Food Distribution Research Society

*Journal of Food Distribution Research*
*Volume 57, Issue 2, pp. 1–28*

# Feasibility Assessment for a Pecan Shelling Cooperative

Edwin Coleman [a]Ⓘ, Rodney B. Holcomb[b], Phil Kenkel[c], Becky Carroll[d], and Kenneth Watkins[e]

[a]*Postdoctoral Research Fellow, Department of Agricultural Economics, Agricultural Hall, Oklahoma State University, Stillwater, OK 74078,USA*

[b]*Professor, Department of Agricultural Economics and Robert M. Kerr Food and Agricultural Products Center, 148 FAPC, Oklahoma State University, Stillwater, OK 74078,USA*

[c]*Professor, Department of Agricultural Economics, Agricultural Hall, Oklahoma State University, Stillwater, OK 74078,USA*

[d]*Department of Horticulture and Landscape Architecture, Oklahoma State University, Stillwater, OK 74078,USA*

[e]*Cimarron Valley Research Station, Oklahoma State University, Stillwater, OK 74078,USA*

## Abstract

Demand for pecans in U.S. is rising, yet small/midsize growers remain price takers. Capturing value requires converting in-shell pecans into value-added shelled products like snack-halves and meal, which demands capital-intensive facilities and compliance systems. We assess whether a producer-owned shelling cooperative can deliver this value. Using a stochastic capital-budgeting model linking prices, kernel yields, and patronage, we estimate cooperative and member Net Present Value (NPV), Internal Rate of Return (IRR), and an end-of-horizon cash-flow solvency check. Baseline results show viability: cooperative NPV is $0.75 million; IRR is 33%; member IRR is 31%. Ending cash-flow is positive in 95% of simulations.

**Keywords:** cooperative, internal rate of return, Monte Carlo simulation, net present value, pecan, stochastic feasibility

Ⓘ Corresponding author: Email: edcolem@okstate.edu

## Introduction

The pecan industry in the United States is experiencing increased demand, due primarily to expanding international markets and recognized health benefits. Domestic consumption remains strong, supported by clinical evidence of cardiometabolic benefits, while export demand continues to drive utilization and prices (McKay et al., 2018; Sidharthan, 2025; USDA-ERS, 2025). In the 2023–2024 marketing year, U.S. shelled-basis pecan exports were estimated to be 61% higher than the previous year (USDA-ERS, 2025). Much of this growth reflects the influence of markets such as China and India (United States Senate, 2025). These trends present substantial opportunities for producers but also underscore the growing need for consistent, high-quality shelled products.

Even with growing domestic and international demand, many small and medium-scale growers remain price takers. They often sell in-shell pecans through accumulators, local brokers, or truckers, losing per-unit value in the process (Texas Pecan Growers Association, 2025). During peak harvest, shellers operate at or near capacity, so delivery slots are scarce. Growers without scheduled intake must either hold inventory or sell quickly into the spot market, which raises costs or forces discounts and leaves them exposed to short-term price drops (Wells, 2024). Although USDA Agricultural Marketing Service (USDA-AMS) reporting on prices, inventories, and trade flows has improved transparency, the advantage still leans toward well-connected buyers and processors, sparking greater interest in producer-owned shelling capacity (Capps Jr, and Williams, 2019).

Modern commercial shelling facilities are capital intensive. They require cracking equipment, possibly an optical sorting to remove shell fragments and defects, a validated sanitation or "kill step" for pathogen control, food-grade space with appropriate environmental controls, and a documented Quality Assurance (QA) system with trained staff (Grocery Manufacturers Association and Peanut and Tree Nut Processors Association, 2016; Peanut and Tree Nut Processors Association, 2022). Under the Food Safety Modernization Act of 2011, shelling plants that are not otherwise exempt must comply with 21 CFR Part 117, which requires current good manufacturing practices, a written hazard analysis plan, preventive controls for sanitation and allergens, and verification and recordkeeping (Electronic Code of Federal Regulations [eCFR], 2025; U.S. Food and Drug Administration, 2025). Pecans are on FDA's "rarely consumed raw" list. That means the Produce Safety Rule in 21 CFR Part 112 does not apply at the farm level (eCFR, 2025). However, facilities that manufacture, process, pack, or hold pecans are still covered by Part 117. Some states also specify sanitizing steps for tree-nut shellers; for example, Oklahoma requires a bactericidal process and recognizes hot-water or hot-air treatments, which can add cost for smaller operators (Bowser, 2017; Oklahoma Administrative Code, 2025). Collectively, these equipment, validation, and documentation requirements raise the bar for individual growers considering a shelling operation and justify the consideration of a shared, cooperative infrastructure.

Given the capital and regulatory requirements for a commercial shelling operation, one question emerges: Can a regionally based pecan shelling cooperative enable local producers to achieve sufficient economies of scale in processing to create a feasible and stable business that can capture

value at the next stage of the value chain? This study addresses that question by conducting a stochastic feasibility assessment of a producer-owned shelling cooperative. The model evaluates whether a cooperative-scale plant could operate effectively, allowing members to retain more value through in-shell deliveries processed into snack-halves, pecan meal, and cracked shells.

The study presents a feasibility analysis that links process yields, operating costs, and financing choices to assess cooperative performance under stochastic member deliveries and market prices. From these simulations we report expected net present value (NPV), internal rate of return (IRR), member-level returns, cumulative cashflow, and the probability that NPV is positive to identify conditions under which a cooperative is financially viable. As with any feasibility analysis, an important step is to identify and understand market opportunities for final products. The financial viability of a value-added processing opportunity is then evaluated under prevailing market conditions.

Our contribution to pecan economics literature is a set of rudimentary but transparent economic findings that producer groups, lenders, and extension professionals can apply across producing regions to guide investment decisions related to the shelling and marketing of pecans. The remainder of the paper describes the cooperative framework, model, and data; presents results with robustness checks; and concludes with managerial and policy implications.

## Materials and Method

*Cooperative Framework*

The study models a producer-owned shelling operation organized as a closed membership cooperative and follows a purchase model. Under a purchase model, the cooperative purchases in-shell pecans at delivery based on the posted grower price and assumes title to the crop at intake, thereby bearing subsequent processing, inventory, and marketing risk. The term "closed membership cooperative" is used in the strict sense that membership shares in the cooperative are limited, and all throughput and patronage arise from member deliveries. Each share of stock has an associated usage right with the total usage rights matching the total processing volume. Under the closed membership structure there is no non-member volume. Members must purchase shares with associated usage rights during the initial equity drive, and after that period a share can only be obtained by purchasing it from an existing member. That structure provides the potential for the shares/usage rights to appreciate in value if individuals want to be able to deliver to the cooperative for the patronage benefits. The closed membership structure also provides a measure of liquidity to the members because they could sell their shares to another qualifying member if they exit pecan production.

Growers become members by purchasing membership common shares, which are nonrevolving, and each share has an associated 1-ton usage (delivery) right. Under the cooperative structure, profits are distributed in proportion to use, so the share does not directly create a return on investment. However, because usage rights are associated with the shares, the member's share of the total patronage will be proportional to their share of the total membership stock investment.

The membership stock also creates a governance right that confers one member, one vote. If a member desired to sell their shares with associated usage rights, the cooperative would not have an active role in that process, but the member purchasing the shares would have to be approved by the board. That approval would generally just require that they are an agricultural producer with the ability to deliver pecans.

The board approves intake and quality rules for member deliveries and annual budgets. The board also adopts a patronage allocation policy that sets the mix of cash and written notices of allocation and a revolvement policy that specifies when patronage equities are redeemed for cash. The baseline allocation of net return is 5% to unallocated reserve (UR), 50% as cash patronage refund (CP), and 45% as nonqualified stock (NQS) patronage refund (see Table 1). Patronage is allocated in proportion to pounds of in-shell pecans delivered by members. This basis is simple to administer and transparent to members. The cooperative is assumed to operate under a 5-year revolvement period, so patronage equities are redeemed on that schedule, subject to cash and loan agreements.

This patronage mix is chosen for tax and cash flow reasons. Both qualified and nonqualified stocks retain cash inside the cooperative, but they differ in tax timing. Qualified stock is deductible to the cooperative and taxable to the member at issuance, which forces members to pay tax without receiving cash and has been unpopular. Since the 2017 tax reform, the corporate rate is often below producers' effective rates once self-employment taxes are included, so it is more efficient to park the tax at the cooperative by issuing nonqualified stock, which is taxed to the member and deductible to the cooperative at redemption. Pairing nonqualified stock with a cash refund provides member liquidity while maintaining tax efficiency and internal capital, so we set qualified stock to zero.

