Best Management Practices for Profitable Distillation of High-Quality Mint Oil

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Optimizing Distillation

Mint Distillation is Difficult to Optimize

It's complicated!

- Every tub design, hay condition, and distillation system is unique
- Increase steam flow rate until breakthrough, then cut back?
- Steam pressure?
- Steam temperature?
- Steam flow rate?
- Optimal distillate temperatures?
- Mint hay condition

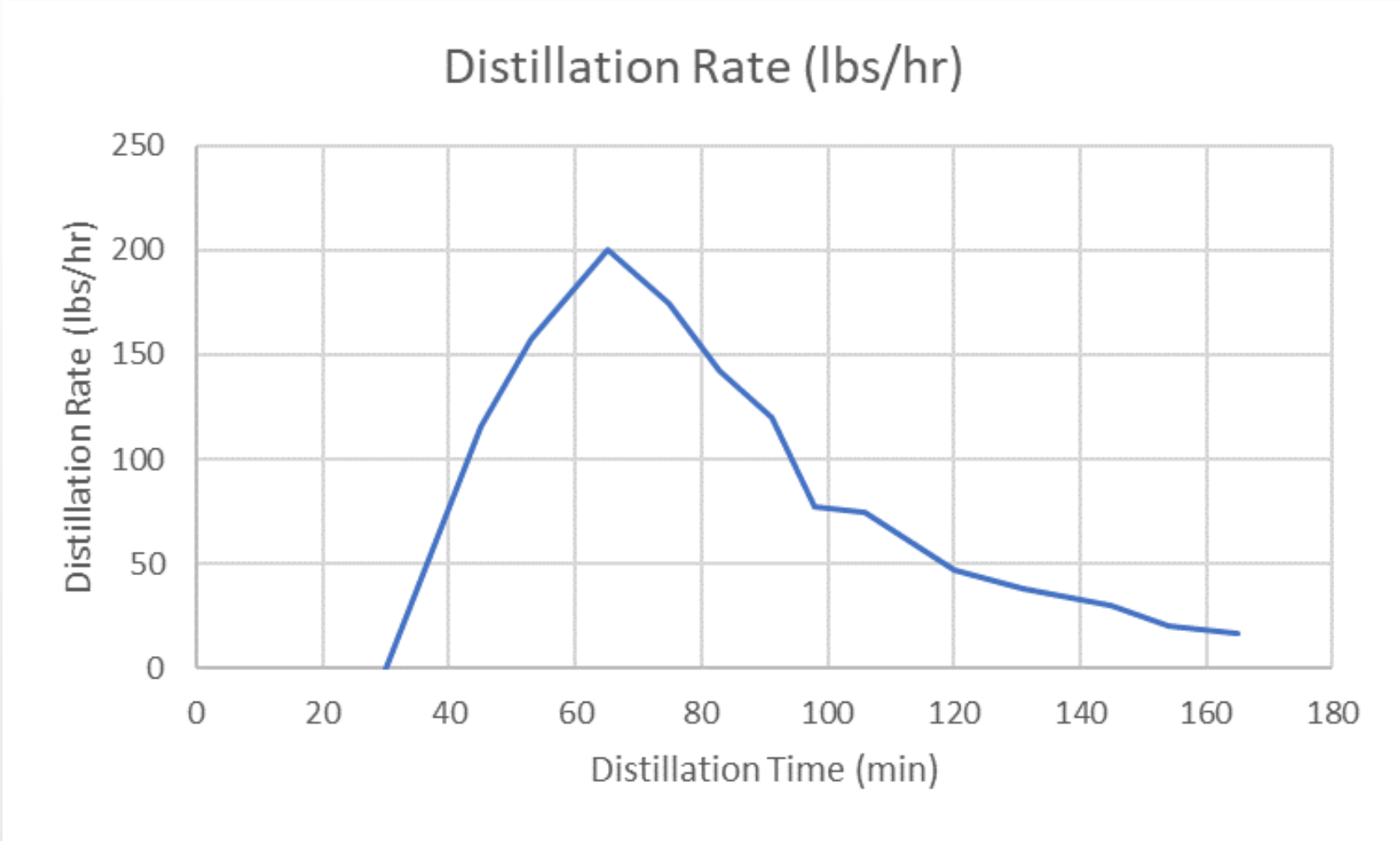
2023 Data Collection

- Met with 3 different grower cooperators
  - 3 spearmint distillation events (2 first cutting, 1 second cutting)
  - 1 peppermint distillation event (single cut)
- Collected mint distillation rates, and mint oil samples at regular intervals (about 10 minute).
- Break-through times and steam temperature and pressure.
- Oil samples submitted for component analysis.
  - Thanks to RCB International!

