Indoor Herbal Crop Production:

Tulsi, Saffron, Cardamom, and Hyssop

Transfarmation

MERCY FOR ANIMALS

Highland ECONOMICS

Important Disclaimer

This document ("Document") or any written material provided to you by Mercy For Animals, Inc., (including Transfarmation™) or any of its affiliates (together, "MFA"), including but not limited to information or written material prepared by third parties, should not be construed as advice or in any way an endorsement or a recommendation by MFA.

The Document should not form the primary basis for any decision that you make in relation to matters referenced herein and is not a substitute for performing any and all necessary due diligence, including consulting independent agricultural, legal, tax, finance, and other expert advisors.

Neither MFA nor any of its officers, directors, agents, or employees makes any warranty, expressed or implied, of any kind or accepts liability for any losses, damages, costs, or expenses of any kind or description relating to the adequacy, accuracy, or completeness of the information contained in the Document.

The Document is for your general information only, and MFA is not soliciting any action based on it. Any views or opinions expressed in the Document are those of the author except where MFA specifically states that they are the views of MFA. Any view or opinions expressed are valid only as of the date indicated. MFA does not accept any responsibility to update any views, opinions, or other information contained in the Document.

1. Introduction

The specialty herbs in this report—tulsi, saffron, cardamom, and hyssop—are native to Asia and the Middle East but used around the globe owing to their important cultural significance.

These herbs have culinary applications as spices, flavorings, and dyes, as well as medicinal properties that are harnessed for use in pharmaceuticals. The herbs vary considerably in prevalence, reflected in their widely ranging cost. For instance, saffron is considered one of the world's most valuable crops, with reported prices surpassing $5,000 per pound (Kothari et al. 2021). Conversely, hyssop is a relatively common shrub around the world and has become so naturalized in North America that it often grows along roadsides in the United States.

Still, demand for specialty herbs has remained steady or risen in recent years due to a number of factors, including increased interest in natural medicines. As the dominant producers of these herbs continue to face production challenges in India, Southeast Asia, and the Middle East, producers in the West can seize opportunities to meet this demand.

This report outlines current market conditions for specialty herbal crops, presents information on typical indoor production practices (where available), and demonstrates the viability of converting a poultry house into a greenhouse for growing specialty herbs.

2. Market

Depending on whether they are used in food or medicinal products, these herbs are sold whole or processed (dried, ground, distilled, etc.).

Practical Uses

The cultural significance of specialty herbs stems from ceremonial and symbolic use in Hinduism, Judaism, and other religions and applications in systems of traditional medicine, such as Ayurveda in India (Banyan Botanicals, n.d.; Engels and Brinckmann 2013).

- **Tulsi**, or "holy basil," is used in Hindu religious ceremonies and as an Ayurvedic medicine and has become popular worldwide for use in herbal oils, medicinal teas, and supplements (Singh and Chaudhuri 2018). The adaptogenic properties of tulsi that aid in stress response, evaluated in numerous studies, have demonstrated applications as antimicrobial, anti-inflammatory, and anticarcinogenic agents (Cohen 2014; Singh and Chaudhuri 2018).
- For millennia, **saffron** has been used as a food additive, colorant, and natural medicine in Iran and India, eventually spreading to China, Spain, and the rest of the world (Britannica 2023). More recently, studies have shown saffron's promising health benefits in the treatment of depression, neurological disorders, diabetes, and heart disease (Singletary 2020).
- Known as the "queen of spices," **cardamom** is a popular ingredient in both sweet and savory dishes around the world. While applications of cardamom are primarily culinary, its essential oils have beneficial properties for controlling asthma, gum infections, and digestive and kidney disorders (Ashokkumar et al. 2020).
- **Hyssop** flowers and stems are used in various foods and beverages, such as stews, teas, and liquor, and its oils can be used medicinally for gastrointestinal health, inflammation, and immune support (Sharifi-Rad et al. 2022; Skrypnik et al. 2022).

Demand

According to the Agricultural Marketing Resource Center, an aging U.S. population and increased interest in alternative medicine—in part spurred by the COVID-19 pandemic—are driving growth in the medicinal herb market (AgMRC 2021). A deeper understanding of the value of specialty herbs and Ayurvedic botanicals has led to a shift in the pharmaceutical industry and fostered an optimistic outlook for the viability of specialty-herb production (Butler 2018).

- The market for **tulsi** and other medicinal herbs has grown in recent years in the United States, prompting research efforts to evaluate the feasibility of cultivating tulsi domestically (Buckland et al. 2022). A new sleep and stress supplement containing tulsi called "Holixer," manufactured by Natural Remedies, was launched in 2022 with promising commercial viability (Marrapodi 2022).
- Widespread use and cultural significance make expanding the production of **hyssop** a feasible venture. It is considered a "cheap source of raw material" for cosmetics and supplements (Dumacheva et al. 2017).

Researchers at Oregon State University are optimistic about the profitability of growing medicinal herbs in the United States. In a national survey of natural-medicine practitioners, almost 90% said they would prefer domestically grown herbs over imported ones (Buckland et al. 2022).

Supply

While increased global interest in specialty herbs has propelled demand, supply challenges related to climate change have motivated production changes and shifted production into new regions.

