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OBJECTIVES

- Incorporate a fermentation step into the overall design.
- Design a complete production process to create a natural facial skin care product.

MARKET ANALYSIS

- From 2014 to 2015, market for natural and organically produced personal care products grew 8.6%
- Facial cleansers with ingredients like charcoal had above average growth in 2017 with 57% of adults showing interest in charcoal-based products
- Charcoal is currently used in products by Neutrogena, Dove, and L'Oreal among others

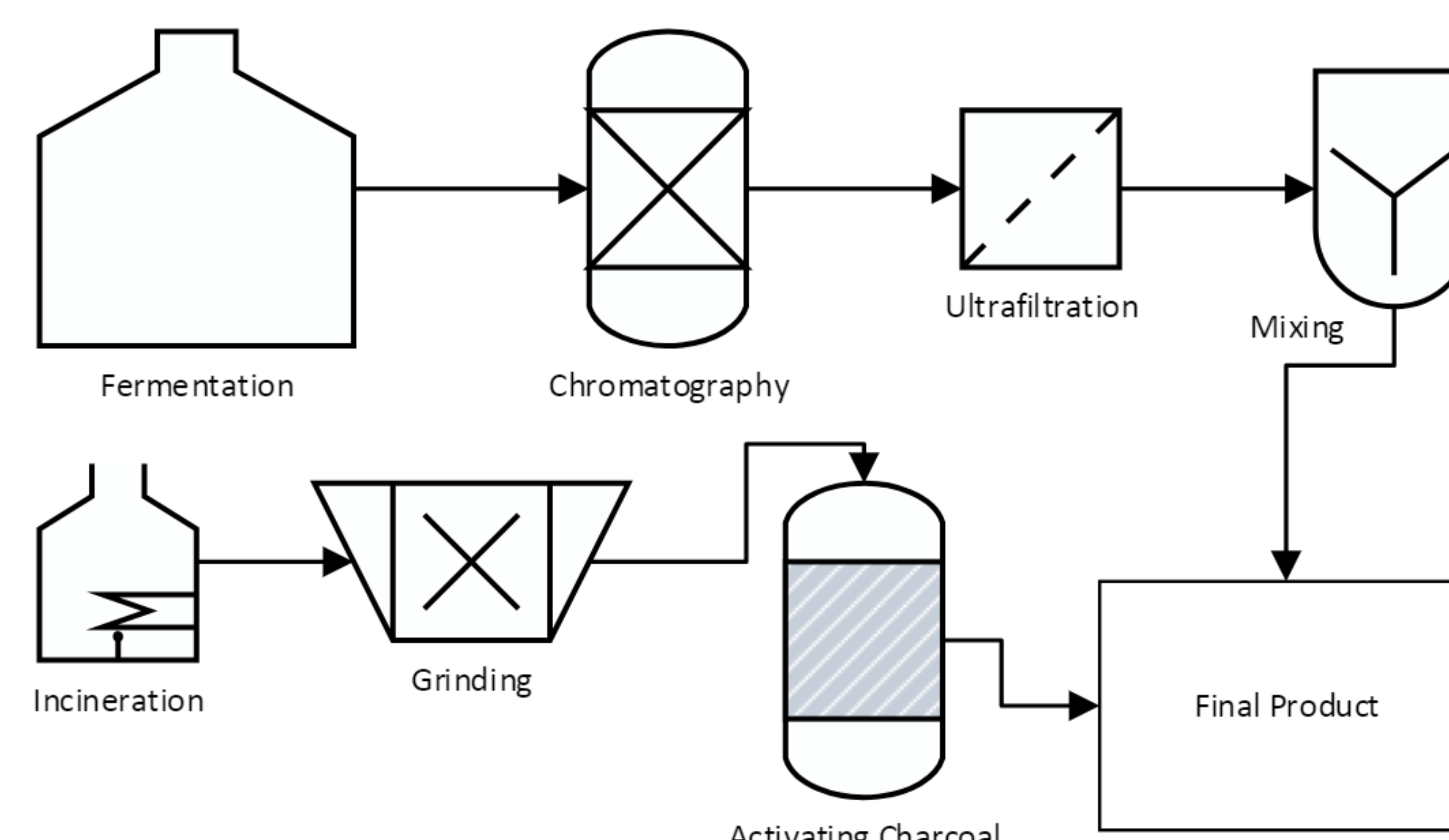
UNIT OPERATION OPTIMIZATION

Operation	Optimization Variable	Parameter Minimized
Incineration	Heat Exchanger area	Total Cost
Fermentation	Tank Diameter	Max. Profit
Separation	Membrane area	Total Cost
Mixing	Volume	Total Cost

FINAL ITERATION

Operation	Capacity	Power Required	Process Time
Incineration	21.5 m ³	1958 kWh	19.2 hours
Fermentation	705 m ³	2864 kWh	4 days
Separation	370 m ³ /s	42.32 kWh	11.6 hours
Mixing	69 m ³	0.17 kWh	0.5 hours