Tax treatment for patronage follows Subchapter T of the U.S. Internal Revenue Code (26 U.S.C. §§ 1381–1388). Cash patronage is deductible to the cooperative and taxable to members in the year declared. Profits retained as unallocated reserves are not designated (allocated) to specific members but are instead collectively owned by the entire membership. Unlike revolving equity, unallocated reserves are never redeemed but instead create a permanent cushion fund. The function of unallocated reserves is to create a category of equity that could be reduced if the cooperative experienced a loss without having to write down the value of the revolving stock or membership stock. Unallocated reserves and nonqualified notices are not deductible at issuance; the cooperative pays income tax on these amounts at the modeled 30% rate. As discussed, members will be taxed on cash patronage when it is issued and the nonqualified stock patronage when it is redeemed. The cooperative will be able to deduct the cash patronage when issued and the nonqualified when it is redeemed, which implies that the cooperative's taxable income in any particular year will include the amount retained as unallocated reserves plus the amount retained as nonqualified revolving stock, less the amount of any previously issued nonqualified equity redeemed. In an actual pecan shelling cooperative, the board of directors would make decisions on the patronage mix each year after considering the cooperative's cash flow situation. They could therefore improve cash flow by reducing the cash patronage percentage or improve member return by issuing a greater proportion of cash. They could also switch from issuing qualified revolving equity patronage to nonqualified or vice versa. For the purposes of our simulation, we maintain

the profit distribution mix at the level logical for the baseline scenario. In doing so, we slightly overstate the probability of negative cash flow in unfavorable conditions because the board could have slightly moderated that condition by decreasing cash patronage. Similarly, we slightly overstate the impact of favorable conditions on member returns because the board could have increased the cash patronage percentage in response to more than adequate cash flow. It would be very difficult to model those flexibilities in profit distribution without complex decision rules. The decision to maintain a constant profit distribution mix across scenarios is therefore defendable.

*Shelling Facility and Capacity Assumptions*

The cooperative operates one shelling line, a single continuous train of equipment laid out for linear flow from receiving to packaging (see Figure 1). At receiving, each delivery is weighed and assigned a lot identity that links the load to the member, date, and variety class for traceability and settlement. Pre-cleaning removes foreign material, such as sticks and leaves, followed by a validated sanitation step. Drying is used as needed to bring moisture into the target range for clean cracking. Products then pass through cracking, shelling, and separation with aspiration and screens, sizing into halves and pieces on the inspection table and packaging. Kernel pieces are routed to meal grinding and sieving. Shells septum (internal partition) are collected along with shell pieces at the separation stage and prepared for bulk sale, primarily for mulch. The overall facility layout and process flow from receiving to packaging are illustrated in Figure 1.

Facility capacity is stated on an in-shell basis in pounds (lbs). The line uses two Savage Equipment pecan crackers, "238C cracker," rated at 750 lbs per hour each, giving a nameplate throughput of 1,500 lbs per hour. Planned operation is 12 hours per day over a 75-day season. Allowing 10% of available time for sanitation, changeovers, and minor stops yields 810 operating hours and an effective seasonal capacity of 1,215,000 lbs. This effective capacity represents the maximum in-shell intake the plant can process in a season. The 75-day operating assumption is based on the seasonal nature of pecan harvests, which occur primarily from October to December. During this period, member deliveries peak, and shelling facilities typically run at high utilization. Limiting the modeled season to 75 days captures this concentrated activity.

A baseline requirement of 1 horsepower (HP) per pound per hour of throughput is assumed as a simplifying engineering approximation to represent aggregate power demand across the shelling line. At the design scale of 1,500 lbs per hour, the line requires 1,500 HP, equivalent to approximately 1,120 kW using a conversion of 0.746 kW/HP. With 810 hours of operation annually, this calculation results in an estimated total energy demand of 972,000 kWh. Because actual equipment-level power requirements vary across processing components and operating conditions, this assumption serves as a planning approximation and may over- or under-estimate realized operating energy costs. To evaluate the robustness of this assumption, a sensitivity analysis was conducted by varying energy requirements from 50% below to 25% above the baseline level to assess the effect on feasibility results (see Results and Discussion section).

Finished goods, specifically snack-halves, pecan meal, and cracked shells, are derived from this intake using percentage coefficients specified in the next section. These coefficients define kernel yield by variety class and the share of kernels routed to snack-halves versus meal. Shell output equals the complement of kernel yield and is modeled as a by-product.

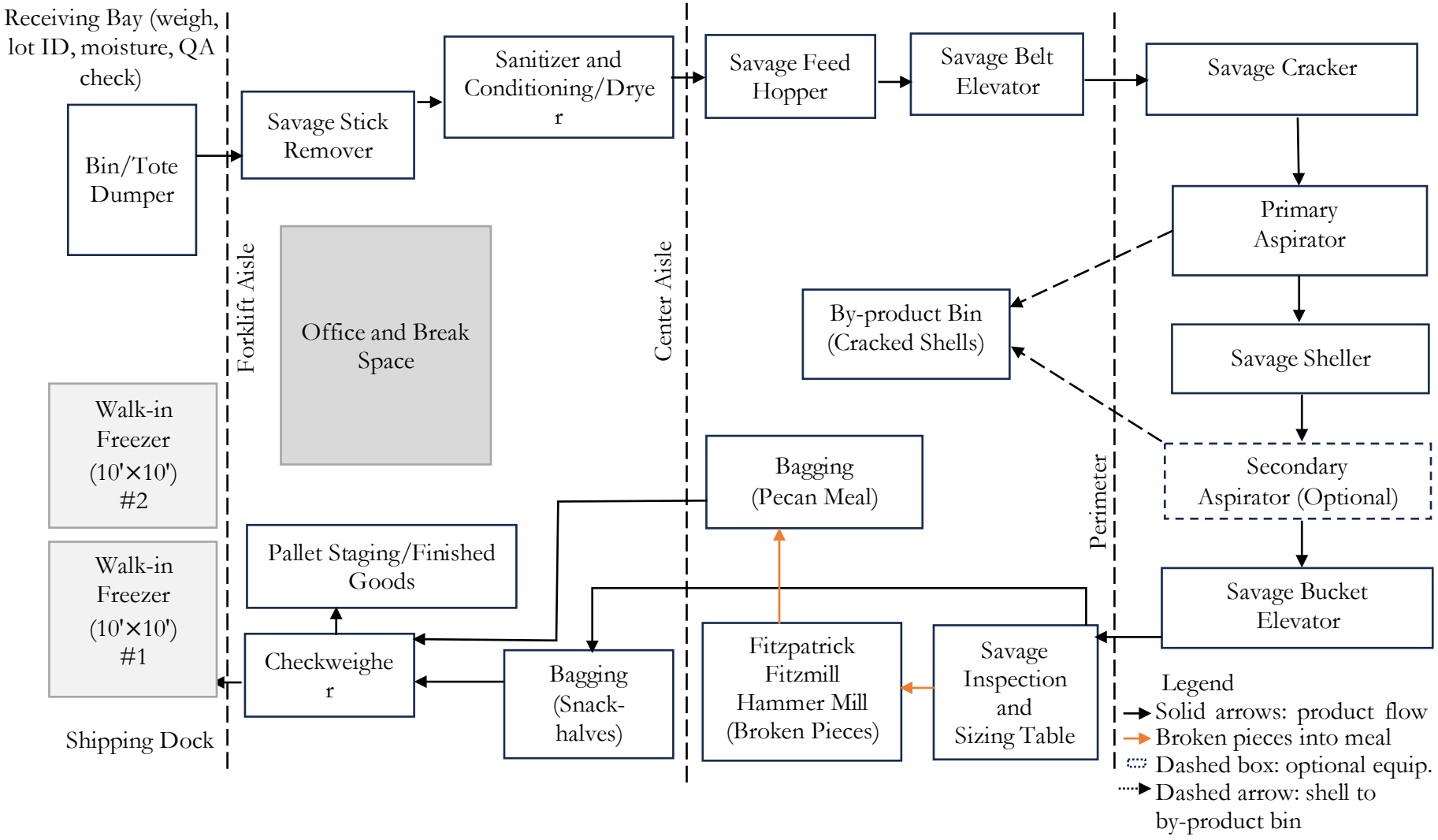



**Figure 1. Process Schematic of the Cooperative Pecan Shelling Line**

Note: At the inspection and sizing table, 15% of kernels are assumed to be broken pieces and routed to the hammer mill for processing into pecan meal. The remaining 85% are collected as snack-halves. Cracked shells are routed to the by-product bin.

*Kernel Yields and Outputs*

This section states the baseline assumptions that convert in-shell deliveries into kernels and shells and that allocate kernels between snack-halves and meal. The goal is to mirror common commercial practices while keeping the model transparent. The cooperative facility assumes a baseline mix of 90% improved varieties and 10% native varieties. This assumption imitates prevailing commercial patterns in which improved cultivars dominate planted acreage and marketed volume because they offer larger nut size, more uniform quality, and better crack out (USDA-NASS, 2024). Sensitivity analysis varies the mix to test how results change when native shares are higher (see the Sensitivity Analysis section).

Kernel yield generally varies by cultivar, orchard conditions, moisture, and maturity, and may fluctuate annually. For modeling clarity, the baseline assumes an average kernel yield of 56% for improved varieties and 42% for native pecans, with these figures subject to sensitivity analysis in subsequent sections. These assumptions align with lower yield ranges reported for native pecans and with higher kernel percentages typical of improved cultivars in industry and extension literature (Stein, Nesbitt, and Kamas, 2015; Caroll and Smith, 2017).

Within edible kernels, 85% are assumed to be recovered as snack-halves and 15% as meal from broken pieces. This allocation captures the facility's objective to maximize whole pecan halves, while acknowledging that a proportion of broken pieces is unavoidable and contributes to secondary product streams. The assumption is further supported by the high efficiency of modern Savage shellers, which are engineered to minimize breakage and recoverable halves (Savage Equipment, 2019). In practice, not all snack-halves would be sold directly to consumers. To reflect prevailing marketing channels, the model apportions edible snack-halves among wholesale and retail outlets, with 60% assumed to be sold at wholesale prices and the remaining 40% marketed at retail prices. This adjustment recognizes both bulk transactions typical of sheller operations and the cooperative's retail objectives.

