Indoor Edible-Flower Production:
Viola, Nasturtium, Marigold, and Chrysanthemum

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1. Introduction

The category of edible flowers represents a broad range of flowering annuals and perennials used for decorative garnishes, teas, and flavoring. Unique sensory attributes and essential oil content have bolstered consumer interest in edible flowers in recent years, especially with increasing demand for healthy food alternatives (Pires Jr. et al. 2023).

The edible flowers in this report have diverse origins, physiology, and growing parameters. Common names in the table below often represent an entire genus containing multiple species and varieties with similar characteristics.

Table 1. Common edible flowers

Common name	Genus	Reproduction
Pansy, viola, violet	*Viola*	Annual
Nasturtium	*Tropaeolum*	Annual
Marigold	*Tagetes*	Annual
Chrysanthemum	*Chrysanthemum*	Perennial

Source: Warmund 2022.

Currently, most producers and consumers of edible flowers are in Asian countries, such as China, India, and Taiwan. In the United States, small producers have been successful in marketing edible flowers in recent years, and producers already growing ornamental plants are especially poised to diversify their offerings and capture a share of this growing industry (Tardivo and Meru 2018; Pires Jr. et al. 2023).

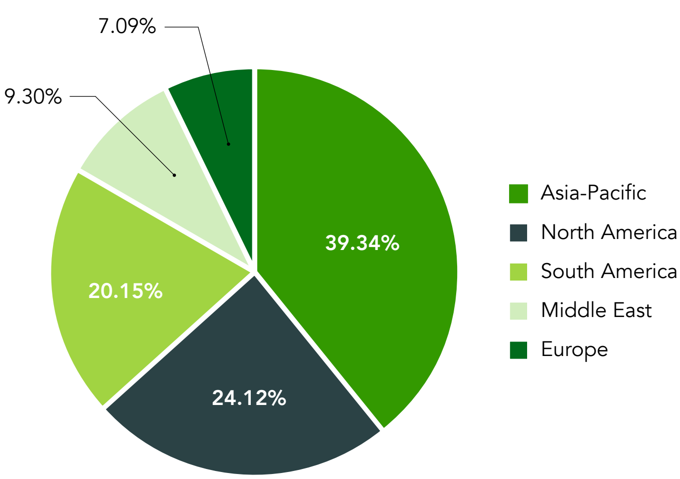

Figure 1. Market share of packaged edible flowers (adapted from Pires Jr. et al. 2023).

This report outlines current market conditions for edible flowers, presents information on typical indoor production practices (where available), and demonstrates the viability of converting a poultry house into a greenhouse for edible-flower production.

2. Market

The market for edible flowers has increased in recent years to meet popular culinary trends and the rising demand for healthy foods with an ornate appeal (Pires Jr. et al. 2023; Fernandes et al. 2019). The global market for packaged edible flowers is expected to surpass $380 million by 2026, growing about $90 million from 2020 (Pires Jr. et al. 2023).

While consumers and food preparers are calling for increased production and supply, challenges remain in evaluating the nutritional and toxicological properties of edible flowers and equipping growers with resources on best ways to produce and preserve them (Purohit et al. 2021; Pires Jr. et al. 2023; Fernandes et al. 2019; Scariot, Ferrante, and Romano 2022).

Global and national production statistics are limited, in part due to the difficulty of exporting edible flowers (Fernandes et al. 2019). Edible flowers are highly perishable, with some lasting only one day before beginning to decay, necessitating local markets or a comprehensive cold chain for transport if sold fresh (Scariot, Ferrante, and Romano 2022). Drying is a common practice for increasing shelf life and expanding market reach but reduces the price received per unit sold (Tuladhar 2021; Dorozko et al. 2019).

Commercial enterprises in Asia currently produce the most and widest variety of edible flowers (Fernandes et al. 2019). Producers in the United States mainly grow edible flowers alongside their fruit and vegetable crops as a way to diversify their product range (Pires Jr. et al. 2023). Few large-scale edible-flower operations exist in the United States and are limited in their offerings (primarily violas and assorted flower mixes) (Fernandes et al. 2019). Infrastructure requirements, yield limitations, crop fragility, and food safety concerns are notable constraints (Pires Jr. et al. 2023).

3. Production Practices

Flowers are highly susceptible to contamination from pesticides and herbicides, and as the flowers are cultivated for consumption, limiting their exposure to harmful chemicals is vital (Pires Jr. et al. 2023). Organic production methods are common, though outdoor systems using organic practices face many challenges from pests and disease (Pires Jr. et al. 2023).

Many ornamental and several edible flowers have been produced hydroponically for both research and commercial sale (Gonçalves et al. 2023; Melo and dos Santos 2011; Rahman et al. 2022; Sarmah, Bora, and Sarmah 2020). The controlled environments in hydroponic greenhouse production systems eliminate the need for weed control and reduce the risk of pest and disease pressure while shortening growing periods and increasing yield (Rahman et al. 2022).