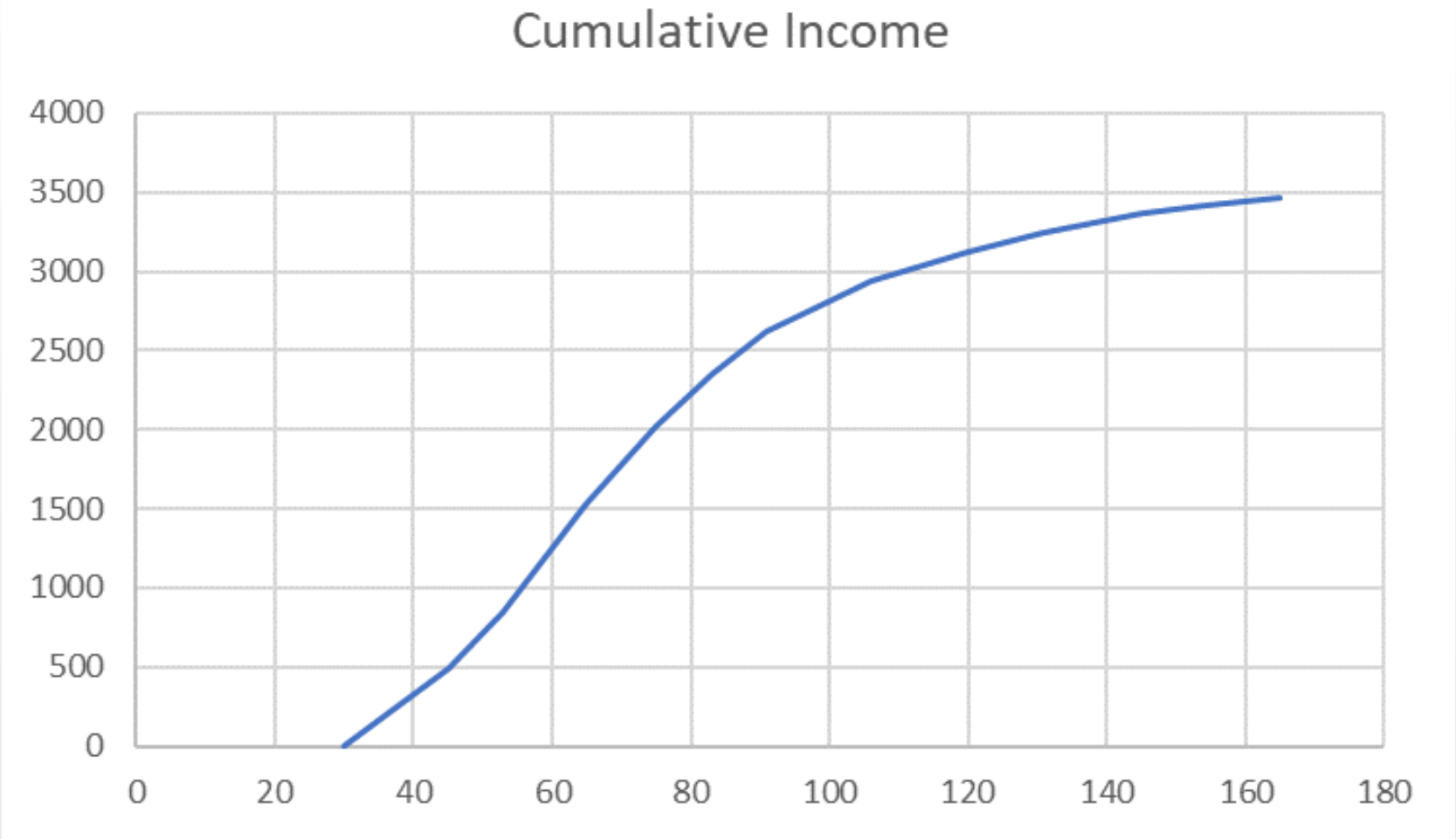

Cooperator 1


Cleaver Brooks
1 Boiler

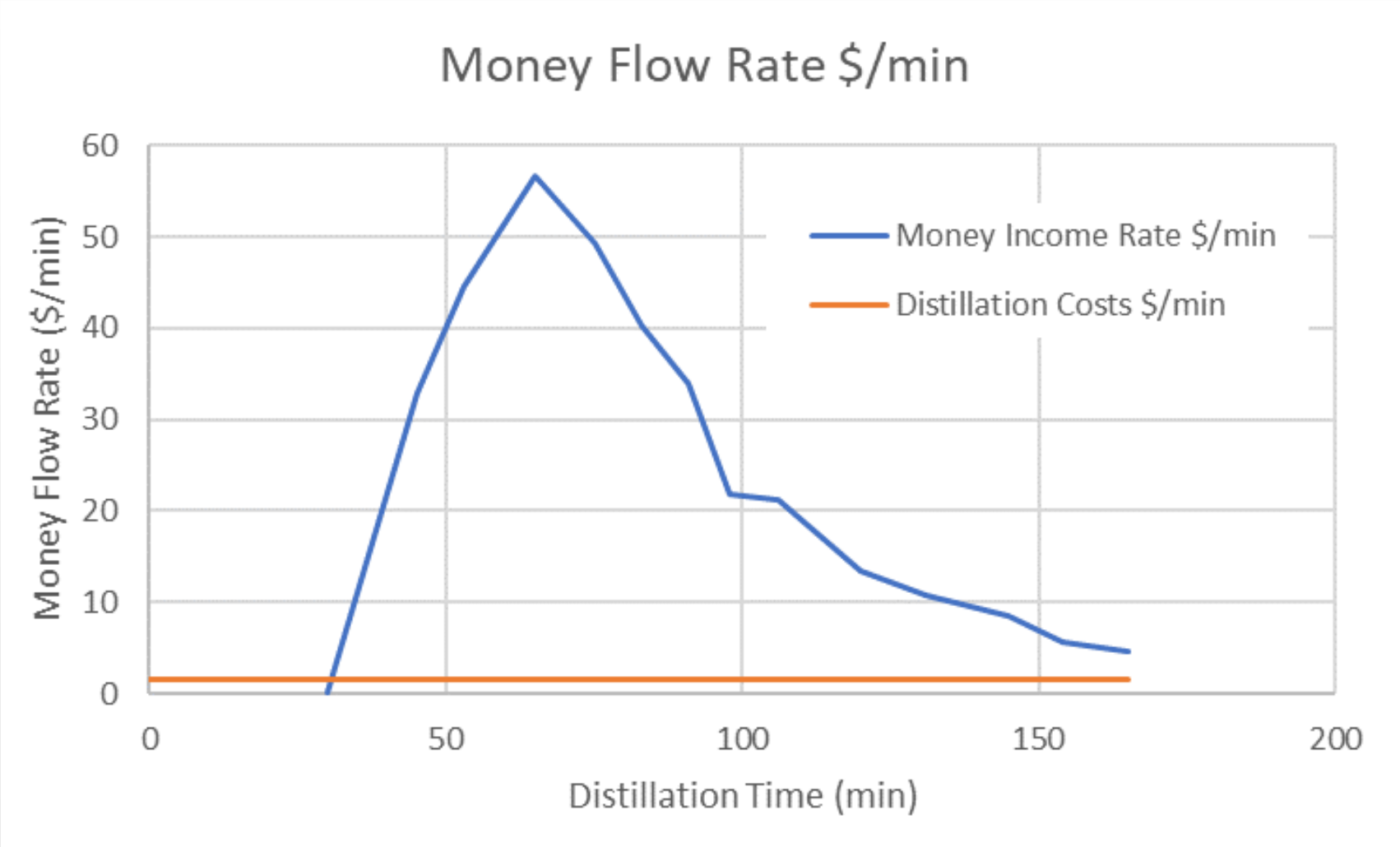
Mint oil distillation rate from cooperator 1. Spearmint



Example cumulative Income from cooperator 1. Spearmint



Example money income from oil vs outflow to distillation costs for cooperator 1. Spearmint