**Table 1. Baseline Financing and Working-Capital Inputs**

| Parameter | Value with Description |
|---|---|
| Debt load | 50% of land, plant property and equipment ($461,496) |
| Loan term (LT) and rate | 10-year loan at 7.50% fixed (amortizing) |
| Annual debt service | $67,233 (constant payment) |
| Year-1 interest (LT) | $34,612 |
| Year-1 principal (LT) | $32,621: year-1 ending balance $428,875 |
| Working capital | 10% of annual sales, with 6% short-term interest rate |
| Aggregate member common stock | $461,496 (governance stock; see cooperative framework) |
| Property tax | 0.50% of land, plant property and equipment |
| Insurance | 2.00% of plant property and equipment |
| Routine maintenance | 3.00% of plant property and equipment |
| Expense inflation rate (annual) | 1.00% |
| Co-operative's income tax rate | 30.00% |
| Unallocated reserve (UR) | 5.00% |

**Table 1 (cont.)**

| **Cash Patronage (CP)** | **50%** |
|---|---|
| Nonqualified stock patronage (NQS) | 45% |
| Revolving period | 5 years |
| Discount rate | 10% |

*Capital Investment and Depreciation*

The cooperative must undertake a set of fixed investments to establish a commercial-scale shelling line and meet food-processing standards. This section specifies assets, states the basis used to value them, and documents the depreciation rules used in the financial model. The cooperative assumes a 2-acre (87,120 $ft^2$) land space to accommodate truck access, stormwater or septic, fire lanes, employee parking, and allows future expansion to a second line without major site rework.

Land is parameterized at $175,000 for the 2 acres (see Table 2). The basis for this value is industrial-zoned listings compiled on "LandSearch," a website that aggregates current asking prices from multiple U.S. brokers. A modelled 6,000$ft^2$ pre-engineered metal building (PEMB) with concrete slab is used and valued at $204,960, inclusive of interior retrofitting costs (BuildingsGuide, 2025). The office space takes about 1,600$ft^2$ of the PEMB. Table 2 shows the breakdown for the PEMB cost. This space comfortably fits one shelling line, a modest office core, quality assurance rooms, and pallet staging, which preserves forklift aisles and egress (see Figure 1). A $25,000 salvage value is assigned to the PEMB to capture recoverable steel and reusable components. The PEMB has an annual building depreciation of $4,614, and it's computed on a 39-year straight-line schedule for nonresidential real property.

The study accounted for two indoor walk-in freezers (10′ × 10′ × 8′) at an installed cost of $36,167 each based on published unit pricing and installation service add-on (Katom, 2025). Each unit is treated as a special purpose building and depreciated on a straight-line basis over 10 years. The combined annual depreciation expense is $7,233 for both units.

**Table 2. Capital Outlays by Asset**

| **Description** | **Value ($)** | **Salvage ($)** | **Depreciation per Year ($)** |
|---|---|---|---|
| Buildings | | | |
| Steel building kit (6,000 $ft^2$) | 96,960 | 15,000 | |
| Concrete slab (6,000 $ft^2$) | 54,000 | 2,000 | |
| Retrofitting of interior (6,000 $ft^2$) | 54,000 | 8,000 | |
| Total cost of buildings | 204,960 | 25,000 | 4,614 (39 years straight line) |
| Special purpose buildings (SPB) | | | |
| Walk-in freezer (10′ × 10′ × 8′ :2 units) | 72,334 | - | 7,233 (10 years straight line) |
| Light trucks and vehicles (LTV) | | | |
| Semi-truck | 100,000 | - | |
| Forklifts | 25,000 | - | |

**Table 2 (cont.)**

| Description | Value ($) | Salvage ($) | Depreciation per Year ($) |
|---|---|---|---|
| Total cost of LTV | 125,000 | - | 25,000 (5 years MACRS with half-year convention) |
| Equipment and heavy rolling stock (EHRS) | | | |
| Savage 3918 feed hopper | 7,135 | - | |
| Savage 1312 - 12' belt elevator | 4,238 | - | |
| Savage 238C cracker (2 units) | 48,670 | - | |
| Savage 704S bucket elevator (4 units) | 24,540 | - | |
| ME & E aspirator/cyclone head blower | 18,556 | - | |
| Savage 410S sheller (2) | 39,670 | - | |
| Savage 520S inspection table | 16,835 | - | |
| ME & E chlorine bath sanitizer | 87,994 | - | |
| ME & E batch meat dryer | 58,560 | - | |
| Used Fitzpatrick Fitzmill hammer mill, Model M5A | 19,500 | - | |
| Miscellaneous | 20,000 | - | |
| Total cost of EHRS | 345,698 | - | 49,400 year 1 (7 years MACRS with half-year convention) |
| Land | 175,000 | - | - |
| Total cost of land, plant property, and equipment | 922,992 | | |

The shelling line is composed of a feeder and conveyor, a validated kill-step batch dryer, a cracker, an aspirator for shell removal, bucket elevators and screens, a sheller, an inspection and sizing table, packaging equipment, and a Fitzpatrick M5A hammer mill for producing pecan meal from broken pieces. These core shelling lines total $345,698, based on supplier quotations from Savage Equipment and modern electronics and equipment (ME & E). The Fitzpatrick M5A for processing broken pieces into pecan meal is not sourced from Savage. It is sourced from a used-equipment dealer, with specifications cross-checked against the manufacturer's brochure. The study obtained a quote of $19,500 for the hammer mill (Federal Equipment, 2025). A budget of $125,000 is allotted for one semi-tractor plus one forklift, consistent with national listing ranges (Forklift Trader, 2025; Truck Paper, 2025).

Depreciation follows the Internal Revenue Service Modified Accelerated Cost Recovery System (MACRS) (Internal Revenue Service, 2024). The shelling train and heavy rolling stock are treated as 7-year property under the half-year convention, yielding $49,400 in first-year depreciation. The semi-tractor and forklift are 5-year property (half-year convention), yielding $25,000 in first-year depreciation.

*Financing, Working Capital and Profit Distribution*

The basic financing assumption for the model is a loan for 50% of the total cost of land, plant, property, and equipment. This cost is financed with an amortizing term loan acquired at an interest rate of 7.5% for a term of 10 years. The 10-year period is also considered as the project timeframe. Working capital was estimated at 10% of annual sales with a short-term interest rate of 6% (Kenkel et al., 2008). Equity complements debt through $461,496 in membership common stock. This investment would imply a per share investment of $760, with each share of stock providing the usage right to deliver 1 ton of in-shell pecans. Patronage allocations follow the baseline policy described previously with 5% to unallocated reserve, 50% as cash patronage, and 45% nonqualified stock patronage. Table 1 presents a summary of this section.

*Economic Model*

Determining whether the cooperative shelling facility is financially viable and worth member investment requires an appropriate economic and financial metric. This study adopts the Expected Net Present Value (ENPV) as the primary measure of feasibility, because it evaluates whether projected returns are sufficient to offset costs and risks. The Net Present Value (NPV) is a standard capital budgeting technique used to discount simulated cash inflows to their present value (Zapata, Ribera, and Palma, 2017; Cowley, Brorsen, and Hamilton, 2019; Adom, Bir, and Lambert, 2023; Coleman et al., 2024). It accounts for both the time value of money and the magnitude of cash flows over the project's lifespan. In addition to NPV, the internal rate of return (IRR) is reported as a complementary measure, defined as the discount rate that sets the net present value of projected cash flows equal to zero. In this study, an IRR greater than or equal to the assumed discount rate is interpreted as indicating financial viability. To incorporate risk and variability, the model was implemented stochastically using Excel @Risk software, which generates probability distributions of results through Monte Carlo simulation (Lumivero, 2022). The estimated ENPV is calculated as:

$$E(NPV_s) = \sum_{t=1}^{T} \frac{E(R_{ts})}{(1+r)^t} \Bigg| s, \tag{1}$$

where $E(R_{ts})$ is the expected annual net return in year $t$ under scenario $s$, and $r$ is the discount rate (10%). The 10% discount rate is consistent with values commonly used in agricultural feasibility analyses and reflects a risk-adjusted cost of capital for cooperative investment decisions (Adom, Bir, and Lambert, 2023; Coleman et al., 2024). The scenarios ($s$) in this study vary according to alternative patronage allocation policies and kernel yield assumptions for improved and native varieties, which are further detailed in the sensitivity analysis. The expected annual net return $E(R_{ts})$ was estimated as:

$$E(R_{ts}) = E(Revenue_t) - E(Cost_t) | s, \tag{2}$$

where $E(R_{ts})$ is the Revenue$_t$ in year $t$ under scenario $s$, less the corresponding cost incurred in that year. The expected annual revenue under scenario $s$ is expressed as a function of snack-halves, cracked shells, pecan meal, and their respective retail prices:

$$E(Revenue_t) = \sum_{i=1}^{2}(W_{it} * PW_{it}) + \sum_{i=1}^{2}(V_{it} * PV_{it}) + C_t * PC_t + M_t * PM_t \Big| s, \quad (3)$$

where $i = 1$ denotes improved varieties and $i = 2$ denotes native varieties. $PW_{it}$ and $PV_{it}$ are the respective wholesale and retail price of snack-halves for variety $i$ in year $t$. $W_{it}$ and $V_{it}$ are the quantity of 1-pound snack-halve bags of variety $i$ sold at the wholesale and retail level in year $t$. The variables $C_t$ and $M_t$ are the quantities of cracked shells and pecan meal sold in year $t$, with retail prices $PC_t$ and $PM_t$, respectively. Unlike snack-halves, which are priced separately for improved and native varieties, cracked shells and pecan meal from both varieties are pooled and sold at a uniform retail price. During the shelling process, we collect all snack-halves as $H_{it}$, which is the summation of wholesale quantities ($W_{it}$) and retail quantities ($V_{it}$). As illustrated in Figure 1, these quantities correspond to the snack-halves bagging stage. The total quantities of snack-halves ($H_{it}$) from the shelling line is determined as:

$$H_{it} = Q_t * (S_{it} * Y_{it} * F_{it}), \quad (4)$$

where $Q_t$ is the total in-shell pecan volume in pounds that is fed into the cracking machine in year $t$. $S_{it}$ is the proportion of in-shell volume for variety $i$ in year $t$. In the baseline 90% of in-shell volume is assumed to be improved varieties and 10% native. The parameter $Y_{it}$ denotes the kernel yield for variety $i$ in year $t$. As mentioned in the kernel yields and outputs section, the baseline assumes $Y_{it}$ of 56% for improved varieties and 42% for native pecans. $F_{it}$ represents the proportion of kernels that remain as snack-halves for variety $i$ in year $t$ and has a baseline value of 85%. The determination of pecan meal quantities ($M_t$) is specified as:

$$M_t = \sum_{i=1}^{2}(S_{it} * Y_{it} * (1 - F_{it}) * Q_t), \quad (5)$$

In Figure 1, this quantity corresponds to the pecan meal bagging stage. Similarly, we specify the determination of cracked shell ($C_t$) quantities based on delivered in-shell volume and kernel yield assumptions as:

$$C_t = \sum_{i=1}^{2}(S_{it} * (1 - Y_{it}) * Q_t), \quad (6)$$

In Figure 1, this quantity corresponds to the by-product bin (cracked shells). The annual cost under scenario $s$ is:

$$E(Cost_t) = VOC_t + FOC_t + IT_t + CE_t|s, \quad (7)$$

where $VOC_t$ is the variable operating cost in year $t$, including the raw in-shell pecan purchases, marketing and packaging materials cost, variable labor costs, utilities, and interest on working capital. Typically, the marketing and packaging materials cost for snack-halves and meal were modeled as the unit packaging cost plus 5% of the product's selling price to capture advertising, promotion, and any other retail expenses. Snack-halves considered for wholesale sales and cracked shells incur packaging costs only. The cost from the raw in-shell pecan purchases is the grower price paid to members in year $t$ multiplied by $Q_t$. The variable $FOC_t$, denotes fixed operating costs, which capture salaried staff, insurance, property tax, routine maintenance, supplies, and miscellaneous. $IT_t$ is the income tax in year $t$, computed from taxable income. $CE_t$ is the capital expenditure for land, plant property, and equipment, which are incurred only at the initial investment period ($t = 0$), accordingly, $CE_t = 0$ for all $t > 0$. Under the cooperative business model, the majority of the income tax obligation is passed through to the member, either immediately, as is the case with cash or qualified stock patronage, or with a delay, as is the case with nonqualified stock patronage. For that reason, the income tax payments reflected in the cooperative's NPV and IRR calculations were minimal.

In addition to the NPV and IRR analysis performed at the cooperative level, a similar analysis was performed at the member level, reflecting the members' investment and cash receipts of cash patronage and stock revolvement payments. In a cooperative, the member IRR can be above or below that of the cooperative IRR. The fact that the member is receiving the income tax obligation and the need for the cooperative to retain some profits by issuing revolving stock patronage reduces the member IRR relative to the cooperative IRR. The leverage effect of debt financing can make the member IRR higher than the cooperative IRR since the members' collective initial investment was less than the total (long-term debt and equity) initial investment in the firm. In this model, member IRR and NPV was lower than the measures at the cooperative level.

## Data

The data used to parameterize the model were primarily sourced from the U.S. Department of Agriculture's Economic Research Service (USDA-ERS), the U.S. Energy Information Administration (EIA), the U.S. Bureau of Labor Statistics (BLS, 2025), retail shops, and the U.S. Environmental Protection Agency (EPA).

*Member Deliveries, Grower and Product Prices*

Annual member deliveries are modeled as a uniform draw between 75% and 100% of plant capacity. This amount reflects the operating reality of a closed, member-only cooperative. Pooling across growers, coordinated harvest and intake scheduling, and physical capacity limits reduce extreme year-to-year swings while preserving meaningful variation. A new draw is taken for each year of the planning horizon, treating production as stochastic to emulate real-world variability. Table 3 reports summary statistics for in-shell production volumes and the other variables used in the stochastic analysis.

The USDA-ERS reports 45 years of data (1980–2023) on grower prices for in-shell pecans, measured in dollars per pound ($/lb) and disaggregated by improved and native varieties (USDA-ERS, 2025). These prices were adjusted for inflation to 2023 dollars and modeled stochastically (see Table 3). Because USDA-ERS does not provide data on shelled pecan prices, the study derived shelled-equivalent prices separately for improved and native pecans by dividing in-shell grower prices by the baseline kernel yield values assumed earlier. Following the approach used in a study by Blayney and Gutierrez (2017), these shelled equivalents were used as proxies for wholesale snack-halve prices.

**Table 3: Summary Statistics for Data Variables Used in Stochastic Analysis**

| Variable | Minimum | Mean | Maximum |
|---|---|---|---|
| Improved variety grower in-shell price ($/lb) | 1.14 | 2.29 | 3.51 |
| Native variety grower in-shell price ($/lb) | 0.71 | 1.45 | 2.43 |
| Wholesale price for snack-halves (improved) | 2.4 | 4.09 | 6.27 |
| Wholesale price for snack-halves (native) | 1.70 | 3.45 | 5.79 |
| Pecan meal price ($/lb) | 5.95 | 13.51 | 18.95 |
| Cracked shell price ($/50lb) | 1.85 | 3.21 | 6.40 |
| In-shell production volume (lb) | 911,250 | - | 1,215,000 |
| Packaging costs (50-lb woven polypropylene bags) | 0.42 | 0.71 | 1.35 |
| Packaging costs (1-lb stand-up pouches) | 0.28 | 0.35 | 0.47 |
| Retail markup/factor | | | |
| Improved variety | 4.14 | | |
| Native variety | 5.47 | | |

Note: All data variables used in stochastic analysis were subject to triangular distribution except for in-shell production volume.

Retail prices for snack-halves were then determined through a markup procedure applied separately to improved and native varieties. Current retail quotes for each variety were collected from pecan shops in 2025, averaged, and adjusted to 2023 dollars (see Table 4). For each variety, a retail markup factor was calculated as the ratio of the adjusted average retail price to the 2023 wholesale proxy price. The markup factor was approximately 4.14 for improved pecans and 5.47 for native pecans. For each project year, retail snack-halve prices were estimated by multiplying the variety-specific markup factor by the simulated, inflation-adjusted in-shell grower price. This approach models retail prices as stochastic while preserving consistency with observed retail margins across varieties.

Historical price data for cracked shells and pecan meal are not available from the USDA. To address this gap, retail price data were gathered through an online search (see Table 5), consistent with approaches used by Adom, Bir, and Lambert (2023) to model quail prices. Summary statistics for cracked shells and pecan meal retail prices used for our stochastic analysis are reported in Table 3. Packaging costs were also modeled stochastically based on online data. The study considered two primary inputs, 50-lb woven polypropylene bags for cracked shells and 1-lb stand-up pouches for snack-halves and pecan meal. The summary statistics used for packaging costs are reported in Table 3.

**Table 4: Retail Collected Prices for Snack-Halves**

| | Retail Price | |
|---|---|---|
| **Source** | **Native Variety ($/lb)** | **Improved Variety ($/lb)** |
| Houston Pecan Company (2025) | 11.00 | 12.75 |
| York Pecan Company (2025) | 13.25 | 14.00 |
| Miller Pecan Company (2025) | 8.59 | 11.99 |
| Rattlesnake Ranch Pecans Company (2025) | 14.99 | 14.99 |
| Gilbert Pecan Company (2025) | 12.00 | 12.00 |
| The Nut House (2025) | 14.99 | 15.99 |
| Valley View Company (2025) | 9.00 | 10.00 |
| Pecan Producers International (2025) | 12.95 | 13.95 |
| Byrd's Pecans (2025) | 14.00 | 13.00 |
| Hammons Pantry (2025) | 17.98 | - |
| Kentucky Nut Corporation (2025) | 17.35 | - |
| Azure (2025) | 12.96 | - |
| Pecan Shop (2025) | 17.05 | - |
| Mean 2025 price | 13.29 | 13.47 |
| Adjusted mean price to 2023 | 12.63 | 12.80 |

**Table 5: Retail Collected Prices for Cracked Shells and Pecan Meal**

| **Cracked Shells** | | **Pecan Meal** | |
|---|---|---|---|
| **Source** | **Retail Price ($/50lb)** | **Source** | **Retail Price ($/lb)** |
| Solutions (2025) | 6.40 | Sunnyland Farms (2025) | 15.75 |
| Texas Native (2025) | 2.15 | Pearson Farm (2025) | 12.50 |
| Minick Materials (2025) | 4.68 | Nuts.com (2025) | 17.49 |
| Pete's Landscaping and Materials (2025) | 2.45 | Young's Premium Foods (2025) | 10.95 |
| Clear Fork Materials (2025) | 1.85 | Shute Pecan Company (2025) | 5.95 |
| Strata Landscape Materials (2025) | 2.43 | The Pecan Pantry (2025) | 18.95 |
| Barela Landscaping Materials (2025) | 3.00 | Millican Pecan (2025) | 12.99 |
| Trees That Please (2025) | 2.75 | - | - |

Note: Cracked shell prices are originally provided in dollars per cubic yard. Using a conversion provided by Mexal et al. (2003), we convert $/cubic yard to $/50 lbs (1,000 lbs/cubic yard).