- Most **saffron** is sold for food products (70%); the rest is used in cosmetics and supplements (Jeffay 2022). Global production of saffron has slowly decreased since 2019 due to laborious production requirements and weather-related challenges, such as irregular rainfall and drought in major production regions, primarily Iran (Kour et al. 2022; Nisa et al. 2023).
- According to the Observatory of Economic Complexity, global **cardamom** exports shrunk by 24% between 2021 and 2022. In India, volatile weather patterns, including low rainfall and high temperatures, are impacting major production regions, leading to decreased global supplies and increased prices (Krishnakumar 2023). Comparatively low prices in Guatemala, a major cardamom producer, are further reducing India's market share and compelling some Indian farmers to take land out of production (Kumar 2022).

3. Production Practices

Specialty herbs were historically—and still are in some cases—harvested from the wild. Now commercial production is primarily conducted in outdoor cropping systems. Literature on greenhouse or hydroponic production of these herbs is limited, though several trials and commercial examples, as well as success in comparable herbal crops, such as basil and cannabis, indicate that indoor production of tulsi, saffron, cardamom, and hyssop is technically feasible on a commercial scale (Atherton and Li 2023; Kour et al. 2022; Nelson 2021; Skrypnik et al. 2022; Walters and Currey 2015). The production practices, growth parameters, and corresponding cost estimates discussed below are derived from research trials and outdoor commercial operations. Studies suggest that the bioactive compounds in medicinal herbs are more concentrated in hydroponic production systems, increasing economic viability (Atherton and Li 2023; Giurgiu et al. 2014).[1]

Temperature and Humidity

Controlled environments are important for the cultivation of herbal crops, as each herb has optimal temperature and humidity conditions, and some may require changes in these specifications throughout their life cycle, such as perennial cardamom and hyssop. Saffron grown indoors requires a "cold shock" to induce flowering (Nelson 2021).

Growing Systems and Media

The growth cycle (length of time to harvest) influences the choice of soilless media used. Two soilless culture systems are most often used in greenhouse herb production:

- Closed hydroponic systems grow plants in troughs or tubes where plants are anchored in gravel, sand, or artificial soilless mixes or without a substrate, sometimes using a nutrient film technique (NFT) (Swain et al. 2021). The nutrient solution circulates through the system via pumps, continuously bathing bare roots (Swain et al. 2021).
- Bag or pot systems use containers filled with artificial media that are drip-irrigated with nutrient solution. The media in these systems must be able to expand to accommodate root growth and usually consist of coir, clay, or combinations of peat and perlite, depending on the level of water retention (drainage) needed (Swain et al. 2021).

Seed Selection

Tulsi, cardamom, and hyssop are typically propagated from seed, which can take from eight to 30 days (BBC Gardeners' World 2021; NC State Extension 2023a; Walters and Currey 2015). Saffron is propagated through corms (bulbs), and sourcing high-quality corms can be expensive and challenging (Kothari et al. 2021). Tulsi seed is inexpensive and can be purchased new at each planting, while cardamom and hyssop seed need to be purchased only once to establish perennial plants. Saffron propagation methods are discussed below.

Spacing

Spacing requirements vary for specialty herb crops, ranging from 20 bulbs per square foot for saffron in high-density systems to six feet between cardamom plants.

Figure 1. Saffron cultivated in a low-density system. (Image from Dewir et al. 2022.)

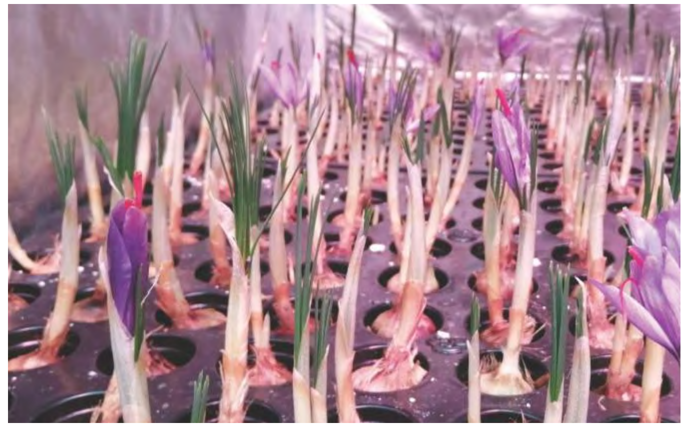


Figure 2. Saffron cultivated in a high-density system. (Image from Nardi et al. 2022.)

Irrigation

Plants need an adequate supply of water and nutrients to their roots, but proper circulation is necessary in hydroponic systems to avoid fungal pathogens in the growing media. Tulsi and saffron (during propagation) can be irrigated weekly, while saffron grown in high-density systems for flowers alone does not need irrigation. Water requirements for cardamom and hyssop are comparatively less, as both are infrequently irrigated in rain-fed field systems and hyssop is drought tolerant (NC State Extension, n.d.-a; NC State Extension, n.d.-b).

Sanitation and Sterilization

Many greenhouses have a sanitation process everyone must follow before entering the production area. In addition, a complete sterilization of the production area should occur between growing cycles.

Postharvest Processing and Packing

Each specialty herb has specific postharvest drying requirements, though all are generally accomplished in less than one day in a temperature- and humidity-controlled chamber (BBC Gardeners' World 2021; IndiaAgroNet.com, n.d.; Nelson 2021). Herbs are commonly packaged in spice bags of various sizes, except saffron, which is often sold in two-gram metal tins.