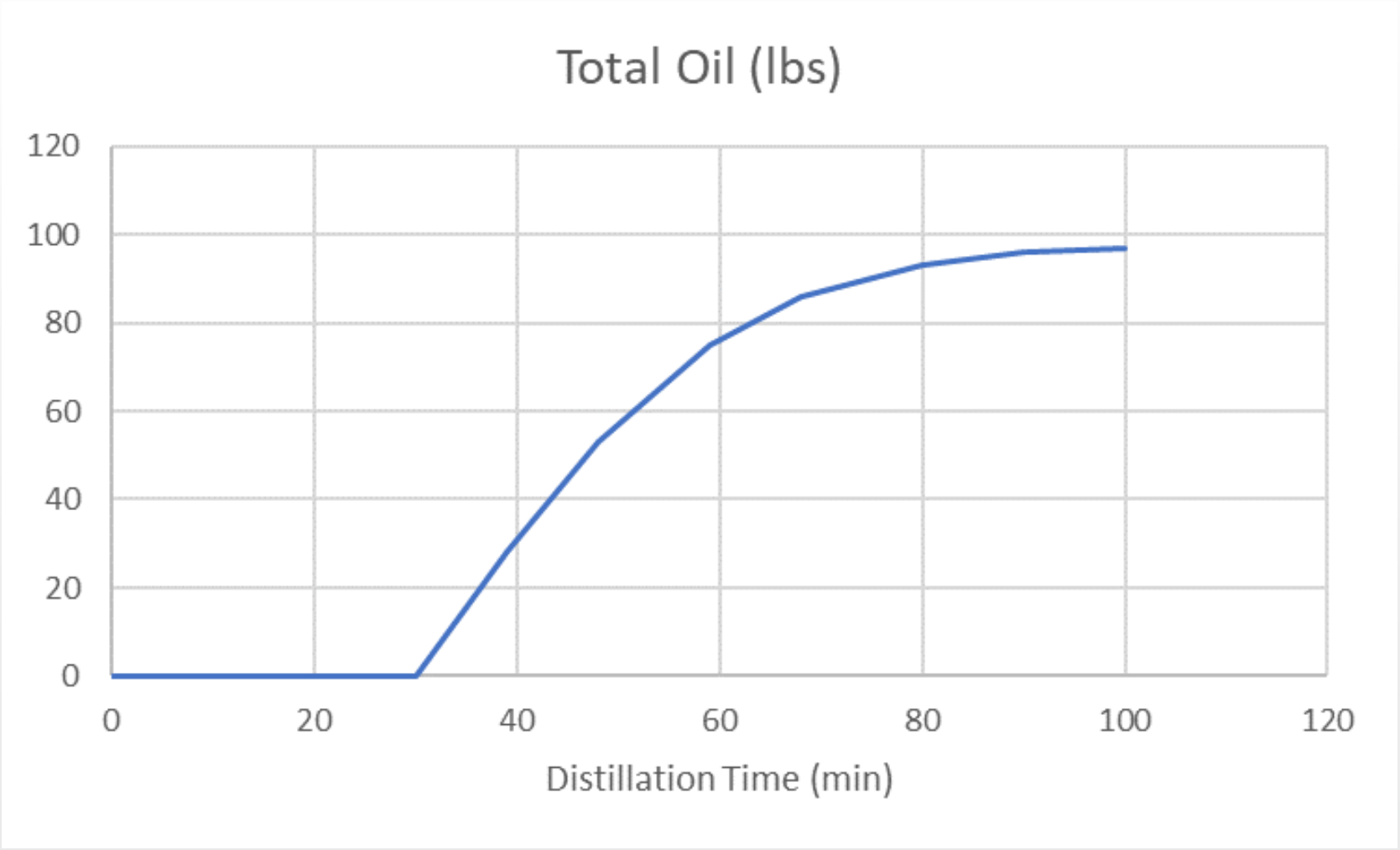


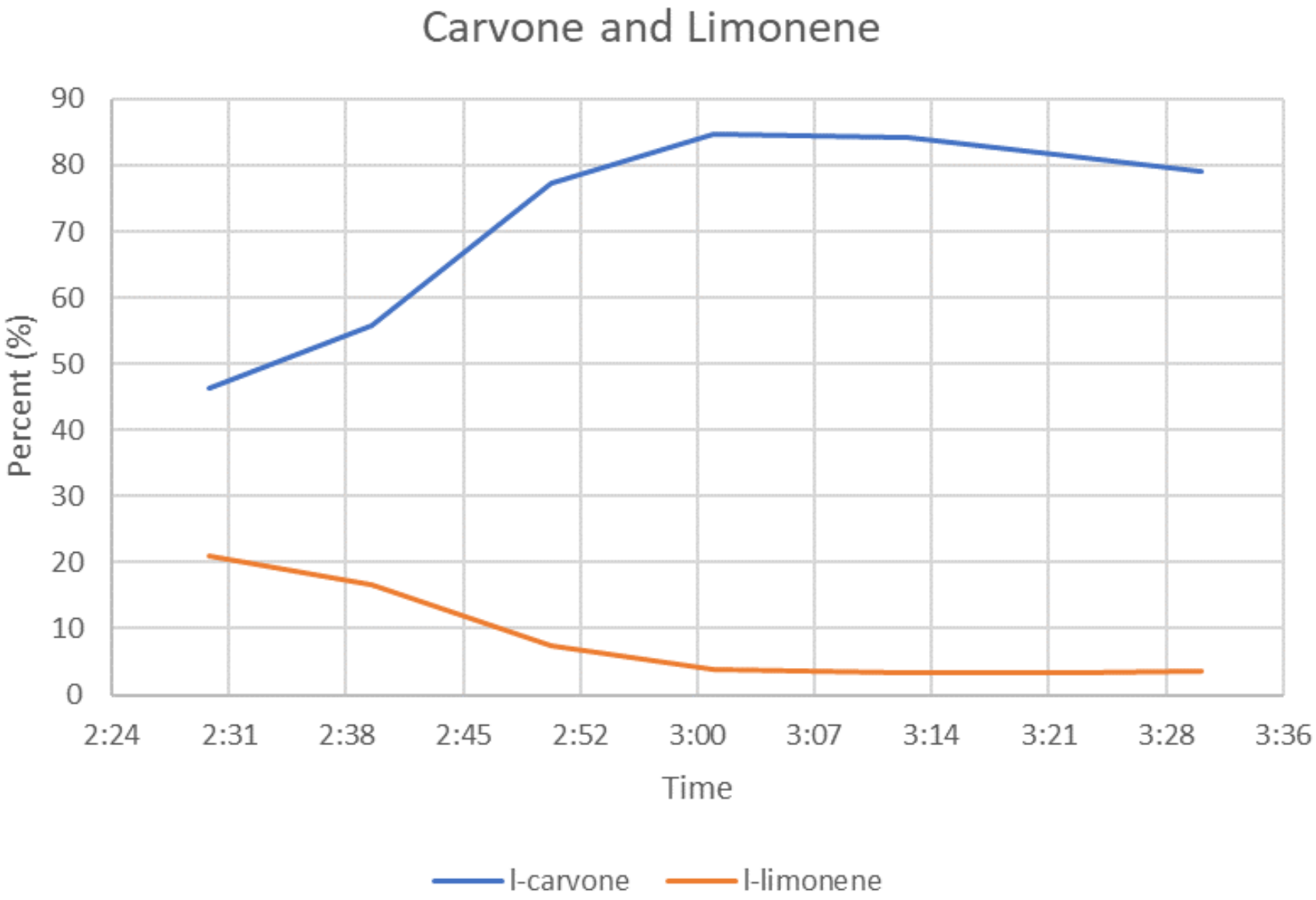

20ml
10ml

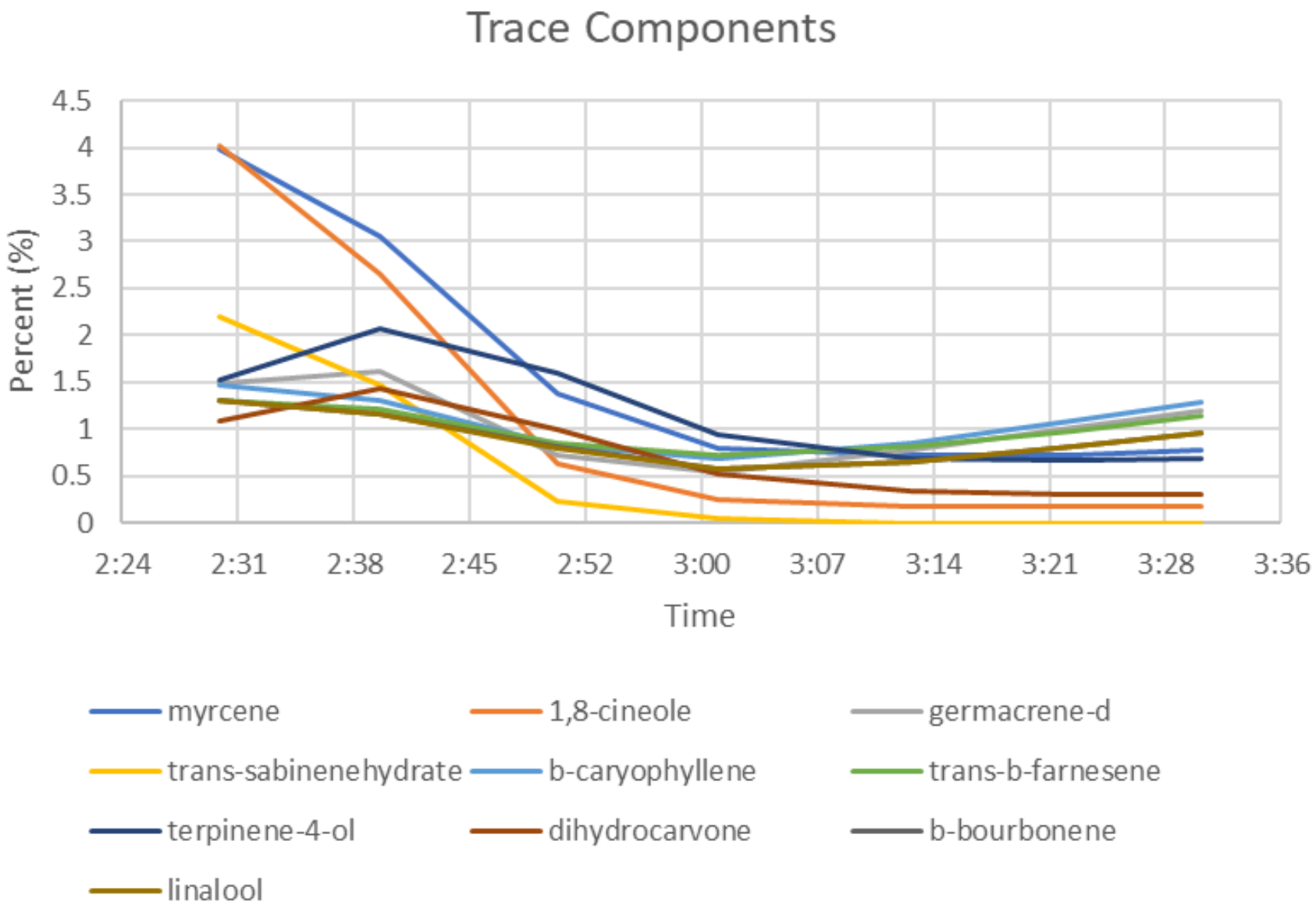