*Labor Costs*

The Bureau of Labor Statistics reports annual mean wages for general managers, sales managers, and secretaries (BLS, 2025, Table 6). To project labor costs forward, this study applies a 1% annual wage escalation rate over the 10-year horizon as a conservative planning assumption consistent with prior cooperative feasibility analyses (Kenkel, Holcomb, and Hill, 2008). In addition, BLS reports average hourly labor costs for food processing workers and packaging and filling machine operators, serving as proxies for unloading, cracking, shelling, packaging, and shipping. These values were converted to dollars-per-pound basis and multiplied by the facility's stochastic annual in-shell pecan throughput to estimate the stochastic total labor costs over the project period.

**Table 6. Labor Cost and Annual Salaries for Full-Time Employees**

| Category | Estimated Annual Salary ($) |
|---|---|
| General manager | $146,510 |
| Assistant manager | $137,740 |
| Secretary | $126,390 |
| Sales manager/agent | $157,380 |
| Unloading ($/lb) | $0.012 per pound ($18.12 per hour) |
| Cracking and shelling ($/lb) | $0.013 per pound ($19.67 per hour) |
| Packaging and shipping ($/lb) | $0.014 per pound ($21.04 per hour) |

Notes: Annual salary estimates are based on Bureau of Labor Statistics Occupational Employment and Wage Statistics (OEWS), food manufacturing industry, and national mean wages. Occupation codes used: Top Executives (SOC 11-1000) for General Manager; Operations Managers (SOC 11-1021) for Assistant Manager; Administrative Services Managers (SOC 11-3010) as a proxy for administrative support staff; and Sales Managers (SOC 11-2022) for Sales Manager/Agent. Reported wages reflect base earnings and exclude fringe benefits, such as insurance and retirement contributions. The facility operates at 1,500 lbs/hr, so the average hourly wages can be converted to $/lb.

*Utility Costs*

Electricity rates were obtained from the U.S. Energy Information Administration (EIA), with the national average industrial retail price reported at $0.0832 per kWh (EIA, 2023). At this rate, the estimated cost of operating the shelling line in year 1 is approximately $80,870. In addition, the facility incurs year-round electricity expenses for office lighting and support systems. With an office space of 1,600 ft², and using the median consumption of 8.7 kWh per square foot per year for commercial buildings (EIA, 2016), annual office electricity use is estimated at 13,920 kWh, equivalent to about $1,160 per year.

Water usage data were obtained from the U.S. Environmental Protection Agency's Water Sense program, which reports an average combined water and wastewater cost of $12.42 per 1,000 gallons for U.S. commercial users (EPA, 2025). Assuming a baseline consumption of 50,000 gallons annually for cleaning, lavatories, sinks, and drinking, the annual water cost is estimated at $621.

The U.S. Energy Information Administration also reports a national average price of $2.52 per gallon for liquefied petroleum (LP) gas (EIA, 2025). The facility's semi-tractor and forklift are

assumed to consume a combined 800 gallons per year, resulting in an annual fuel cost of approximately $2,016.

Telephone and internet costs include voiceover internet protocol (VOIP) phone service and high-speed internet access. VOIP service averages $25 per user per month (RingCentral, 2025), giving a total monthly cost of $100 for four staff members. To ensure reliable communication and data transfer, a high-speed business internet plan is assumed at $200 per month (Brooks, 2026).

*Sensitivity Analysis*

The robustness of results was assessed by including a set of sensitivity analyses on key assumptions. First, kernel yields were varied around the baseline of 56% for improved varieties and 42% for native varieties to show annual and orchard-level fluctuations. Second, the allocation of edible kernels between snack-halves and meal (85%:15%) was tested to examine the effect of higher breakage rates on cooperative returns. Third, the percentage share of native and improved varieties in member deliveries was adjusted away from the 10%:90% baseline to evaluate how cultivar mix influences throughput and product values. Because the baseline scenario for snack-halves sales was wholesale-heavy (60%:40%), we tested different scenarios, such as retail-heavy and balanced sales, to verify its robustness. Finally, financial assumptions regarding patronage allocation were varied from the baseline policy of 5% unallocated reserve, 50% cash patronage, and 45% nonqualified stock patronage.

## Results and Discussion

The results are summarized in Table 7, Figure 2, and Table 8. For each scenario, the cooperative and member outcomes were evaluated in terms of NPV and IRR. Taken together, the simulation generated 12 distinct mean NPV and mean IRR outcomes that provide a basis for assessing alternative strategies and risk exposure. We also track the cooperative's year-10 cumulative cash balance as a terminal solvency check, reporting its mean and the probability it is positive.

Under the baseline scenario (see Table 7), the cooperative's NPV ranged from -$2,148,865 to $3,596,233, with a mean of $754,064 over the 10-year planning horizon. These values represent the discounted returns from shelling operations after accounting for the time value of money. The cooperative achieved a positive NPV in 83.8% of simulations, indicating that in five out of six runs the discounted revenue stream exceeds the discounted costs. The mean cooperative IRR was 33.36%, with approximately 87% probability of meeting or exceeding the assumed discount rate of 10%. This finding implies that, even under baseline assumptions, the cooperative investment is financially viable and offers a rate of return substantially above typical borrowing costs. The end-of-horizon liquidity is generally maintained, as year-10 cumulative cash averages $113,009 and is positive in 95% of runs.

For individual members, the baseline scenario also yielded favorable outcomes. The mean member NPV was $779,487, with outcomes ranging from -$534,741 to $2,428,924. The mean IRR of 30.79% shows strong profitability potential, and the probability of members achieving an IRR of

at least 10% was nearly 100%. These results indicate that, although the cooperative bears substantial fixed-cost risk, members capture relatively greater benefits once the facility operates at scale. In practical terms, this means that the baseline cooperative structure transfers much of the investment risk to the collective entity, while individual members are positioned to realize high and relatively stable returns.

Overall, the baseline results suggest that the cooperative is financially feasible, though not without risk. The probability of negative cooperative NPV highlights the exposure to downside scenarios, particularly under conditions of low capacity and weaker market prices for snack-halves and pecan meals. However, the relatively high member-level returns indicate that, under the baseline assumptions, the cooperative delivers on its central objective of improving member welfare while pooling investment risk across participants. Subsequent sensitivity analysis identifies the conditions under which cooperative-level viability may be threatened, and to highlight strategies that preserve both organizational sustainability and member profitability.

When the share of native pecans was increased to 30% (with 70% improved), both cooperative and member outcomes weakened compared to the baseline (see Table 7). The mean cooperative NPV dropped to $325,414, and the probability of a positive NPV fell to 68.70%. Members experienced similar effects, with mean NPV reduced to $456,596 and IRR falling to 23.26%. The weaker performance depicts the lower kernel recovery and quality premiums typically associated with native pecans, which limit the value of shelled output even when procurement costs are lower. By contrast, shifting entirely to improved pecans enhanced returns, producing the highest mean cooperative NPV of $966,611 and the strongest member mean IRR of 34.45%. A balanced mix yielded the least favorable results (see Table 7). These patterns reinforce that cooperative profitability is highly sensitive to variety composition. Among the three variety mixes, the all-improved option also delivers the strongest liquidity. Year-10 cumulative cash averages $211,005 and is positive in 67% of runs, indicating a positive ending cash balance in most cases. These results suggest that, for a value-added pecan cooperative, prioritizing improved varieties enhances both profitability and solvency relative to mixes with higher native shares.

Under low kernel yields of 38% native and 52% improved (see Table 7), performance collapses relative to the baseline. The cooperative's mean NPV falls to -$853,454 with only a 14.40% probability of a positive outcome, and member results show a similar decline. Because cash flows are largely negative in this case, IRR values are omitted as they become undefined or unstable. Conversely, when improved-variety yields rise to 60%, the cooperative's mean NPV increases to approximately $2.3 million with a 99.8% probability of being positive. Member outcomes follow the same pattern, with mean NPV reaching $1.9 million. These results demonstrate that kernel recovery is the key driver of financial performance in a pecan shelling facility. Higher kernel yields translate into substantially stronger outcomes, whereas lower yields expose both the cooperative and its members to significant financial risk. These results further indicate that kernel recovery rates near the baseline assumptions define the approximate break-even region for cooperative feasibility, as small reductions below these levels result in negative mean NPV outcomes.