4. Enterprise Budget

No published or reported enterprise budgets exist for the specialty herbs and development context considered in this analysis. For purposes of developing estimates of production costs for herbal crops produced in a greenhouse, we rely on crop production costs in similar systems. Cardamom and hyssop are not typically grown indoors, likely due to their perennial nature, size, and suitability for growing outdoors. Tulsi and saffron are produced indoors in research settings in the United States, and saffron is grown hydroponically on a commercial scale. All herbal crops are assumed to be minimally processed (dried) after harvest and packaged for retail sale via an e-commerce website where the customer assumes shipping costs. An e-commerce website is estimated to cost around $1,200 per year in membership fees, and order fulfillment costs a producer $3 per transaction (Barn2Door, n.d.; Shvetsova 2022; Shopify, n.d.).

4.1 Crop-Specific Costs

Substrate prices were compiled from retail data online, and materials commonly used as substrate cost an average of $12.20 per cubic foot. Container prices are based on comparable enterprise-budget estimates or retail data found online. We have based costs of nutrient solution and fertilizer on comparable enterprise-budget estimates, online retail data, and typical water and nutrient requirements for a given crop, assuming about 0.00375 gallons of nutrient solution per gallon of irrigation water (Tye-Dyed Iguana, n.d.).

4.1.1 Tulsi

Iowa State University conducted trials of tulsi grown in a hydroponic NFT system, which we rely on here along with labor requirements, inputs, and packaging expenses drawn from enterprise budgets for outdoor basil and hydroponic lettuce published by Iowa State University and The Ohio State University, respectively (Chase and Hanlon 2020; Donnell et al. 2015). Tulsi is modeled to be started from seed and harvested twice per 12-week planting, a total of eight harvests per year.

The Iowa State study reports hydroponic tulsi yields to be about 4.7 grams per plant (Walters and Currey 2015). Dried tulsi leaves retail from $0.03 to $0.10 per gram, depending on package size (Monterey Herb Co., n.d.-a; Homeshop Essentials, n.d.). Labor for planting, management, harvest, and maintenance is estimated to be 540 hours.

4.1.2 Saffron

Saffron can be grown indoors in two types of systems. A low-density system entails a one-time purchase of corms, which are sprouted in a growing medium, harvested after flowering one time per year, and propagated throughout the rest of the year in the same containers (Dewir et al. 2022). In this perennial system, yield and space are not optimized, but planting material replicates each season and yield per plant may increase over time. This production method requires a hydroponic ebb-and-flow NFT system and nutrient solution to facilitate plant growth and development.

In high-density saffron production, comparably little hydroponic infrastructure is used. Corms are planted in a light-, temperature-, and humidity-controlled environment on simple trays with minimal soilless media, such as perlite (Nardi et al. 2022). A much higher planting density can be achieved, and corms can be induced to flower and harvested as many as four times per year. Compared with low-density production, however, this system requires the repeated purchase of planting stock and involves more labor (with increased efficiency).

Some combination systems exist, where after high-density cultivation and harvest is carried out in simple controlled-environment chambers plants are transplanted into greenhouse areas for the remainder of the year to multiply planting stock. It is difficult to model how these systems can be combined and how forced dormancy and overlapping cultivation periods could maximize productivity. Thus, this budget presents the two systems separately.

Saffron yields in various controlled-environment experiments are around 0.03 grams of dried stigma per corm (Mehta 2023; Nelson 2021). Retail saffron prices vary depending on quality, with lower-quality saffron selling for around $5 per gram and higher-quality saffron for as much as $20 per gram (Mehta 2023; Skinner, Parker, and Ghalehgolabbehbahani 2020). For our budget, we estimate a likely average price of $10 per gram.

Growers using a low-density system can sell saffron corms after the first year. We model this gross profit potential at a rate of four corms per plant and $0.21 per corm (half the purchase price), which reflects the smaller size relative to that of the mature corms purchased initially. Labor requirements are estimated according to published information regarding high- and low-density production systems for saffron and similar crops (Hydroponics Space, n.d.; Northeast Organic Farming Association of Vermont 2017; Skinner, Parker, and Ghalehgolabbehbahani 2020). Labor for low-density saffron is estimated at 233 hours per year, and labor for high-density saffron is estimated at 2,174 hours.

4.1.3 Cardamom

Cardamom production in a hydroponic system is difficult to model, as little information exists on how a hydroponic system would compare with outdoor production in terms of productivity. A cardamom plant is large and long-lived, up to 10 years, characteristics that are not typically selected for hydroponic crop production. For purposes of this budget, we assume that cardamom plants are planted in individual pots and watered through hydroponic drip irrigation.

Cardamom yields in outdoor systems vary by variety and average around 1.42 pounds of dried cardamom pods per plant (Vijayan, Pradip Kumar, and Remashree 2018). Depending on variety, prices for dried whole cardamom generally range from $37 to $48 per pound (Monterey Herb Co., n.d.-b; Spice Jungle, n.d.). Labor requirements are estimated according to published information for outdoor systems (AgriFarming 2019).

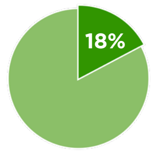
4.1.4 Hyssop

Like cardamom, hyssop is a large perennial plant. Hydroponic trials of hyssop have been conducted to evaluate the essential oil content of the plant before typical full maturity but suggest that it can be cultivated long-term in hydroponic systems (Skrypnik et al. 2022). For purposes of this budget, we assume that cardamom plants are planted in individual pots and watered through hydroponic drip irrigation.