Cooperator 2

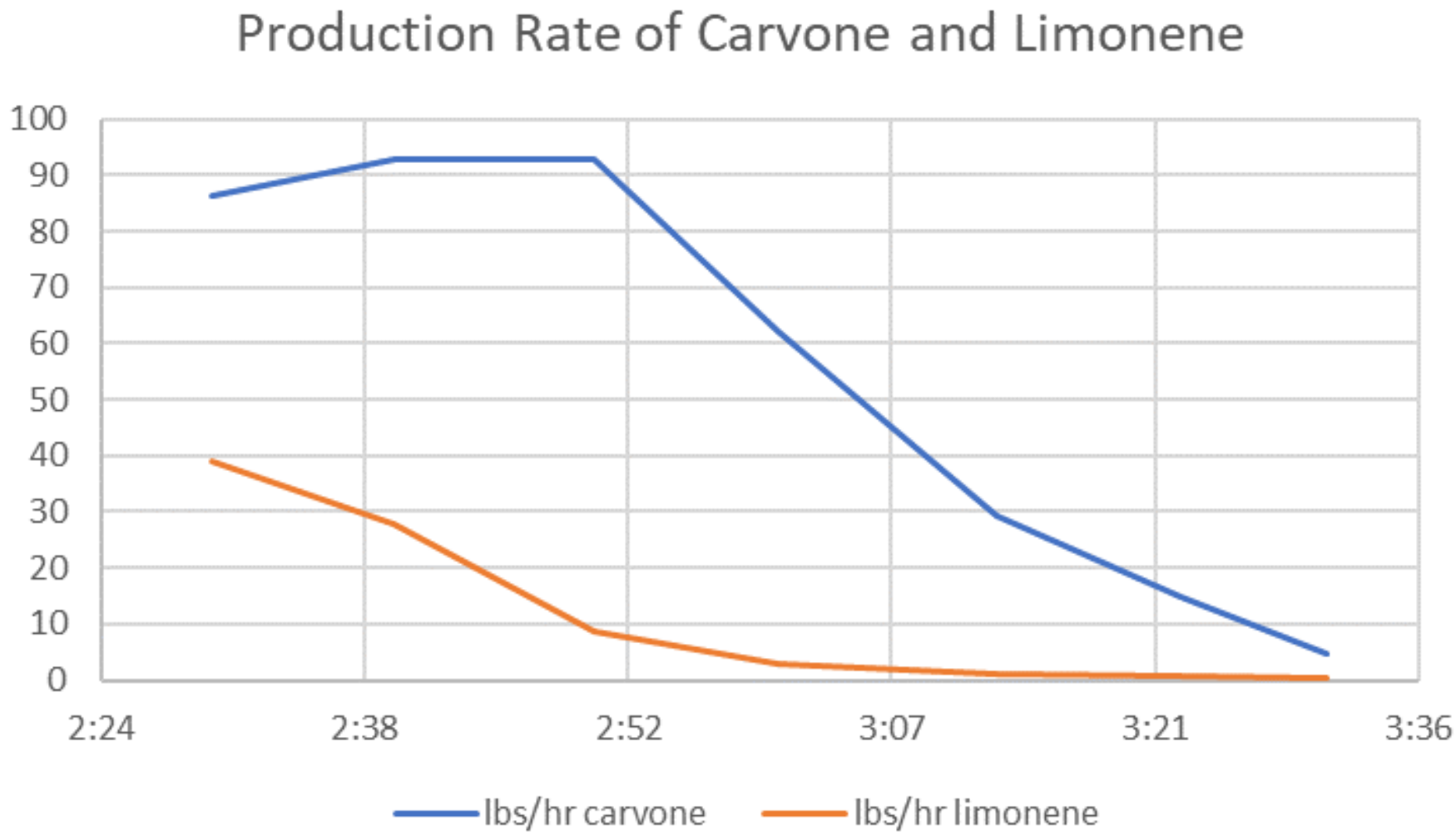

#2 W. 16
1:00
#2 W 3
1:15
NEWHOUSE
MFG. CO., INC. REDMOND, OR.