Temperature, Humidity, and Light

Edible flowers vary in their temperature, humidity, and light requirements, though they are generally grown between 65°F and 75°F and 50% and 70% humidity (AsiaFarming 2023). In the case of both annual and perennial flowering plants, these conditions are altered in greenhouse production to induce growth, flowering, and—in perennials—dormancy (Proietti et al. 2022). The perennial chrysanthemum is often over-wintered in outdoor production, but dormancy can be artificially induced through short-day photoperiods and temperature reduction (Proietti et al. 2022). In commercial greenhouse production of chrysanthemums, shortening growing periods can maximize productivity.

Growing Systems and Media

The growth cycle (length of time to harvest) influences the selection of soilless media used in greenhouse production. Common soilless culture systems used in hydroponic production of edible flowers consist of anchor media, such as rockwool, that are drip-irrigated with nutrient solutions (Currey 2021a; Currey 2021b; Swain et al. 2021). For larger or perennial plants, producers often use bag or pot systems filled with artificial media, such as coir, and drip-irrigated with nutrient solutions (Swain et al. 2021).

Figure 2. Hydroponic rose production in rockwool. (Image from Grodan, n.d.)

Seed Selection

Annual and perennial edible flowers are started from seed, as they typically have short germination periods and are subsequently transplanted (Kaiser and Ernst 2021; Currey 2021b). To ensure adequate germination, enterprises often overseed and thin as needed to achieve optimal planting density (Gonçalves et al. 2023).

Spacing and Maintenance

Spacing and maintenance requirements for the annual edible flowers in this report are similar, roughly 2.5 plants per square foot, according to an enterprise budget for greenhouse flowers developed by the University of Florida (Wei, Khachatryan, and Rihn 2020). Perennial chrysanthemum plants grow larger over their life cycles and require about one square foot per plant (Rahman 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. Most hydroponic production of edible flowers is conducted using a drip-irrigation system that supplies nutrients to the surface of the growing substrate (Currey 2021a).

Sanitation and Sterilization

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

Postharvest Processing and Packing

When sold fresh, edible flowers are typically packed into clamshells and cooled as quickly as possible (Kaiser and Ernst 2021). If desired or if market limitations exist, edible flowers may be dried and packaged in bags (Dorozko et al. 2019). As mentioned, dried flowers have a much longer shelf life but considerably lower retail value (Dorozko et al. 2019).

4. Enterprise Budget

Although a wide variety of edible flowers are suitable for greenhouse hydroponic systems, crop-specific information is not always available. For the edible flowers in the budgets below, information on hydroponic growing systems, primarily from academic research, and commercial enterprise data were available. Where possible, we combine cultivation information (growing period, yield, etc.) from research and production data (cost of inputs, labor requirements, etc.) from enterprise sources. These budgets are designed to approximate production costs for specific flower genera in the development context presented but may be applied to other edible flowers similar in size, cost, time to maturity, and yield.

We assume edible flowers, both fresh and dried, are packaged for sale via an e-commerce website where the customer pays 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.). For all budgets, we assume the percentage of product sold fresh to be 75%.

4.1 CROPPING SYSTEM

In the following enterprise budgets, substrate prices are based on retail data found online and common materials that could be used ($85 per bag of rockwool and an average cost of $12.20 per cubic foot of soilless media). Container prices are based on retail data found online and vary by size. We base fertilizer costs on comparable budget estimates, though these costs are approximate and may differ if fertilizer is applied in the form of soluble nutrient solutions through a hydroponic system, estimates for which are unavailable. We assume the price received for all edible flowers to be $0.55 per fresh flower and $7 per ounce of dried flowers (Cherry Valley Organics, n.d.-a; Cherry Valley Organics, n.d.-b; Frost 2018).

4.1.1 Annual Edible Flowers – Viola, Nasturtium, Marigold

For annual edible flowers, this budget assumes that seeds are placed in rockwool slabs and drip-irrigated with a nutrient solution dispersed and recollected via a Dutch-bucket system. We base yield and length of growing periods—germination and growing period plus harvest period—on production-budget information and hydroponic research trials specific to each crop. We estimate labor hours according to production information specific to each crop and harvest labor information for similar crops (cut flowers and microgreens). After each harvest, growers must purchase new seed and substrate.

Table 2. Production information for select annual edible flowers

	Viola	Nasturtium	Marigold
Growing period (weeks)	13	20	15
Flower yield (per plant)	9	10	20
Harvests per year (approx.)	4	2.5	3.5
Annual labor hours (seeding, transplanting, harvesting, processing, packing)	7,762	4,045	7,453

Sources: Gonçalves et al. 2023; Melo and dos Santos 2011; Sarmah, Bora, and Sarmah 2020; Wei, Khachatryan, and Rihn 2020; Sánchez and Berghage 2023; Lewis et al. 2021.