Because available data on hydroponic trials was collected before the plants reached full maturity, information about yields in hydroponic systems is lacking. Thus, for this budget we model an outdoor hyssop yield of 0.26 pounds of dried hyssop leaves per harvest. Dried hyssop retail prices range from $20 to $65 per pound, depending on quantity (Solo Therapy, n.d.; Urth Spirit, n.d.). Labor requirements are estimated according to published information for outdoor thyme production (Almansour and Ali 2021).

4.2 Utilities

Utility requirements of a greenhouse include fuel for heating, electricity for fans, water, sewerage, and communication. In this budget, we estimate natural gas requirements of 2,180,000 cubic feet at a cost of $9.52 per 1,000 cubic feet. In addition, we expect the electricity requirements to be 50,000 kilowatt hours of energy per year and estimate a cost of $0.12 per kilowatt hour. Telephone (cell) and internet costs for the business are modeled at $1,400 per year. Utilities represent around 18% of the greenhouse operation's total variable costs.



4.3 Other Operating Costs

Miscellaneous costs include laboratory fees, such as for analysis of leachate, tissue, and nutrient solution, estimated at $1,440 per year; office supplies ($600); postage; and marketing materials ($600). In total, we expect such costs to be $2,640 per year.

4.4 Cash Overhead

Property taxes for the operation will be specific to the location but are modeled at $250 per month, or $3,000 per year. Some states may impose income or other applicable taxes on top of property tax, but these are not modeled here. This analysis does not assume any land cost, so the profit identified below can be considered a return-on-land estimate. We model general liability insurance at $70 per month and property insurance at $200 per month. Total insurance costs are estimated at $3,240 annually. The table below outlines the operating costs common to all three crops.

Table 1. Operating costs for greenhouse production common to all herb types

Description	Unit	Quantity	Price per unit	Cost
Fungicide or pesticide	Gallon	18	$20.00	$360
Sanitizer	Gallon	14	$24.00	$336
Natural gas	1,000 ft.^{3}	2,180	$9.52	$20,754
Electricity	kWh	50,000	$0.12	$6,000
Telephone and internet				$1,400
Miscellaneous				$2,640
Property tax				$3,000
Insurance				$3,240
E-commerce site				$1,200
Total common costs				**$38,930**

In addition to these common costs, production will entail operating costs that vary by crop type, such as labor and packaging. These are outlined in table 2, along with profit estimates for each type.

Table 2. Representative enterprise budget for specialty herbal crops

	Tulsi	Saffron, low density	Saffron, high density	Cardamom	Hyssop
Gross returns	$34,182	$6,194	$192,000	$12,663	$46,430
Variable costs:					
Seed	$70	$8,671	$268,800	$111	$1.50
Containers	$2,296	$36,982	$2,297	$899	$8,094
Fertilizer / nutrient solution	$1,585	$2,251	n/a	$470	$3,053
Labor	$9,492	$4,090	$38,218	$6,261	$2,095
Packaging	$60	$310	$9,600	$13	$41
Fulfillment	$4,527	$929	$28,800	$950	$3,095
Total variable costs	$18,030	$53,232	$347,715	$8,703	$16,379
Total common costs	$38,930	$38,930	$38,930	$38,930	$38,930
Operating profit					
Year 1	-$22,778	-$85,968	-$194,645	-$34,971	-$8,879
Year 2+		-$59,955[2]	-$153,948	-$29,506	-$366

Note: Individual figures may not sum to totals due to rounding.

4.5 Capital Costs and Noncash Overhead

The capital cost of converting a poultry house into a greenhouse is estimated at $6.02 per square foot, or $96,272 for the structure (16,000 square feet of production area).[3] A commercial dryer for postharvest drying of herbal crops is estimated at $1,342 (Hydrobuilder, n.d.). We estimate the cost of the hydroponic system used in production at $39,336, according to a quote from Carolina Greenhouses for a Dutch-bucket system adjusted to 2023 dollar values.[4] In addition, we estimate a cost of $25,245 for environmental controls and other necessary equipment, identified from a list of requirements developed by The Ohio State University Extension, with costs indexed to 2023 dollar values:

- Backup generator: $5,720
- Cooling system: $2,640
- Fan jets (two): $2,860 ($1,430 each)
- Computer for environmental controls: $3,630
- Heating system: $2,860
- Miscellaneous building supplies: $2,200
- Sprayer: $110
- CO2 generator: $550
- Fertilizer mixing pump: $55
- Feeding system: $3,520
- Meters, monitors, sensors, and scale: $1,100

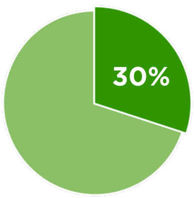
Thus, the total capital expenditure estimate is **$162,195**. This analysis further assumes the owner could finance the conversion through existing programs offered by the Small Business Administration (SBA), the United States Department of Agriculture, and possibly other lenders. Our analysis models the debt-service terms of the SBA 504 program: 10% equity requirement (90% financed), or $16,219. The SBA loan would cover 40% of the total cost; thus 50% of the capital costs would need to be financed through a bank. With these conditions, we anticipate the entire financing package would be close to the prime rate (currently 8.5%).