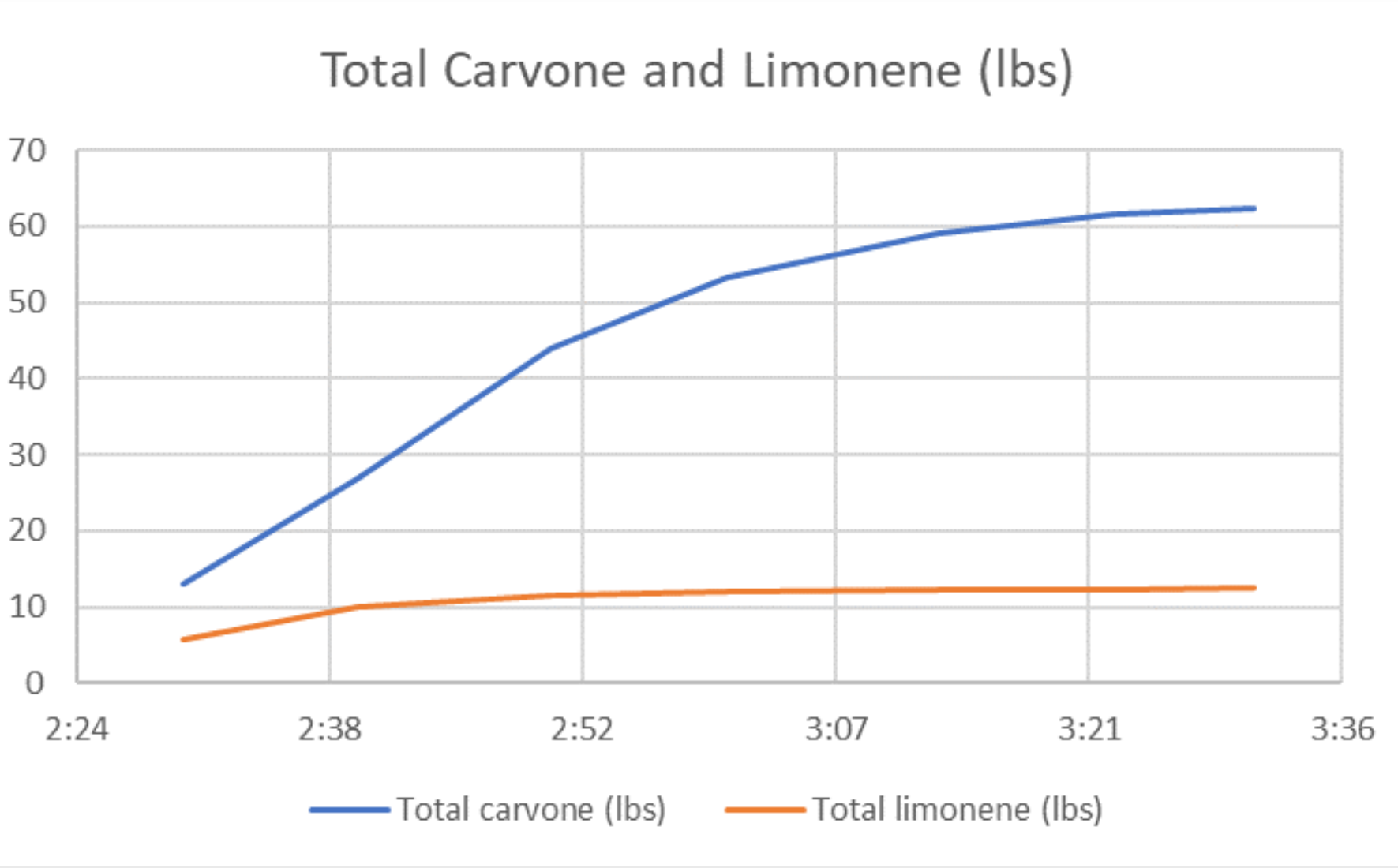
Example cumulative Income from cooperator 2. Spearmint



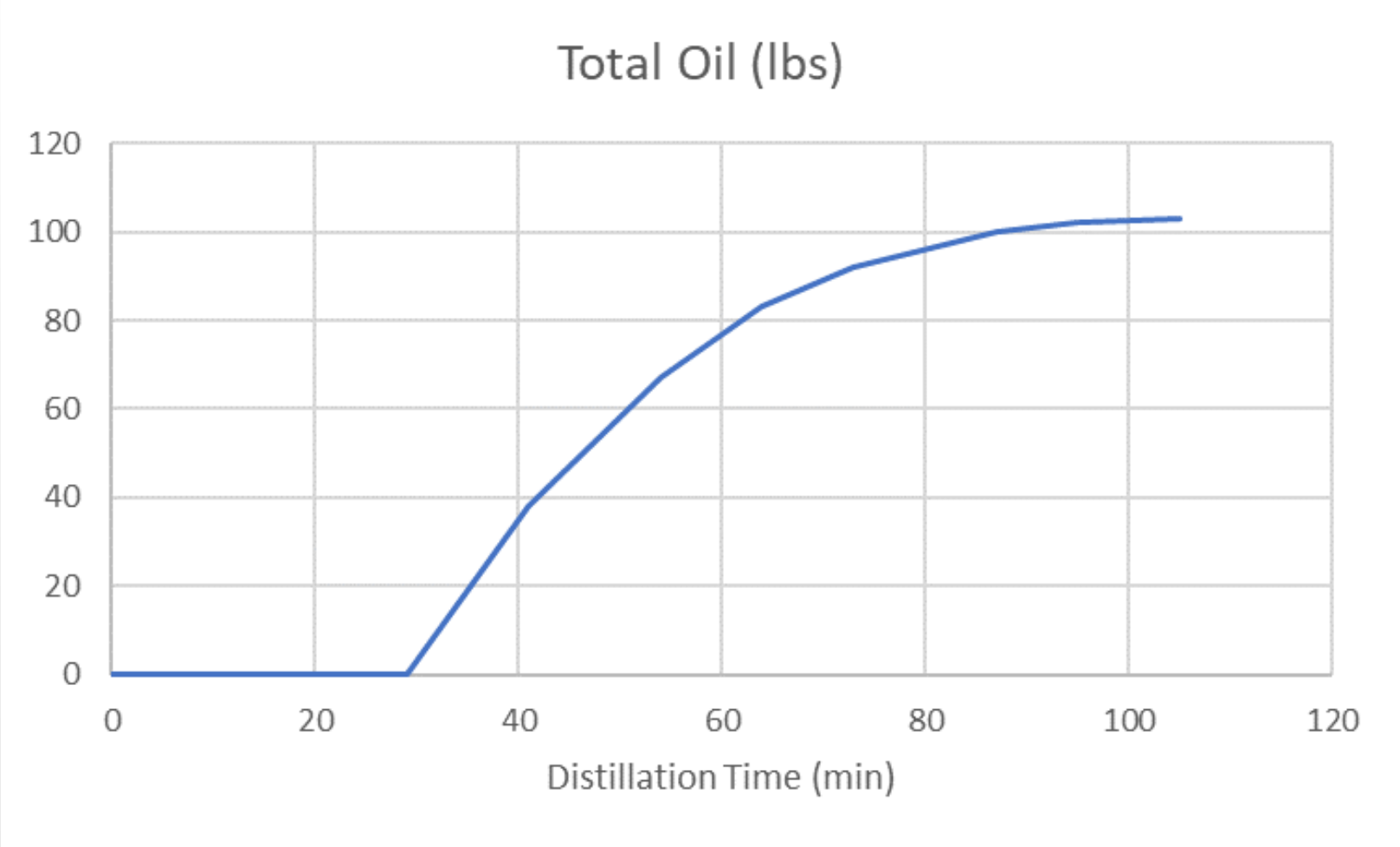

Carvone and Limonene
90
80
70
60
50
40
30
20
10
0
Percent (%)
2:24
2:31
2:38
2:45
2:52
3:00
3:07
3:14
3:21
3:28
3:36
Time
l-carvone
l-limonene