**Table 7. Net Present Value and Internal Rate of Return for Baseline Scenario and Sensitivity Analysis on Variety Mix and Kernel Yield**

| Scenarios | | Co-operative | | | Member | |
|---|---|---|---|---|---|---|
| | | Cum. Cashflow (CCF) (Year 10) | NPV | IRR (%) | NPV | IRR (%) |
| Baseline scenario | Minimum | -$2,327,468 | -$2,148,865 | -40.55% | -$534,741 | -24.8% |
| | Mean | $113,009 | $754,064 | 33.36% | $779,487 | 30.79% |
| | Maximum | $1,769,174 | $3,596,233 | 125.41% | $2,428,924 | 73.37% |
| | Prob. of positive CCF/NPV/IRR ≥10% | 95.00% | 83.80% | 86.90% | 98.10% | 98.30% |
| Variety mix | | | | | | |
| Higher native variety share (30% native; 70% improved) | Minimum | -$2,668,406 | -$2,217,246 | -68.01% | -$700,484 | -34.24% |
| | Mean | -$132,653 | $325,414 | 22.99% | $456,596 | 23.26% |
| | Maximum | $1,315,645 | $2,949,517 | 106.00% | $1,884,269 | 60.87% |
| | Prob. of positive CCF/NPV/IRR ≥10% | 43.00% | 68.70% | 75.00% | 92.00% | 93.00% |
| All improved variety (0% native; 100% improved) | Minimum | -$2,327,523 | -$2,098,931 | -32.91% | -$455,462 | -12.32% |
| | Mean | $211,005 | $966,611 | 38.34% | $948,156 | 34.45% |
| | Maximum | 1,714,839 | $4,040,585 | 150.37% | $2,722,803 | 77.58% |
| | Prob. of positive CCF/NPV/IRR ≥10% | 67.00% | 87.20% | 89.70% | 99.00% | 99.20% |
| Balanced (50% native; 50% improved) | Minimum | -$2,874,303 | -$2,115,935 | -64.52% | -$753,903 | -37.09% |
| | Mean | -$458,272 | -$108,885 | 12.66% | $155,648 | 15.37% |
| | Maximum | $1,051,275 | $1,974,270 | 82.84% | $1,619,014 | 47.38% |
| | Prob. of positive CCF/NPVIRR ≥10% | 19.90% | 43.10% | 54.40% | 70.80%% | 74.90% |
| Kernel yield | | | | | | |
| Low yield for both varieties (38% native; 52% improved) | Minimum | -$5,039,764 | -$4,022,374 | - | -$1,260,334 | - |
| | Mean | -$1,544,756 | -$853,454 | - | -$175,379 | - |
| | Maximum | $1,193,867 | $2,153,076 | - | $1,213,284 | - |
| | Prob. of positive CCF/NPV/IRR ≥10% | 2% | 14.40% | - | 32.40% | - |
| High improved variety yield (42% native; 60% improved) | Minimum | -$713,286 | -$837,738 | 2.13% | $371,623 | 21.80% |
| | Mean | $1,085,557 | $2,266,291 | 63.04% | $1,860,802 | 51.24% |
| | Maximum | $2,201,810 | $4,970,005 | 173.91% | $4,104,839 | 108.26% |
| | Prob. of positive CCF/NPV/IRR ≥10% | 99.60% | 99.80% | 99.90% | 100.00% | 100.00% |

Note: Each scenario isolates the effect of a single variable by holding all other parameters constant at their baseline values. IRR values are omitted in the low kernel yield scenario because nonconventional cash flow patterns made the IRR undefined or unstable.

Figure 2, subplots a and b, show how kernel breakage influences cooperative and member outcomes relative to the baseline. When breakage rises to 20% and more kernels are processed into meal, both cooperative and member distributions shift to the right, with higher mean NPVs and IRRs. This outcome suggests that, despite the additional pecan meal processing cost, meal may provide a reliable outlet that stabilizes returns when priced close to snack-halves (see Tables 4 and 5). It also raises an important managerial question: If meal markets remain strong, should cooperatives consider allocating more product to meal even when kernels are unbroken? A practical implication is that cooperatives could pursue contracts or partnerships with ingredient buyers to ensure consistent meal demand, thereby reducing reliance on premium snack-halve markets alone. At the other extreme, Figure 2c and 2d show that when breakage falls to 7%, distributions compress around zero or become negative. Either way, it shifts to the left, signaling greater downside risk when relying heavily on snack-halves.

Figure 2, subplots e-h, show how reallocating snack-halves between wholesale and retail changes performance relative to the baseline. When the cooperative adopts a retail-heavy strategy (60% retail, 40% wholesale), both distributions move strongly to the right. The cooperative's mean NPV rises to $3.2 million and members to $2.6 million, with substantially higher IRR's. These gains show the higher unit margins available in retail markets, which more than offset the additional marketing and distribution costs. On the other hand, the balanced strategy (50% retail, 50% wholesale) delivers more modest improvements relative to baseline, with a cooperative mean NPV of $2 million and member NPV of $1.6 million. Even though retail sales clearly drive stronger returns, they also expose the cooperative to greater variability in demand and higher marketing risks. The results highlight that channel strategy is a decisive factor in financial performance, with retail expansion offering higher payoffs but requiring stronger market access and risk management.

The next section of results highlights how patronage allocation decisions shape cooperative and member outcomes. Under the cash-heavy allocation (70% cash patronage, 25% nonqualified stock, 5% unallocated reserve), the cooperative posts a 10.2% higher mean NPV ($831,081) than baseline, with an 84.90% probability of positive returns. Members also benefit, with mean NPV rising to $881,339 and IRR above 35%. Nonetheless, a heavy nonqualified stock allocation (25% cash patronage, 70% nonqualified stock, 5% unallocated reserve) weakens outcomes. We observe that cooperative mean NPV declines to $660,622 and member NPV to $652,926. These results suggest that higher immediate cash refunds improve perceived member welfare and maintain cooperative viability. However, solvency tells a different story. Under the cash-heavy policy, year-10 cumulative cash averages -$73,920 and is positive in only 48.2% of runs. This finding signals a frequent end-of-horizon shortfall. By contrast, the heavy nonqualified stock policy averages $347,107 of year-10 cash, with 95% of runs ending positive, indicating a much stronger liquidity position. In short, higher immediate cash refunds lift NPV and member IRR but strain cash balances, whereas heavier use of nonqualified stock keeps returns moderate yet preserves solvency. A balanced rule is to set the cash-patronage rate to the lowest level that meets a solvency target while keeping member IRR attractive, rather than maximizing cash refunds every year.

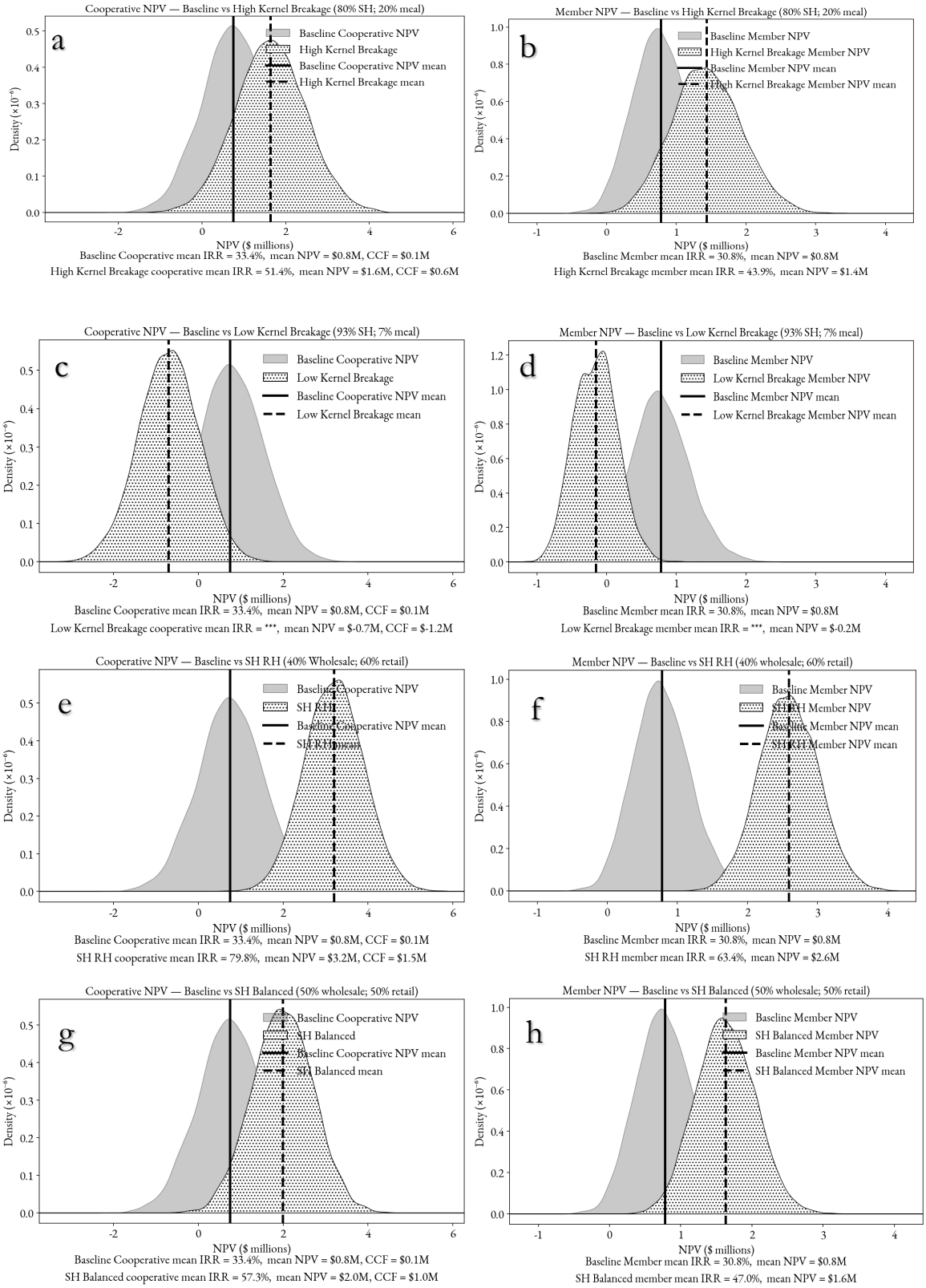



**Figure 2. Sensitivity Analysis for Kernel Allocation and Snack-Halves Sales**

Note: SH Implies Snack-Halves; RH Implies Retail-Heavy, CCF Implies Cumulative Cash Flow (Year 10).