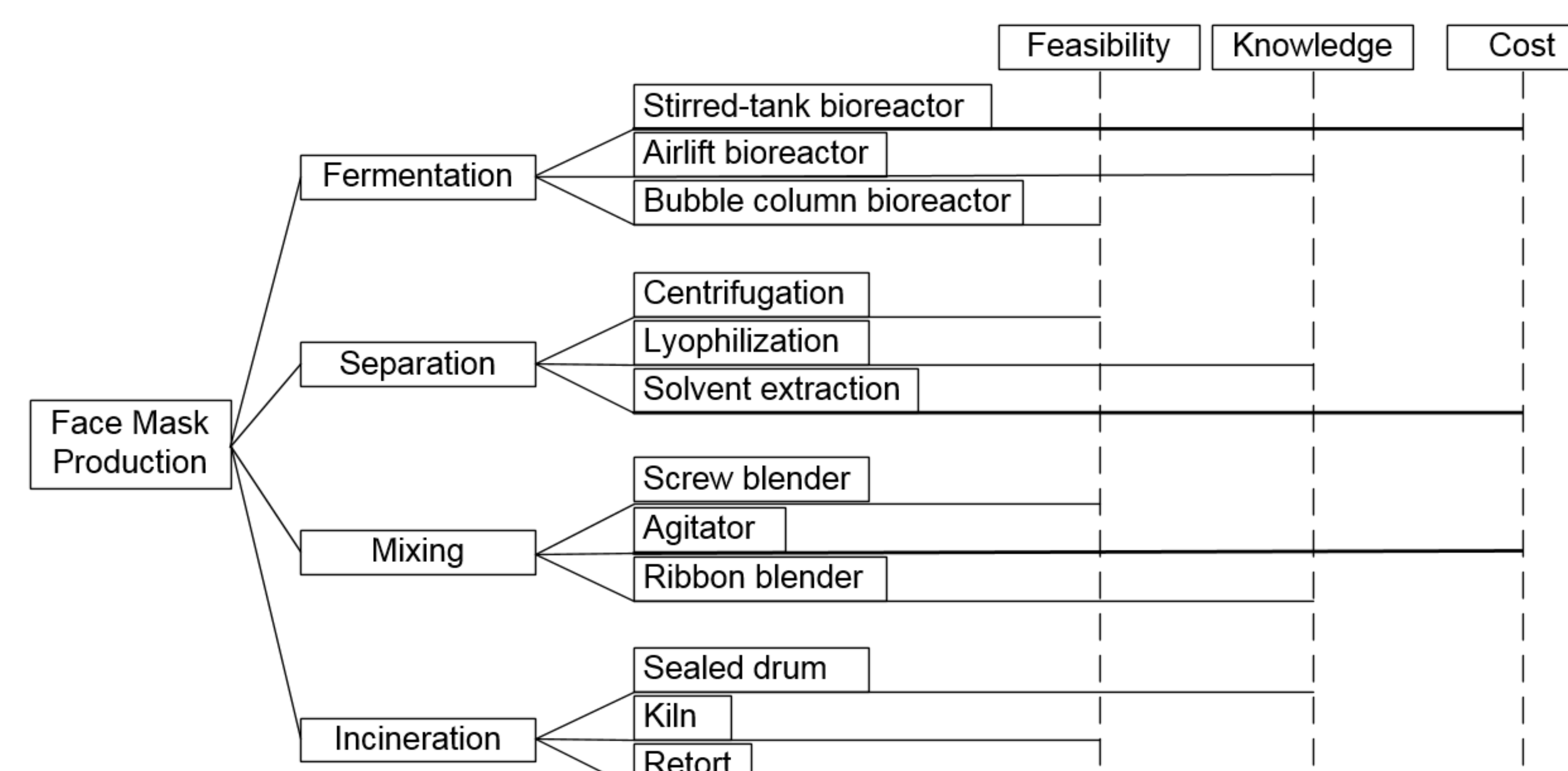
PROCESS FLOW DIAGRAM



PRODUCTION PROCESS



EVALUATION OF ALTERNATIVES



ECONOMIC ANALYSIS

Operation	Life-time	Purchased Cost (\$1000)	Direct Costs (\$1000)	Indirect Costs (\$1000)
Incineration	10	27.5	99	39.6
Fermentation	10	3,800	13,680	5,472
Separation	6	343	1,234.8	493.9
Mixing	10	85.4	307.4	122
Total		4,255.9	15,321.2	6,128.5
Fixed Capital Investment (85% TCI)				\$21,449,736
Total Capital Investment (TCI)				\$25,237,487
Annualized TCI				\$5,150,401
Annual Operating Expenses				\$5,279,295
Annual Raw Material Cost				\$460,607,551
Annual Labor (\$20/hr, 12 employees/shift)				\$1,920,000
Variable Cost/Unit				\$19.75
Units/year (250mg beta-carotene)				23,688,000
Annual Gross Profit (\$20/unit)				\$802,752
Annual Net Profit (35% Tax Rate)				\$521,788

SUSTAINABILITY

- Soybean hulls are an inevitable waste stream of soybean processing. Soybean crops are stably produced in the Midwestern region annually.
- If properly maintained, ultrafiltration membranes can have a long operational life.

FUTURE WORK

- Further optimize plant design and update equipment needs to meet demand and improve technology
- Continue experimenting with fermentation/separation processes to maximize yield of beta-carotene.
- Optimize fermentation process to reduce input costs