4.6 Profit Potential

According to the cost assumptions outlined above, including projected yield, the break-even price for tulsi, saffron, cardamom, and hyssop grown in a 16,000-square-foot greenhouse is $.08 per gram, $20.40 per gram, $152 per pound, and $45 per pound, respectively. All but one of these price points (hyssop) is above the range of prices growers could expect to receive.

The expected operating profit is negative for all the crops modeled, including both systems modeled for saffron. A vertical system with a dedicated area for indoor propagation could be a more economically viable option for producers to consider, albeit at higher capital costs. The reason for lack of profitability is likely the production cost competitiveness of existing sources. Profitability for most of these crops would require increased operational efficiencies (from what is modeled), such as vertical production, or higher price points.

Hyssop is the only crop modeled with a strong likelihood of profitability (around 45%). This crop has a break-even price of $45.35 per pound, slightly above the expected price of $45. Selling hyssop at the high end of the price range, producers could see a profit margin of nearly 30%.



Debt-service coverage ratio (DSCR) is a measurement of a firm's available cash flow to pay current debt obligations, calculated as the net operating income divided by debt obligations (principal and interest payments). A DSCR less than 1.00 indicates potential solvency problems, while a DSCR of at least 2.00 is generally considered very strong. The DSCR is negative for all crops in this analysis sold at likely price points. Hyssop sold at the high end of the price range (30% operating profit) would have a DSCR of 1.25 with a 20-year note at 8.5% interest and annual payments of $15,425. Such a DSCR indicates financial solvency but would not be considered strong.

4.7 Sensitivity

We undertook a sensitivity analysis to evaluate the impact of key assumptions on the profit estimate for an enterprise producing hyssop as modeled. These assumptions are as follows:

- Yield (387 to 645 pounds per plant per harvest, two harvests per year)
- Price received ($20 to $64 per pound)
- Labor requirements for production (95 to 143 hours)
- Natural gas usage (1,800,000 to 2,200,000 cubic feet)
- Fulfillment price ($2.50 to $5.00 per package)

As figure 3 shows, price and yield have the greatest impact on profitability. Most iterations indicate a negative profit potential, but nearly half show positive operating profits for hyssop.

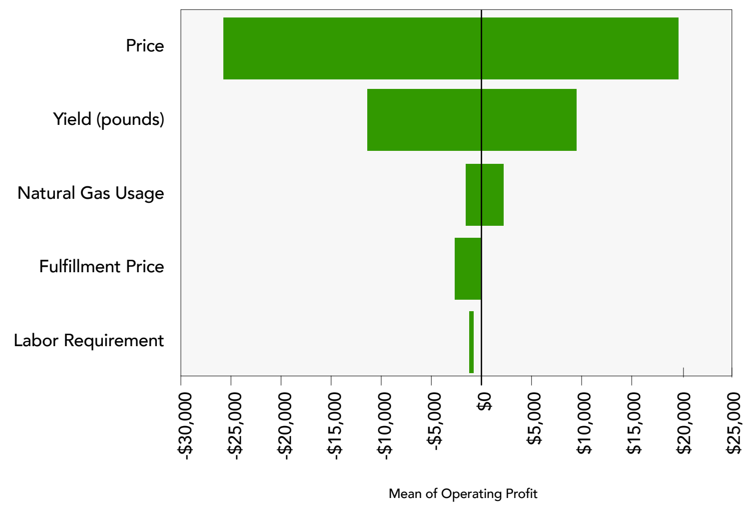


Figure 3. Sensitivity analysis results.

Endnotes

1 No information is available on the correlation between the type of growing system and price received.

2 Includes the sale of saffron corms in year 2 as described in section 4.1.2.

3 Quotes for the conversion of a chicken house to a greenhouse for crop production range from $3 to $8 per square foot, depending on the type of material used in covering the structure (Sullivan and Howard 2022). $6.02 represents the adjusted (indexed to 2023 dollar values) midpoint estimate between double-layer film and corrugated polycarbonate. This cost includes fans, groundcover, ventilation control, and shade cloth, along with the labor and material costs for conversion of the structure (Kardos, Kuzma, and Ragon 2022; Sullivan and Howard 2022).

4 The quote for a Dutch-bucket system for 100 feet of greenhouse totaled $11,175 (Sullivan and Howard 2022). This budget assumes 320 feet of greenhouse space for crop production, which would total $35,760, or $39,336 when indexed to 2023 dollar values. Simplistic hydroponic container systems could also be used and represent lower capital costs but are not modeled here. An NFT system could likely be used for tulsi and low-density saffron crops, but because of these crops' negative profit potential, for this analysis we model only a Dutch-bucket system.

References

AgMRC. 2021. "Herbs." Last modified November 2021. https://www.agmrc.org/commodities-products/specialty-crops/herbs.

AgriFarming. 2019. "Cardamom Cultivation Income (Elachi), Project Report." Last modified September 17, 2019. https://www.agrifarming.in/cardamom-cultivation-income-elachi-project-report#the-yield-of-cardamom-per-acre.

Almansour, Baraa Munir, and Ghaith Amin Ali. 2021. "Economic Analysis of Thyme (*Origanum syriacum*) Production for Smallholder Farmers." *IOP Conference Series: Earth and Environmental Science* 923, no. 1 (November): 012001. https://doi.org/10.1088/1755-1315/923/1/012001.