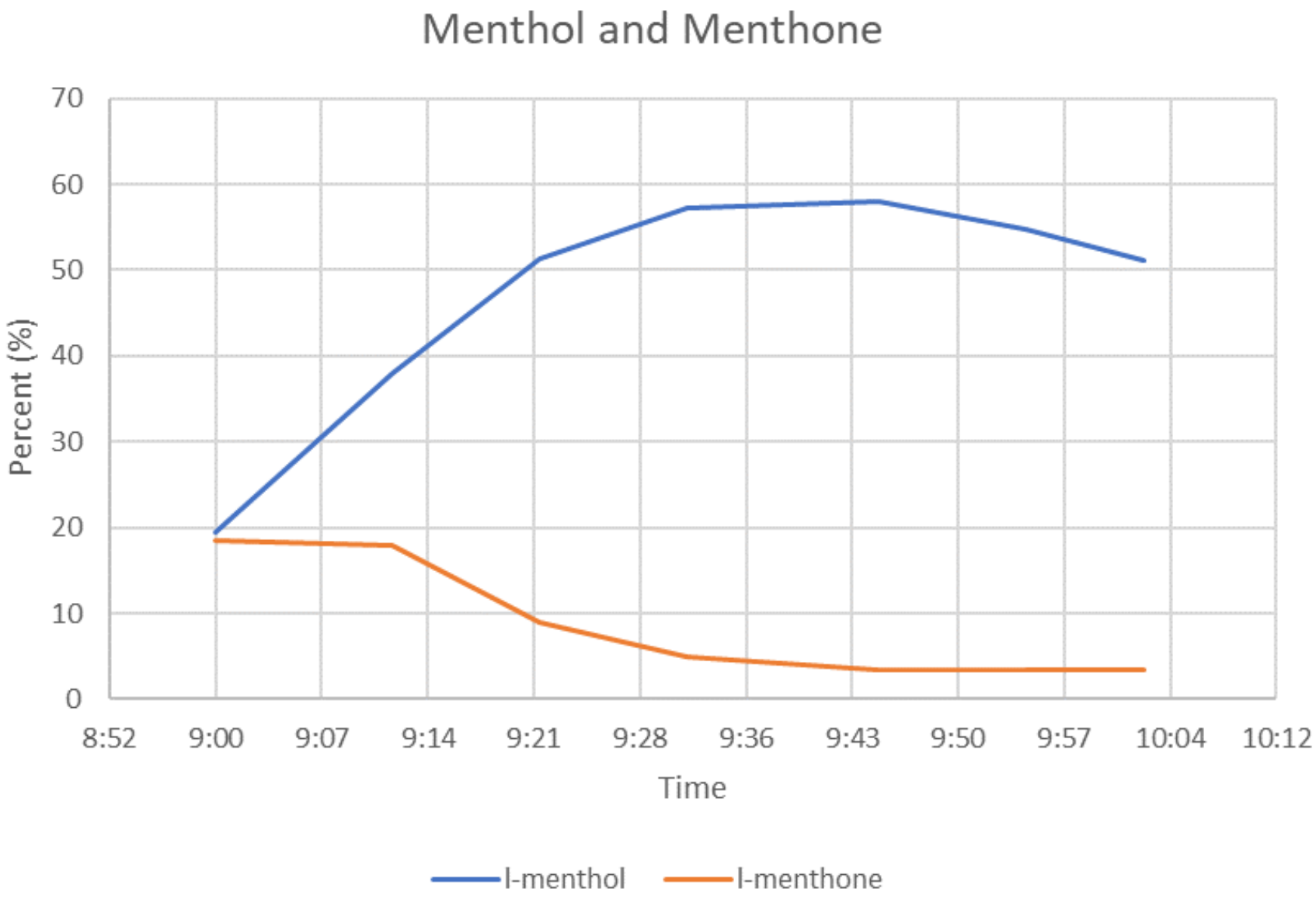

Trace Components
Percent (%)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
2:24
2:31
2:38
2:45
2:52
3:00
3:07
3:14
3:21
3:28
3:36
Time
myrcene
1,8-cineole
germacrene-d
trans-sabinenehydrate
b-caryophyllene
trans-b-farnesene
terpinene-4-ol
dihydrocarvone
b-bourbonene
linalool