**Table 8: Sensitivity Analysis on Patronage Allocation and Energy Requirement Assumptions**

| Scenarios | | Co-operative | | | Member | |
|---|---|---|---|---|---|---|
| | | Cum. Cashflow /CCF (Year 10) | NPV | IRR (%) | NPV | IRR (%) |
| Cash heavy (5% UR; 70% CP; 25% NQS) | Minimum | -$2,494,837 | -$2,352,114 | -43.46% | -$706,304 | -35.10% |
| | Mean | -$73,920 | $831,081 | 35.37% | $881,339 | 36.02% |
| | Maximum | $1,174,811 | $3,555,141 | 142.00% | $2,566,644 | 100.94% |
| | Probability of positive CCF/NPV or IRR ≥10% | 48.20% | 84.90% | 88.30% | 98.50% | 98.90% |
| Heavy nonqualified stock (5% UR; 25% CP; 70% NQS) | Minimum | -$1,963,167 | -$1,992,432 | -44.17% | -$612,871 | -27.57% |
| | Mean | $347,107 | $660,622 | 30.75% | $652,926 | 25.41% |
| | Maximum | $3,444,505 | $4,243,191 | 126.22% | $2,160,134 | 54.96% |
| | Probability of positive CCF/NPV or IRR ≥10% | 95.00% | 81.00% | 85.00% | 97.10% | 97.00% |
| 50% below assumed energy requirement (0.5 HP per lb/h) | Minimum | -$2,101,274 | -$1,997,539 | -37.42% | -$784,364 | -23.71% |
| | Mean | $275,535 | $963,470 | 37.51% | $917,905 | 33.65% |
| | Maximum | $1,745,144 | $3,878,889 | 135.12% | $2,643,800 | 77.34% |
| | Probability of positive CCF/NPV or IRR ≥10% | 71.8% | 89.20% | 90.90% | 99.20% | 99.40% |
| 25% above assumed energy requirement (1.25 HP per lb/h) | Minimum | -$2,479,454 | -$2,108,263 | -51.41% | -$619,018 | -34.87% |
| | Mean | $22,019 | $650,311 | 31.15% | $713,906 | 29.31% |
| | Maximum | $1,619,251 | $3,342,736 | 123.95% | $2,175,762 | 66.38% |
| | Probability of positive CCF/NPV or IRR ≥10% | 54.90% | 80.01% | 83..80% | 97.10% | 97.30% |

Note: Each scenario isolates the effect of a single variable by holding all other parameters constant at their baseline values.

The final set of results examines the effects of varying aggregate energy requirements from 0.5 to 1.25 HP per pound per hour around the baseline assumption of 1 HP per pound per hour. These variations did not alter the study's overall feasibility conclusions. Mean cooperative NPV remained positive across all scenarios, ranging from $650,311 to $963,470, whereas cooperative IRR remained well above the 10% benchmark (see Table 8). Although the cooperative remains financially viable across this plausible range of energy requirements, electricity demand represents an important cost component that can influence profitability. This suggests that careful management of energy use and equipment efficiency could further improve financial performance and enhance returns to cooperative members.

## Conclusion

This study evaluated the feasibility of a producer-owned pecan shelling cooperative under stochastic prices, production volumes, kernel yields, and patronage allocation policies. It is important to note that any shelling decision should be based on quantified demand potential for the end products prior to planning investment in a facility. Only with recognized market potential can the financial viability of a proposed shelling venture be accurately determined.

The baseline analysis indicates that such a cooperative can be financially viable, with positive NPVs in most simulations and IRRs well above the assumed discount rate of 10%. Members consistently realize higher and more stable returns than the cooperative itself, indicating how collective ownership shifts fixed-cost risk to the organization while distributing value-added benefits to individual growers. Sensitivity analyses show that kernel recovery is the most critical determinant of financial performance, with higher yields driving markedly stronger outcomes. Variety composition, breakage rates, and the balance between wholesale and retail channels further shape profitability. Patronage allocations also directly determine how benefits are distributed between members and the cooperative.

The analysis is not without limitations. Publicly available information and previous research related to pecan shelling economics are virtually nonexistent. Thus, it is difficult to compare these findings with historical returns to shelling operations. To combat this uncertainty, the authors visited pecan shelling operations and received equipment lists and quotes from reliable suppliers. Reliable long-run data exist for in-shell pecan prices, but not for retail snack-halve prices. To address this issue, the study applied a derived shelled-equivalent and markup procedure. While practical, this method may not fully capture actual retail pricing behavior. In addition, the model assumes uniform member participation and does not account for behavioral responses, such as delivery choices or bargaining strategies.

Despite the limitations of this study, the resulting model will be made publicly available to interested pecan growers. These growers will be allowed to modify many parts of the model to fit their specific business scenarios. As they assess situations specific to their pecan production parameters and market opportunities, their feedback will be used to make future modifications and address previously untested risk parameters.

Future research could extend the framework by incorporating member behavioral dynamics, examining alternative marketing strategies such as export contracts, and quantifying the stabilizing role of risk management tools, including forward contracts or insurance. For practitioners, three implications emerge. First, improving kernel yields and maintaining quality are central to cooperative viability. Second, developing stable outlets for both snack-halves and pecan meal can reduce downside risk and at the same time capture retail margins where feasible. Third, boards should design patronage policies that balance organizational liquidity with members' need for timely cash returns. Overall, the results indicate that a pecan shelling cooperative offers a promising pathway for producers to capture more value, but long-run success will depend on disciplined kernel yield management through production, market diversification, and financial policies that align cooperative resilience with member welfare.

## Declaration of Interest Statement/Competing Interest

The authors declare no conflict of interest.

## Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

## Data Availability

The various data used to parameterize the model are documented in the paper. They were primarily sourced from the U.S. Department of Agriculture–Economic Research Service (USDA-ERS), the U.S. Energy Information Administration (EIA), U.S. Bureau of Labor Statistics (BLS, 2025), retail shops, and the U.S. Environmental Protection Agency (EPA).

## References

Adom, E., C. Bir, and L.H. Lambert. 2023. "A Financial Comparison of Small-Scale Quail and Laying Hen Farm Enterprises." *Poultry Science* 102(4):1–9.

Azure. 2025. *Pecans Fancy Native, Raw, Halves, Organic.* Available online: https://www.azurestandard.com/shop/product/food/nuts/pecans/halves/pecans-fancy-native-raw-halves/22792?package=NU229.

Barela Landscaping Materials. 2025. Available online: https://barelalandscaping.com.

Blayney, D., and P. Gutierrez. 2017. *Economic Importance of the Pecan Industry*. Las Cruces, NM: New Mexico State University, Extension Publication Guide Z-501. Available online: https://pubs.nmsu.edu/_z/Z501.pdf.

Bowser, T., P. Weckler, and R. Mackey. 2017. *Low-Cost Pecan Sanitizer Plans for Small-Scale Producers.* Stillwater,OK: Oklahoma State University, Extension Publication ID FACP-208. Available online: https://extension.okstate.edu/fact-sheets/low-cost-pecan-sanitizer-plans-for-small-scale-producers.html.

Brooks, A. 2026. "How Much Does Internet Cost Per Month?" *Forbes.* Available online: https://www.forbes.com/home-improvement/internet/internet-cost-per-month/.

BuildingsGuide. 2025. *Metal Building Prices: Cost per Square Foot and Estimator*. Available online: https://www.buildingsguide.com/metal-building-prices/.

Byrd's Pecans. 2025. *Missouri Native Pecan Halves.* Available online: https://byrdspecans.com/product/missouri-native-pecan-halves/.

Capps Jr, O., and G.W. Williams. 2019. *Economic Benchmark Model and Analysis of the Effects of the Chinese Tariff on the U.S. Pecan Industry*. Irving, TX: American Pecan Council. Available online: https://americanpecan.com/wp-content/uploads/2020/04/Benchmark-Pecan-Model-Final-Report-to-APC-12-18-2019.pdf [Accessed August 16, 2025].

Caroll, B., and M.W. Smith. 2017. *Pecan Varieties for Oklahoma*. Stillwater, OK: Oklahoma State University, Extension Publication ID HLA-6201.

Clear Fork Materials. 2025. *Pecan Shells*. Available online: https://clearforkmaterials.com/products/pecan-shells mulch?_pos=1&_sid=b98222911&_ss=r.

Coleman, E., C. Bir, R.K. Taylor, D. Landolt, and A. Koller. 2024. "Estimated Feasibility of Controlled Corn Seed Orientation. *Journal of the ASABE* 67(4):903–908.

Cowley, C.A., B.W. Brorsen, and D. Hamilton. 2019. "Economic Feasibility of Anaerobic Digestion with Swine Operations." *Journal of Agricultural and Applied Economics* 51(1):49–68.

Electronic Code of Federal Regulations. 2025. *Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption*, 21 § CFR 112.2. Available online: https://www.ecfr.gov/current/title-21/chapter-I/subchapter-B/part-117?toc=1&utm_.

Forklift Trader. 2025. Available online: https://www.forklifttrader.com/.

Gilbert Pecan Company. 2025. Pecan Halves. Available online: https://gilbertpecan.com/products/1-nativepecanhalves.

Grocery Manufacturers Association and Peanut and Tree Nut Processors Association. 2016. *Industry Handbook for Safe Processing of Nuts: A Technical Guidance for Industry.* Washington, DC: Grocery Manufactuerers Association.