Ashokkumar, Kaliyaperumal, Muthasamy Murugan, M. K. Dhanya, and Thomas D. Warkentin. 2020. "Botany, Traditional Uses, Phytochemistry and Biological Activities of Cardamom (*Elettaria cardamomum* (L.) Maton)—a Critical Review. *Journal of Ethnopharmacology* 246 (January): 112244. https://doi.org/10.1016/j.jep.2019.112244.

Atherton, Hallam R., and Pomin Li. 2023. "Hydroponic Cultivation of Medicinal Plants—Plant Organs and Hydroponic Systems: Techniques and Trends." *Horticulturae* 9, no. 3 (March): 349. https://doi.org/10.3390/horticulturae9030349.

Banyan Botanicals. n.d. "The Benefits of Tulsi (Holy Basil)." Accessed August 15, 2023. https://www.banyanbotanicals.com/info/plants/ayurvedic-herbs/tulsi-holy-basil-benefits/#growing.

Barn2Door. n.d. "Simple and Transparent Pricing." Accessed December 12, 2023. https://www.barn2door.com/pricing.

BBC Gardeners' World. 2021. "How to Grow Hyssop." August 26, 2021. https://www.gardenersworld.com/how-to/grow-plants/how-to-grow-hyssop/.

Britannica. 2023. "Saffron." May 9, 2023. https://www.britannica.com/topic/saffron.

Buckland, Kristine, Ben Marx, Peg Schafer, Alexandra Stone, Nick Andrews, and Ann Rasmussen. 2022. *Medicinal Herb Production in the Pacific Northwest*. Corvallis: Oregon State University Extension. https://extension.oregonstate.edu/catalog/pub/em-9349-medicinal-herb-production-pacific-northwest.

Butler, Karen. 2018. "Ancient Wisdom in Modern Times: Ayurvedic Botanicals Help Today's Consumers Improve General Well-Being." *Natural Products Insider* 8, no. 2 (January): 5–10. https://www.naturalproductsinsider.com/herbs-botanicals/ayurvedic-botanicals-traditional-remedies-find-modern-application.

Chase, Craig, and Olivia Hanlon. 2020. *Iowa Fruit and Vegetable Production Budgets: Annual Crops*. Ames: Iowa State University Extension and Outreach. https://www.extension.iastate.edu/agdm/crops/html/a1-17.html.

Cohen, Marc Maurice. 2014. "Tulsi—*Ocimum sanctum*: A Herb for All Reasons." *Journal of Ayurveda and Integrative Medicine* 5, no. 4 (October–December): 251–59. https://doi.org/10.4103/0975-9476.146554.

Dewir, Yaser Hassan, Abdullah Alsadon, Abdullah Ibrahim, and Mohammed El-Mahrouk. 2022. "Effects of Growing Substrate, Mode of Nutrient Supply, and Saffron Corm Size on Flowering, Growth, Photosynthetic Competence, and Cormlet Formation in Hydroponics." *HortTechnology* 32, no. 2 (July): 234–40. https://doi.org/10.21273/HORTTECH04980-21.

Donnell, Mary, Ted Short, Robert Moore, and Chad Draper. 2011. *Hydroponic Greenhouse Lettuce Enterprise Budget*. Columbus: The Ohio State University. https://u.osu.edu/greenhouse/hydroponic-crop-program-economic-budgets/.

Dumacheva, Elena V., Vladimir I. Cherniavskih, Elena I. Markova, Sergey V. Filatov, Valeriy K. Tokhtar, Lyudmila A. Tokhtar, Tatyana A. Pogrebnyak, Elena N. Horolskaya, Anzhelika A. Gorbacheva, Oksana V. Vorobyova, and Tatyana N. Glubsheva. 2017. "Biological Resources of the Hyssopus I on the South of European Russia and Prospects of Its Introduction." *International Journal of Green Pharmacy* 11, no. 3 (July–September): S476–80. https://doi.org/10.22377/ijgp.v11i03.1160.

Engels, Gayle, and Josef Brinckmann. 2013. "Holy Basil: *Ocimum tenuiflorum* (*O. sanctum*): Family: *Lamiaceae*." *HerbalGram* 98 (Summer): 1–6. https://www.herbalgram.org/resources/herbalgram/issues/98/table-of-contents/hg98herbpro-holybasil/.

Giurgiu, R. M., G. A. Morar, Adelina Dumitras, Paunita Boanca, B. M. Duda, and Cristina Moldovan. 2014. "Study Regarding the Suitability of Cultivating Medicinal Plants in Hydroponic Systems in Controlled Environment." *Research Journal of Agricultural Science* 46 (2): 84–92.

Homeshop Essentials. n.d. "Authentic and Premium Quality Dried Tulsi Leaves (Holy Basil), 250g / 8.8 oz." Ebay. Accessed December 12, 2023. https://www.ebay.com/itm/304750949199?chn=ps&norover=1&mkevt=1&mkrid=711-213727-13078-0&mkcid=2&itemid=304750949199&targetid=4580840333842793&device=c&mktype=&googleloc=&poi=&campaignid=603247655&mkgroupid=1235852063340218&rlsatarget=pla-4580840333842793&.