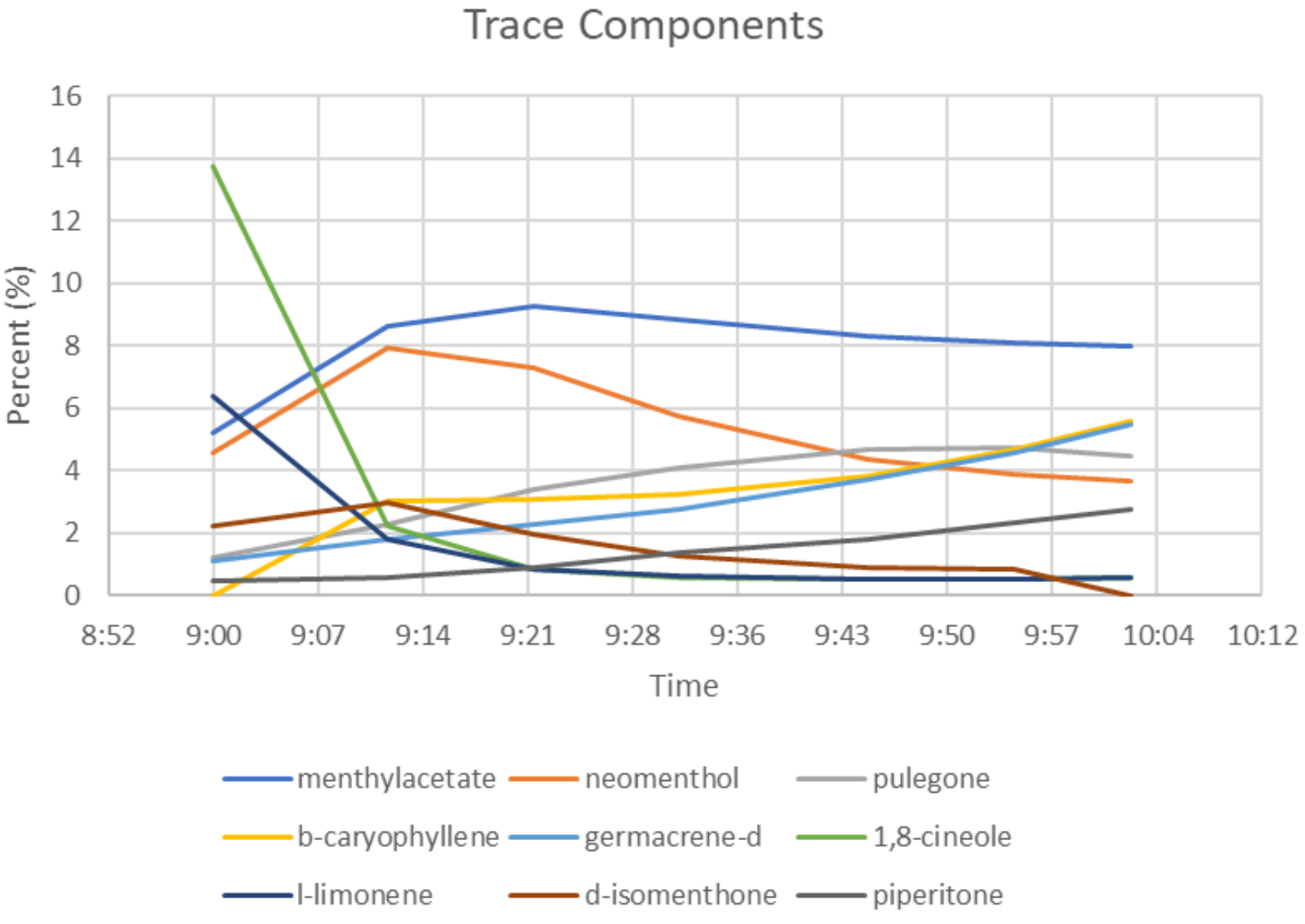

Production Rate of Carvone and Limonene
100
90
80
70
60
50
40
30
20
10
0
2:24
2:38
2:52
3:07
3:21
3:36
lbs/hr carvone
lbs/hr limonene

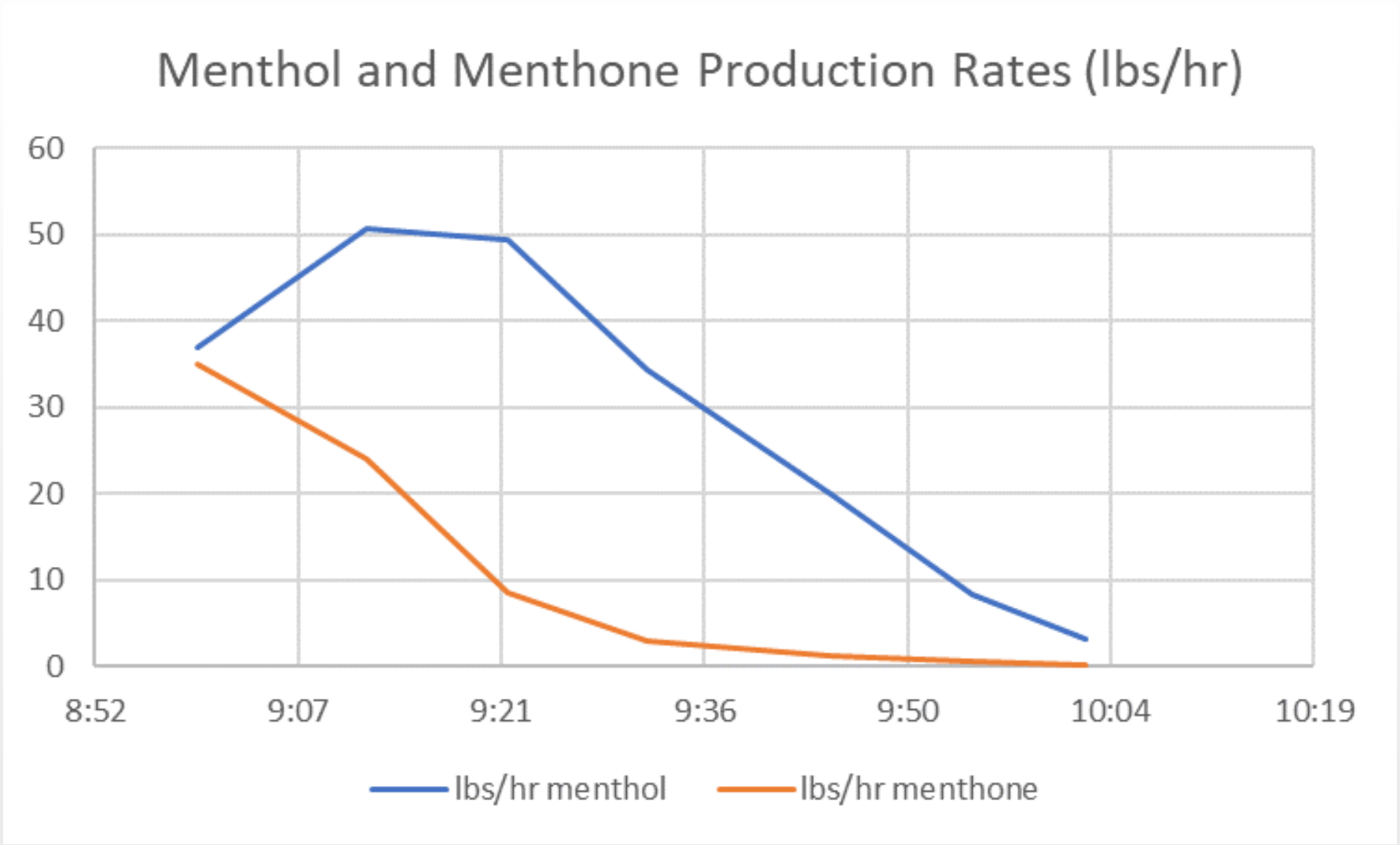

Total Carvone and Limonene (lbs)
70
60
50
40
30
20
10
0
2:24
2:38
2:52
3:07
3:21
3:36
Total carvone (lbs)
Total limonene (lbs)