4.1.2 Perennial Edible Flowers – Chrysanthemum

For perennial chrysanthemums, plants are seeded in containers with soilless media, such as coir, and irrigated with a nutrient solution dispersed and recollected via a Dutch-bucket system. After initial germination and flowering, chrysanthemums can be induced to flower repeatedly by artificially creating short-day conditions (Proietti et al. 2022). This budget assumes that short-day conditions are imposed in the entire greenhouse, enabling 1.75 harvests in the first year and about 3.7 thereafter. We base yield estimates for fresh chrysanthemum flowers on hydroponic studies, which suggest an average of 28.76 flowers per plant (Rahman et al. 2022). We estimate labor hours according to production information specific to chrysanthemums and harvest labor information for similar crops (cut flowers and microgreens), totaling about 1,798 hours in the first year and 2,248 hours thereafter (Sánchez and Berghage 2023; Lewis et al. 2021; Wei, Khachatryan, and Rihn 2020). Chrysanthemums can flower for up to three years (Baessler 2023).

4.2 UTILITIES

Utility requirements of a greenhouse include fuel for heating, electricity for fans, water, sewerage, and communication. In this budget, we assume 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 a 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 here 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 costs, 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. We estimate total insurance costs at $3,240 annually. The table below outlines the operating costs common to all four crops.

Table 3. Operating costs for greenhouse edible-flower production common to all crops modeled

Description	Unit	Quantity	Price	Value
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				**$38,570**

In addition to these common costs, production will entail operating costs that vary by crop and system. These are outlined in tables 4 through 7, followed by a discussion of debt-service coverage ratios.

Table 4. Production budget for edible viola flowers

Viola				
Description	**Unit**	**Price**	**Quantity**	**Cost**
Gross returns:				
Fresh flowers	Flower	$0.55	758,679	$418,763
Dried flowers	Ounce	$7.00	20	$142
Variable costs:				
Seeds	Seed	$0.05	224,794	$10,790
Rockwool slabs	Bag	$85.00	672	$57,120
Fertilizer	Pound	$4.20	5,955	$25,038
Labor	Hour	$17.58	7,762	$136,462
Fresh packaging	Clamshell	$0.28	15,174	$4,249
Dried packaging	Bag	$0.40	1	$0.40
Fulfillment	Order	$3.00	15,175	$45,525
Total variable costs				**$279,183**
Total common costs				**$38,570**
Operating profit				**$101,010**

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

Table 5. Production budget for edible nasturtium flowers

Nasturtium				
Description	**Unit**	**Price**	**Quantity**	**Cost**
Gross returns:				
Fresh flowers	Flower	$0.55	371,429	$205,015
Dried flowers	Ounce	$7.00	255	$1,787
Variable costs:				
Seeds	Seed	$0.01	99,048	$1,331
Rockwool slabs	Bag	$85.00	416	$35,360
Fertilizer	Pound	$4.20	3,634	$15,278
Labor	Hour	$17.58	4,045	$71,119
Fresh packaging	Clamshell	$0.28	7,429	$2,080
Dried packaging	Bag	$0.40	16	$6.38

Fulfillment	Order	$3.00	7,445	$22,334
Total variable costs				**$147,507**
Total common costs				**$38,570**
Operating profit				**$18,938**

Table 6. Production budget for edible marigold flowers

Marigold				
Description	**Unit**	**Price**	**Quantity**	**Cost**
Gross returns:				
Fresh flowers	Flower	$0.55	1,040,000	$574,042
Dried flowers	Ounce	$7.00	6,114	$42,799
Variable costs:				
Seeds	Seed	$0.01	138,667	$1,851
Rockwool slabs	Bag	$85.00	582	$49,504
Fertilizer	Pound	$4.20	4,455	$18,733
Labor	Hour	$17.58	7,453	$131,017
Fresh packaging	Clamshell	$0.28	20,800	$5,824
Dried packaging	Bag	$0.40	382	$153
Fulfillment	Order	$3.00	21,182	$63,546
Total variable costs				**$270,628**
Total common costs				**$38,570**
Operating profit				**$264,844**

Table 7. Production budget for edible chrysanthemum flowers

Chrysanthemum				
Description	**Unit**	**Price**	**Quantity**	**Cost**
Gross returns:				
Fresh flowers	Flower	$0.55	301,980	$166,682
Dried flowers	Ounce	$7.00	1,775	$12,427
Variable costs:				
Seeds	Seed	$0.02	16,000	$267
Containers	10″ pot	$3.30	8,000	$26,400
Substrate	Cubic foot	$12.20	4,898	$59,778
Fertilizer	Pound	$4.20	1,371	$5,765
Labor	Hour	$17.58	1,798	$31,612
Fresh packaging	Clamshell	$0.28	6,040	$1,691
Dried packaging	Bag	$0.40	111	$44
Fulfillment	Order	$3.00	6,151	$18,452
Total variable costs				**$144,010**
Total common costs				**$38,570**
Operating profit				**-$15,898**