Hydrobuilder. n.d. "Covert 8′ x 8′ Deluxe Harvest Drying Package with Odor Control and Extraction Kit with Automated Ventilation Package." Accessed December 12, 2023. https://hydrobuilder.com/trimmers-harvest/complete-harvest-drying-packages/high-rise-8-x-8-deluxe-harvest-drying-package-with-odor-control-and-extraction-kit.html.

Hydroponics Space. n.d. "Hydroponic Saffron—a Guide for Making a 6 Figure Income." Accessed December 12, 2023. https://www.hydroponicsspace.com/hydroponic-saffron-a-guide-for-making-a-6-figure-income/?expand_article=1#google_vignette.

IndiaAgroNet.com. n.d. "Crop Cultivation Guide: Cardamom." Accessed October 2, 2023. https://indiaagronet.com/indiaagronet/crop%20info/Cardamom.htm.

Jeffay, John. 2022. "Indoor Farming Revolution for World's Priciest Spice." NoCamels, November 23, 2022. https://nocamels.com/2022/11/indoor-farming-revolution-for-worlds-priciest-spice/.

Kardos, Josh, Joy Kuzma, and Sam Ragon. 2022. *Plans for Converting a Chicken House into a Greenhouse and Systems and Crops for Production* (for Mercy For Animals). Blacksburg: Virginia Tech College of Agriculture and Life Sciences School of Plant and Environmental Sciences.

Kothari, Deepak, Meenakshi Thakur, Robin Joshi, Amit Kumar, and Rakesh Kumar. 2021. "Agro-climatic Suitability Evaluation for Saffron Production in Areas of Western Himalaya." *Frontiers in Plant Science* 12 (March): 657819. https://doi.org/10.3389/fpls.2021.657819.

Kour, Kanwalpreet, Deepali Gupta, Kamali Gupta, Guarav Dhiman, Sapna Juneja, Wattana Viriyasitavat, Hamidreza Mohafez, and Mohammad Aminul Islam. 2022. "Smart-Hydroponic-Based Framework for Saffron Cultivation: A Precision Smart Agriculture Perspective." *Sustainability* 14, no. 3 (February): 1120. https://doi.org/10.3390/su14031120.

Krishnakumar, P. K. 2023. "Scanty Rainfall Hits Cardamom Production, Prices Set to Spiral to Record Levels." Money Control, August 16, 2023. https://www.moneycontrol.com/news/economy/agriculture/scanty-rainfall-hits-cardamom-production-prices-set-to-spiral-to-record-levels-11197301.html.

Kumar, V. Sajeev. "Growing Concerns. 2022. "2023 Looks Bleak for Cardamom on Lower Production, Prices." *The Hindu Business Line*, December 28, 2023. https://www.thehindubusinessline.com/economy/agri-business/2023-looks-bleak-for-cardamom-on-lower-production-prices/article66313002.ece.

Marrapodi, Alissa. 2022. "Natural Remedies Launches Holy Basil Ingredient Called Holixer for Sleep, Stress." Nutritional Outlook, October 7, 2022. https://www.nutritionaloutlook.com/view/natural-remedies-launches-holy-basil-ingredient-called-holixer-for-sleep-stress.

Mehta, Somya. 2023. "Inside the UAE's First Saffron Farm." *Khaleej Times*, January 9, 2023. https://www.khaleejtimes.com/lifestyle/inside-the-uaes-first-saffron-farm.

Monterey Herb Co. n.d.-a. "Tulsi Leaf Granules—Bulk." Accessed December 12, 2023. https://www.herbco.com/p-1445-tulsi-leaf-cs.aspx.

Monterey Herb Co. n.d.-b. "Wholesale Cardamom." Accessed December 12, 2023. https://www.herbco.com/c-216-cardamom.aspx.

Nardi, Luca, Giulio Metelli, Marco Garegnani, Maria Elena Villani, Silvia Massa, Elisabetta Bennici, Raffaele Lamanna, Marcello Catellani, Silvia Bisti, Maria Anna Maggi, Olivia C. Demurtas, Eugenio Benvenuto, and Angiola Desiderio. 2022. "Farming for Pharming: Novel Hydroponic Process in Contained Environment for Efficient Pharma-Grade Production of Saffron." *Molecules* 27, no. 24 (December): 8972. https://doi.org/10.3390/molecules27248972.

NC State Extension. n.d.-a. "*Elettaria cardamomum*." Accessed December 5, 2023. https://plants.ces.ncsu.edu/plants/elettaria-cardamomum/.

NC State Extension. n.d.-b. "*Hyssopus officinalis*." Accessed December 5, 2023. https://plants.ces.ncsu.edu/plants/hyssopus-officinalis/.

Nelson, Laura. 2021. "AVF Lab and Indoor Saffron—Growing Specialty Products with Vertical Farming Technology." Association for Vertical Farming, December 21, 2021. https://vertical-farming.net/blog/2021/12/21/avf-lab-and-indoor-saffron-growing-speciality-products-with-vertical-farming-technology/.

Nisa, Rifatun, B. A. Alie, Tanveer Ahmad Ahngar, and Arif Hussain Bhat. 2023. "Indoor Saffron Production—How and Why." *Just Agriculture* 3, no. 10 (June): 272–78. https://justagriculture.in/files/newsletter/2023/june/45.%20Indoor%20Saffron%20Production%20-%20How%20and%20Why.pdf.

