with the months that most children are in school. For example, melons accounted for half of the fruit produced in South Dakota in 2017, but its growing season is only in the summertime. Thus, this crop is only feasible for FTS procurement when most schools are on summer break. This issue is even more pronounced in states like South Dakota, which have long winters and short growing seasons. However, programs such as Farm to Summer can be leveraged to implement FTS activities in sites participating in the Summer Food Service Program to provide and grow local fruits and vegetables during their peak growing season.[127] High tunnels provide an alternative avenue for expanding growing seasons for FVs such as lettuce and tomatoes. Climate can be controlled by enclosing crops planted in the ground with polyethylene along with heaters; thus, expanding growing seasons.[128]

Another caveat in the presented findings is that the proportion of FV processed versus being sold direct market was not able to be calculated. Roughly 210 million pounds of the apples grown in Michigan in 2017 were utilized for canning, while 75 million pounds were utilized for juice and cider production.[129] Of the 829,000 bearing acres of grapes produced in California for processing, 68% was utilized for wine production, 20% for raisins, and 13% for table grapes.[129] In the United States in 2017, tomatoes that were sent to be processed (219,085,340 cwt) were roughly ten times greater than tomatoes that went to the fresh market in their original form (20,969,700 cwt).[123] Due to processing data being unavailable from the NASS Census, our analysis did not account for fruits and vegetables that are processed into foods that are not eligible for school meal programs.

For instance, conversations with South Dakota State University Extension's horticulture specialist revealed that about 90% of grapes grown in South Dakota are used for wine production (Dr. Rhoda Burrows, personal communication, 2023). If this estimate is correct, only 12 acres of grapes were grown for non-wine purposes in South Dakota in 2017, or roughly 258 edible cups. Pumpkin production is another example where the total edible cups estimated in our model are likely inflated due to usage trends. Most pumpkins grown in South Dakota are grown and sold with the intention of being used for decoration (Dr. Rhoda Burrows, personal communication, 2023), however, the exact amount is not recorded or quantified in the Ag Census. Although aronia berries and grapes were included in this study, further discussion revealed that raw consumption of these products would not be desirable for K-12 school meal settings, and processing would need to take place to make these products palatable (Dr. Lang, personal communication, 2024). From this information, the number of total cups available from FV production for use in K-12 schools would be overestimated, as these crops would not be deemed appropriate for school service. Future research could investigate ways to account for the total amount of produce harvested for processing or other means not towards consumption.

Our model could also not account for the fact that some of the FVs grown in South Dakota are inevitably shipped and sold elsewhere. In 2017, international exports of processed vegetables from South Dakota produced a revenue of $1.4 million, while fresh vegetables brought in a revenue of $800,000. International fruit exports from South Dakota have not produced a revenue large enough to record since 2014.[130]

The major strength of this study is that it is the first known study of its kind that analyzed secondary data from both the USDA NASS Census of Agriculture and the SD Department of Education to determine state-level FTS capacity. One limitation is that the yields for each FV were sourced from national averages or Cooperative Extension resources instead of South Dakota-specific crop yields. Yet, this was the most valid information available, as small producers (like the ones who grow FV in South Dakota) rarely keep records of their crop yields. More detailed yield record keeping at the regional or state level could help further strengthen the estimates of future studies of this kind. Other limitations, as discussed previously, include the model's inability to account for seasonality, processing, and exporting of FVs.

## Implications for Research and Practice

This study highlighted the need for nutrition and agricultural scientists to work collaboratively to collect information that will help inform the development of local food systems. Data collection of total yield, processing, and distribution of FVs should be jointly accessible to provide a more precise understanding of FV production. By state, farmers and the Ag Census should collect and record the yield in pounds of FVs annually. With this information, totals in pounds of produce that remains in its "true" form along with total pounds of FVs that are processed should be recorded. From here, clarification of distribution by pounds should be stated. That is whether FVs are exported out of country or state, if they are distributed through contracts with companies or to consumers through grocery stores or farmers markets. By creating this progression, the total amount of fresh FVs in pounds that are distributed within the state could be determined. This way, nutritionists could partner with the Ag Census to provide the total cups of fresh produce within the state and have this information accessible with the previous agricultural information. This would allow for further analysis of whether state production of FVs would be sufficient to meet the recommended FV intakes from the Dietary Guidelines for Americans. Furthermore, utilization of fresh FV for use in programs such as FTS could be determined by using methods such as those presented in this study.

Further FTS research could explore other factors, beyond growing capacity, that affect schools' ability to procure local FVs. Kitchen space and equipment, as well as labor shortages in the school food service profession, could also impact the capacity of school districts to implement FTS. Many schools utilize a central kitchen model, where all meals are prepared at one location and then transported to other schools to serve.[131] This model could prevent the satellite schools from implementing FTS procurement. Even schools that prepare meals on-site might not have the space, equipment, or training to properly prepare fresh produce for school meals. In a survey of 724 North Carolina public schools, George et al. reported that 41% of respondents did not want to prepare local FVs for school meals due to increased time consumption and lack of labor capacity.[132] Further quantification of these barriers could help nutrition educators develop innovative ways to assist schools in improving their individual capacities for FTS procurement.

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