Hammons Pantry. 2025. *Native Pecan Halves*. Available online: https://www.hammonspantry.com/collections/other-nut-varieties/products/native-pecan-halves.

Houston Pecan Company. 2025. *Native Pecan Halves.* Available online: https://houstonpecan.com/collections/nuts/products/pecan-native?variant=14197166276666.

Internal Revenue Service. 2024. *How to Depreciate Property*. Washington, DC: Internal Revenue Service, Publication 946. Available online: https://www.irs.gov/pub/irs-pdf/p946.pdf.

Katom. (2025). Nor-Lake Indoor Walk-in Freezer. Retrieved September 3, 2025, from https://www.katom.com/378-KLF771010C.html?srsltid=AfmBOopY6N49kcqvcY2FVc0-dLnjWE8QC-bRelNn9hgfLQ0oLN5HTfEP.

Kenkel, P.L., R.B. Holcomb, and A. Hill. 2008. "Feasibility of a Co-operative Winery." *Journal of Agribusiness* 26(2):199–215.

Kentucky Kernel. 2025. *Shelled Wild Seedling Pecans.* Available online: https://www.kykernelpecans.com/product/shelled-wild-seedling-pecans/.

Lumivero. 2022. @Risk Software. Denver, CO: Author.

McKay, D.L., M. Eliasziw, C.O. Chen, and J.B. Blumberg. 2018. "A Pecan-rich Diet Improves Cardiometabolic Risk Factors in Overweight and Obese Adults: A Randomized Controlled Trial. *Nutrients* 10(3):339.

Mexal, J.G., E.A. Herrera, T.W. Sammis, and W.H. Zachritz. 2003. *Noncommensurable Values of the Pecan Industry*. Las Cruces, NM: New Mexico State University, Cooperative Extension Service, Guide H-654. Available online: https://pubs.nmsu.edu/_h/H654.pdf.

Miller Pecan Company. 2025. *Farm Fresh Fancy Native Pecan Halves.* Available online: https://millerpecancompany.com/products/farm-fresh-fancy-native-pecan-halves-keto-whole30-paleo-friendly.

Millican Pecan. 2025. *Pecan Meal.* Available online: https://millicanpecan.com/products/buy-pecan-meal.

Minick Materials. 2025. *Pecan Hulls Mulch.* Available online: https://shop.minickmaterials.com/product/pecan-hulls-mulch/.

Nuts.com. 2025. *Pecan Meal*. Available online: https://nuts.com/nuts/pecans/meal/1lb.html.

The Nut House. 2025. *Native Pecan Halves.* Available online: https://66nuts.com/Native-Pecan-Halves---8-oz-to-5-Pounds?srsltid=AfmBOorBHOe7GfrA0MHox6vsn8pK6-AREaA6tJQUqENoSkIqwkVeN_16.

Oklahoma Administrative Code. 2025. *Tree Nut Crackers/Shellers*, CFR § 310:260-5-1. Available online: https://www.law.cornell.edu/regulations/oklahoma/OAC-310-260-5-1.

Peanut and Tree Nut Processors Association. 2022. *Handbook for Safe Processing of Nuts,* 4th ed. Alexandria, VA: Author.

Pearson Farm. 2025. *Pecan Meal.* Available online: https://pearsonfarm.com/products/pecan-meal.

Pecan Pantry. 2025. *Premium Pecan Meal.* Available online: https://thepecanpantry.com/products/1-lb-pecan-meal?_pos=2&_sid=55d3ddeb7&_ss=r.

Pecan Producers International. 2025. *Raw, Native Halves.* Available online: https://pecanproducersonline.com/product/raw-native-halves/.

Pecan Shop. 2025. *Fresh Texas Native Pecan Halves*. Available online: https://pecanshop.com/collections/pecans/products/fresh-texas-native-pecan-halves-unsprayed-raw-organic-practice?variant=31674073022531.

Pete's Landscaping and Materials. 2025. Available online: https://www.peteslandscaping.com/materials.

Rattlesnake Ranch Pecans Company. 2025. *2025 Native Pecan Halves.* Available online: https://rattlesnakeranchpecans.com/products/native-pecan-halves.

RingCentral. 2025. *RingCentral.* Belmont, CA: Author.

Savage Equipment Company. 2019. *Savage* Shellers. Available online: https://www.savageequipment.com/images/Brochures/Shellers%20Flyer%202_26_19.pdf.

Shute Pecan Company. 2025. *Pecan Meal.* Available online: https://shutepecan.com/product/pecan-meal-1-lb/.

Sidharthan, C. 2025. *Pecans and Health: Evidence from Clinical Studies*. Manchester, United Kingdom: AZoNetwork UK Ltd. Available online: https://www.news-medical.net/health/Pecans-and-Health-Evidence-from-Clinical-Studies.aspx.

Solutions. 2025. *Pecan Shell Mulch*. Available online: https://soilutions.net/products/pecan-shells.

Stein, L., M. Nesbitt, and J. Kamas. 2015. *Native Pecans*. College Station, TX: Texas A&M University, Agrilife Extension Publication E-610. Available online: https://aggie-horticulture.tamu.edu/fruit-nut/wp-content/uploads/sites/6/2015/04/pecans_native_2015.pdf.

Strata Landscape. 2025. *Materials*. Available online: https://www.stratalandscape.com/materials.

Sunnyland Farms. 2025. *Pecan Meal.* Available online: https://www.sunnylandfarms.com/products/pecan-meal-1lb-bag?variant=852.

Texas Native. 2025. *Bulk Texas Native Pecan Shell Mulch***.** Available online: https://www.texasnative.com/product-page/bulk-texas-native-pecan-shell-mulch-1-c-y.

Texas Pecan Growers Association. 2025. *Marketing for the Small Pecan Grower*. Bryan, TX: Author. Available online: https://tpga.org/educations/marketing-for-the-small-pecan-grower/.https://66nuts.com/Native-Pecan-Halves---8-oz-to-5-Pounds?srsltid=AfmBOorBHOe7GfrA0MHox6vsn8pK6-AREaA6tJQUqENoSkIqwkVeN_16.

Trees That Please. 2025. Available online: https://www.treesthatplease.org.

TruckPaper. 2025. *Sleeper Trucks*. Available online: https://www.truckpaper.com/listings/search?Keywords=FREIGHTLINER+CASCADIA+126+Sleeper+Trucks+For+Sale.

U.S. Bureau of Labor Statistics. 2025. *Occupational Employment and Wage Statistics Query System*. Washington, DC: U.S. Bureau of Labor Statistics. Available online: http://data.bls.gov/oes/#/home.

U.S. Food and Drug Administration. 2024. *Hazard Analysisand Risk-based Preventive Controls For Human Food: Guidance for Industry (Draft Guidance)*. Silver Spring, MD: U.S. Food and Drug Administration, Center for Food Safety and Applied Nutrition. Available online: https://www.fda.gov/regulatory-information/search-fda-guidance-documents/draft-guidance-industry-hazard-analysis-and-risk-based-preventive-controls-human-food.

U.S. Food and Drug Administration. 2025. *FSMA Final Rule for Preventive Controls for Human Food*. Silver Spring, MD: Author.

U.S. Department of Agriculture. 2025. *Fruit and Tree Nuts Data—Fruit and Tree Nuts Yearbook Tables*. Washington, DC: U.S. Department of Agriculture, Economic Research Service.

U.S. Department of Agriculture. 2024. *Pecan Production Down 6 Percent from Last Season.* Washington, DC: U.S. Department of Agriculture, National Agricultural Statistics Service. Available online: https://downloads.usda.library.cornell.edu/usda-esmis/files/5425kg32f/nv936p236/00001m546/pecnpr24.pdf.

U.S. Energy Information Administration. 2016. *Commercial Buildings Energy Consumption Survey (CBECS)*. Washington, DC: Author. Available online: https://www.eia.gov/consumption/commercial/data/2012/c%26e/cfm/pba4.php.

U.S. Energy Information Administration. 2023. *Electricity Explained.* Washington, DC: Author. Available online: https://www.eia.gov/energyexplained/electricity/data-and-statistics.php.

U.S. Energy Information Administration. 2025. *Heating Oil and Propane Update.* Washington, DC: Author. Available online: https://www.eia.gov/petroleum/heatingoilpropane/.

U.S. Environmental Protection Agency. 2025. *Data and Information Used by WaterSense*. Washington, DC: Author. Available online: https://www.epa.gov/watersense/data-and-information-used-watersense.

U.S. Senate. 2025. *Letter to U.S. Department of Agriculture Regarding Pecan In-shell Exports*. Available online: https://www.ossoff.senate.gov/wp-content/uploads/2025/06/pecan_in-shell_letter_to_usda.pdf.

Valley View Company. 2025. Pecans. Available online: https://valleyviewpecans.com/collections/pecans.

Wells, L. 2024. *An Explanation of Current Pecan Prices.* Athens, GA: University of Georgia, Extension. Available online: https://site.extension.uga.edu/pecan/2024/11/an-explanation-of-current-pecan-prices/.

York Pecan Company. 2025. *Wild Native Halves*. Available online: https://www.yorkpecanshop.com/products/topper-halves-native-pecans.

Young's Premium Foods. 2025. *Pecans for Baking.* Available online: https://youngspremiumfoods.com/collections/pecans-for-baking.

Zapata, S.D., L.A. Ribera, and M.A. Palma. 2017. "Effect of Production Parameters on the Economic Feasibility of a Biofuel Enterprise." *Journal of Agricultural and Applied Economics* 49(3):347–362.