Northeast Organic Farming Association of Vermont. 2017. *Cost of Production Project: Potatoes*. Richmond: Northeast Organic Farming Association of Vermont. https://www.nofavt.org/sites/default/files/files/resources/potatoes-cop-factsheet__0.pdf.

Observatory of Economic Complexity. n.d. "Cardamoms." Accessed May 30, 2024.

https://oec.world/en/profile/hs/cardamoms.

Sharifi-Rad, Javad, Cristina Quispe, Manoj Kumar, Muhammed Akram, Mewish Amin, Mehwish Iqbal, Niranjan Koirala, Oksana Sytar, Dorota Kregiel, Silvana Nicola, Andrea Ertani, Montserrat Victoriano, Nafiseh Khosravi-Dehaghi, Miquel Martorell, Mohammed M. Alshehri, Monica Butnariu, Marius Pentea, Lia Sanda Rotariu, Daniela Calina, Natália Cruz-Martins, and William C. Cho. 2022. "Hyssopus Essential Oil: An Update of Its Phytochemistry, Biological Activities, and Safety Profile." *Oxidative Medicine and Cellular Longevity* 2022, no. 3 (January): 8442734. http://doi.org/10.1155/2022/8442734.

Shopify. n.d. "Plans & Pricing." Accessed December 12, 2023. https://www.shopify.com/pricing.

Shvetsova, Yuliia. 2022. "Ecommerce Fulfillment Costs: What You'll Pay for an Order Fulfillment." Elogic Commerce, June 1, 2022. https://elogic.co/blog/ecommerce-fulfillment-costs-what-youll-pay-for-an-order-fulfillment/.

Singh, Deepika, and Prabir K. Chaudhuri. 2018. "A Review on Phytochemical and Pharmacological Properties of Holy Basil (*Ocimum sanctum* L.)." *Industrial Crops and Products* 118 (August): 367–82. https://doi.org/10.1016/j.indcrop.2018.03.048.

Singletary, Keith. 2020. "Saffron: Potential Health Benefits." *Nutrition Today* 55, no. 6 (November–December): 294–303. https://doi.org./10.1097/NT.0000000000000449.

Skinner, Margaret, Bruce L. Parker, and Arash Ghalehgolabbehbahani. 2020. *Saffron by the Numbers*. Burlington: University of Vermont. https://www.uvm.edu/~saffron/Old/Workshops/Saffron%20Workshop%202020/Saffron%20by%20the%20numbers%20 2020.pdf.

Skrypnik, Liubov, Pavel Feduraev, Tatiana Styran, Anton Golovin, Dmitriy Katserov, Sofia Nebreeva, and Pavel Maslennikov. 2022. "Biomass, Phenolic Compounds, Essential Oil Content, and Antioxidant Properties of Hyssop (*Hyssopus officinalis* L.) Grown in Hydroponics as Affected by Treatment Type and Selenium Concentration." *Horticulturae* 8, no. 11 (November): 1037. https://doi.org/10.3390/horticulturae8111037.

Solo Therapy. n.d. "Dried Cut Herb, 3 oz. *Hyssopus officinalis*, Hyssop Tea." Amazon. Accessed December 12, 2023. https://www.amazon.com/Hyssopus-Officinalis-Natural-Resealable-Packaged/dp/B09DTJHP8J/ref=sr_1_3?crid=1KDPKTX45963A&keywords=hyssopus+officinalis&qid=1701804874&s=grocery&sprefix=hyssopus+officinalis%2Cgrocery%2C376&sr=1-3.

Spice Jungle. n.d. "Whole Green Cardamom, 16 oz." Accessed December 12, 2023. https://www.spicejungle.com/green-cardamom-pods#amount=453.

Sullivan, Gary, and Joanne Howard. 2022. *Material and Labor Quotes for Greenhouse Coverings, Optional Equipment and Crop Production Systems for the Conversion of a Chicken House to Crop Production* (for Mercy For Animals). Carolina Greenhouses.

Swain, Aurosikha, Subhrajyoti Chatterjee, M. Viswanath, Anindita Roy, and Amit Biswas. 2021. "Hydroponics in Vegetable Crops: A Review." *Pharma Innovation Journal* 10, no. 6 (June): 629–34.

Tye-Dyed Iguana. n.d. "How Much Hydroponic Solution Do I Need to Use?" Accessed December 12, 2023. https://thetyedyediguana.com/blog/how-much-hydroponic-solution-do-i-need-to-use/.

Urth Spirit. n.d. "1 lb Hyssop Cut (*Hyssopus officinalis*)." Accessed December 12, 2023. https://www.urth-spirit.com/product-page/1-lb-hyssop-cut-hyssopus-officinalis?utm_source=google&utm_medium=wix_google_channel&utm_campaign=-freelistings.

Vijayan, A. K., K. Pradip Kumar, and A. B. Remashree. 2018. "Small Cardamom Production Technology and Future Prospects." *International Journal of Agricultural Sciences* 10, no. 16 (August): 6943–48. http://doi.org./10.13140/RG.2.2.28724.50567.

Walters, Kellie J., and Christopher J. Currey. 2015. "Hydroponic Greenhouse Basil Production: Comparing Systems and Cultivars." *HortTechnology* 25, no. 5 (October): 645–50. https://doi.org/10.21273/HORTTECH.25.5.645.