Edible flowers are not heavily commercialized in the United States, and expressions of yield in published information vary according to retail unit (weight or mass versus flower count). Moreover, where yield information for fresh flowers is available, determining associated quantities of dried flowers is sometimes impossible. Another important area of uncertainty concerns the percentage of harvestable yield that is sold fresh versus dried, as it greatly impacts operating profit due to the vast price difference between the two product forms. One source indicates that the harvestable and marketable yield for edible flowers could be as low as 30%, while scientific hydroponic trials have achieved much higher yields (Fernandes et al. 2019). This variation is due to several factors beyond flower quality, as profit is largely dependent on postharvest efficiency and successful marketing of a highly perishable commodity. This uncertainty is built into the sensitivity analysis below.

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).[1] 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. A 50-square-foot walk-in cooler would be necessary to accommodate a full load of clamshells for the highest-yielding crop, marigold, and is estimated to cost $80 per square foot, or $4,000 total. In addition, we estimate a cost of $26,587 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:

- Dryer: $1,342
- 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 **$166,195**. 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. 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%). This would result in a total annual cost of up to **$22,796** (10-year note, 8.5% interest, 90% financed).[2]

4.6 PROFIT POTENTIAL

The budgets presented above indicate a high likelihood of positive operating profit for several concepts modeled. All concepts modeled except chrysanthemum showed positive operating profit, ranging from nearly $19,000 for nasturtium (9% profit margin) to over $260,000 annually for marigold (43% profit margin). We further evaluate the operating profit for viola (expected to be slightly more than $100,000, or a 24% profit margin) in the sensitivity analysis below.

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 would indicate potential solvency problems, while a ratio of at least 2.00 is generally considered very strong. The DSCR of the viola concept is expected to be 4.50, which is above the minimum ratio that banks would consider lending and is an indication that the operation should be able to cover all operating and financing costs.

[1] 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 cost for conversion of the structure (Kardos, Kuzma, and Ragon 2022; Sullivan and Howard 2022).

[2] A 20-year loan would have annual payments of $15,806 (8.5% interest rate).

4.7 SENSITIVITY

We undertook a sensitivity analysis to evaluate the impact of key assumptions on the operating profit estimate for an enterprise growing edible viola flowers (pansy, viola, and violet). These assumptions are as follows:

- Yield, flowers per plant (eight to 10 per cycle, four harvests per year)
- Yield, percentage of flowers sold for fresh markets (30% to 80% of yield)[3]
- Price received ($0.48 to $0.63 per plant), fresh flowers
- Labor requirements of 5,822 hours to 9,703 hours (75% to 125% of reported labor requirements)
- Natural gas usage (1,744,000 to 2,616,000 cubic feet)

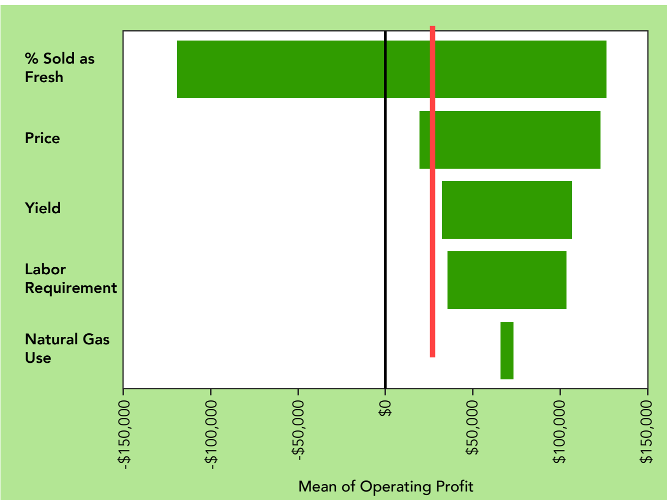

Figure 3. Sensitivity analysis results.

As the figure shows, the percentage of the yield sold fresh has the greatest influence on operating profit, with outcomes at the lower end of the range resulting in operating profits below the principal and interest costs (red line). But at the expected level (75%) or high end (80%), the operating profits are above the cost of capital. Price and yield are the second- and third-most sensitive variables modeled here. Apart from the percentage of yield sold fresh, all possible variables considered in the sensitivity analysis show a positive operating profit potential and are above the principal and interest payments modeled for the loan to cover capital costs.

[3] The remainder are sold as dried flowers at a steep discount.

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