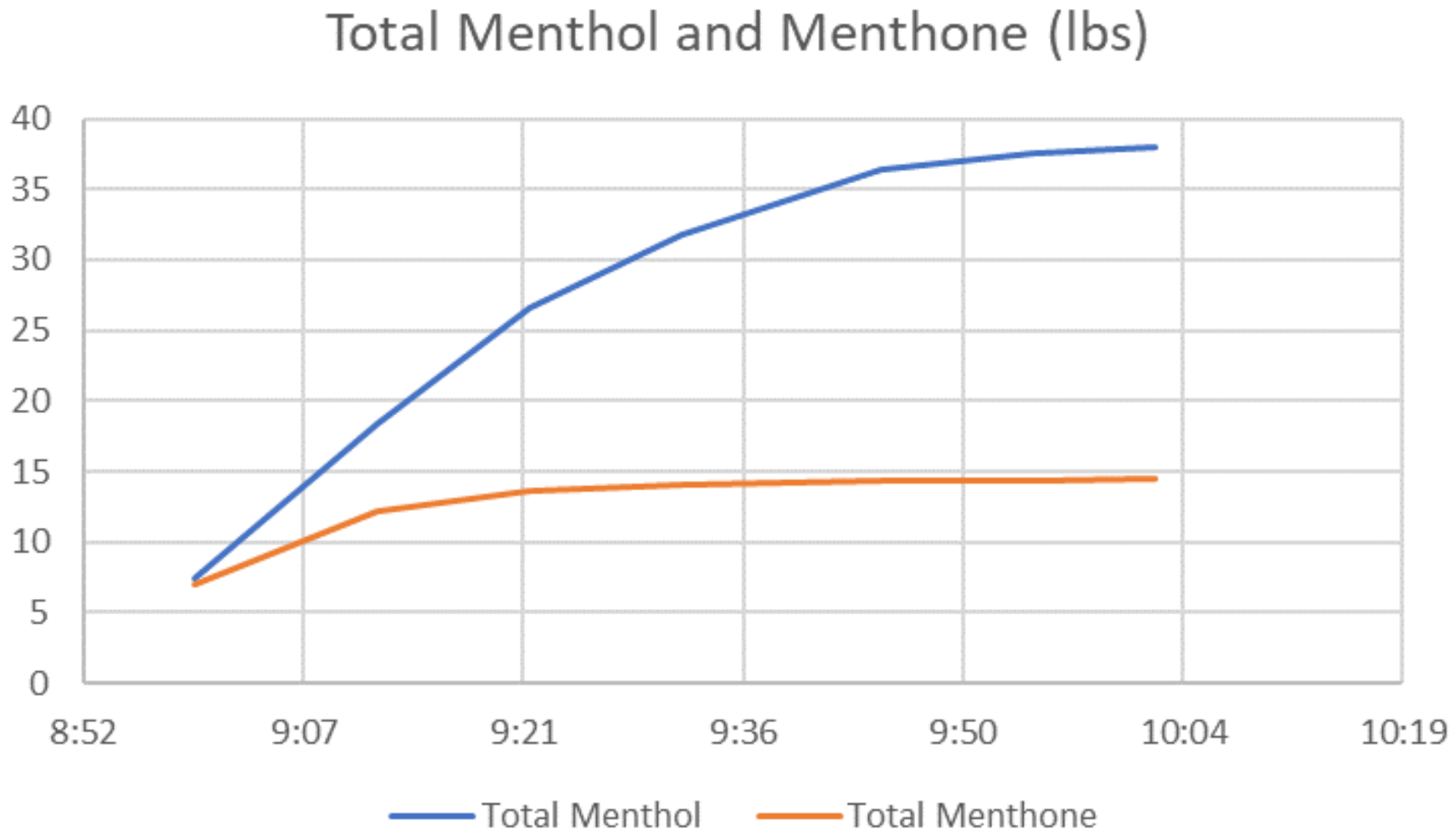
Example cumulative Income from cooperator 2. Peppermint



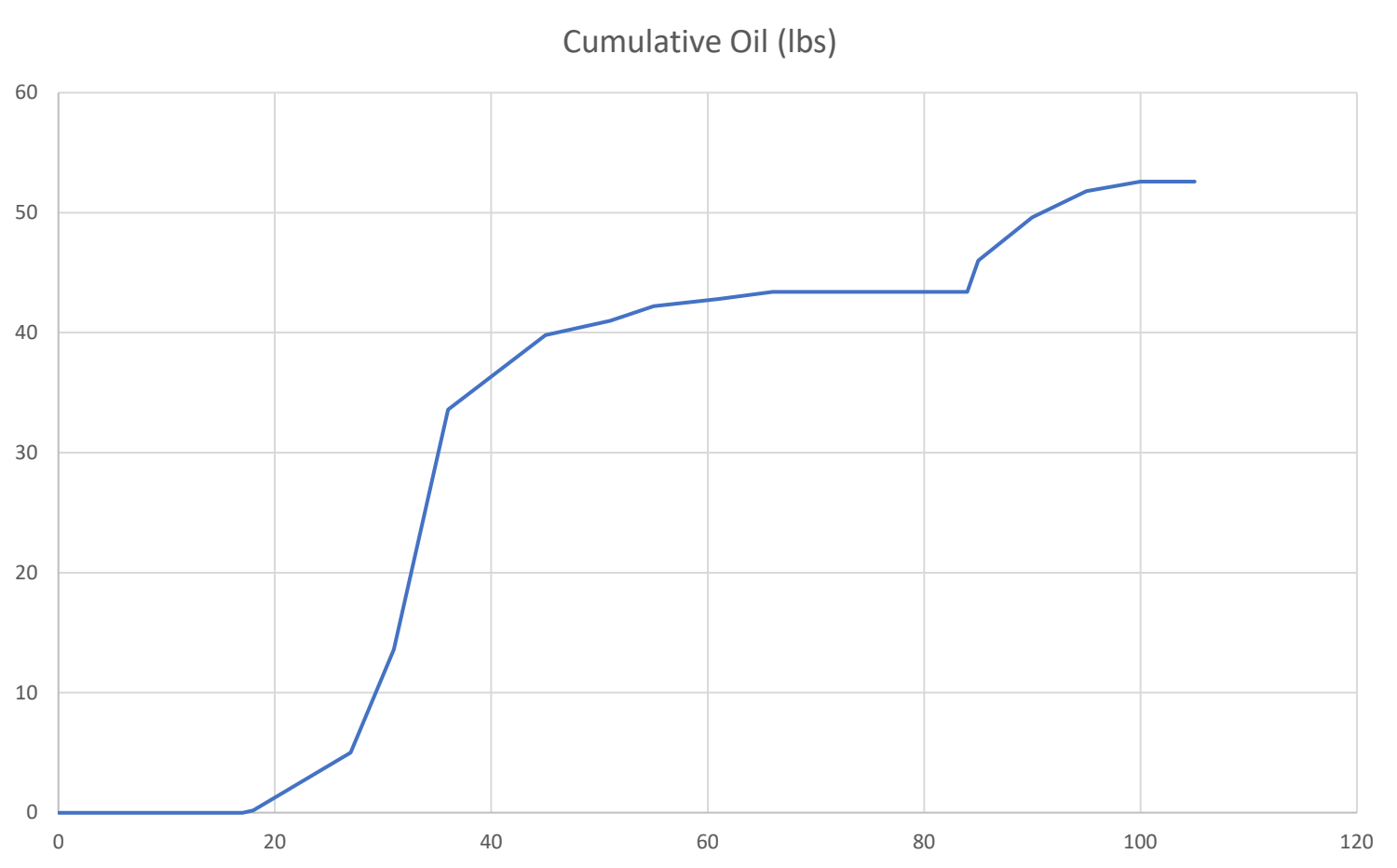

Menthol and Menthone
70
60
50
40
30
20
10
0
Percent (%)
8:52
9:00
9:07
9:14
9:21
9:28
9:36
9:43
9:50
9:57
10:04
10:12
Time
l-menthol
l-menthone


Trace Components
Percent (%)
16
14
12
10
8
6
4
2
0
8:52
9:00
9:07
9:14
9:21
9:28
9:36
9:43
9:50
9:57
10:04
10:12
Time
menthylacetate
neomenthol
pulegone
b-caryophyllene
germacrene-d
1,8-cineole
l-limonene
d-isomenthone
piperitone

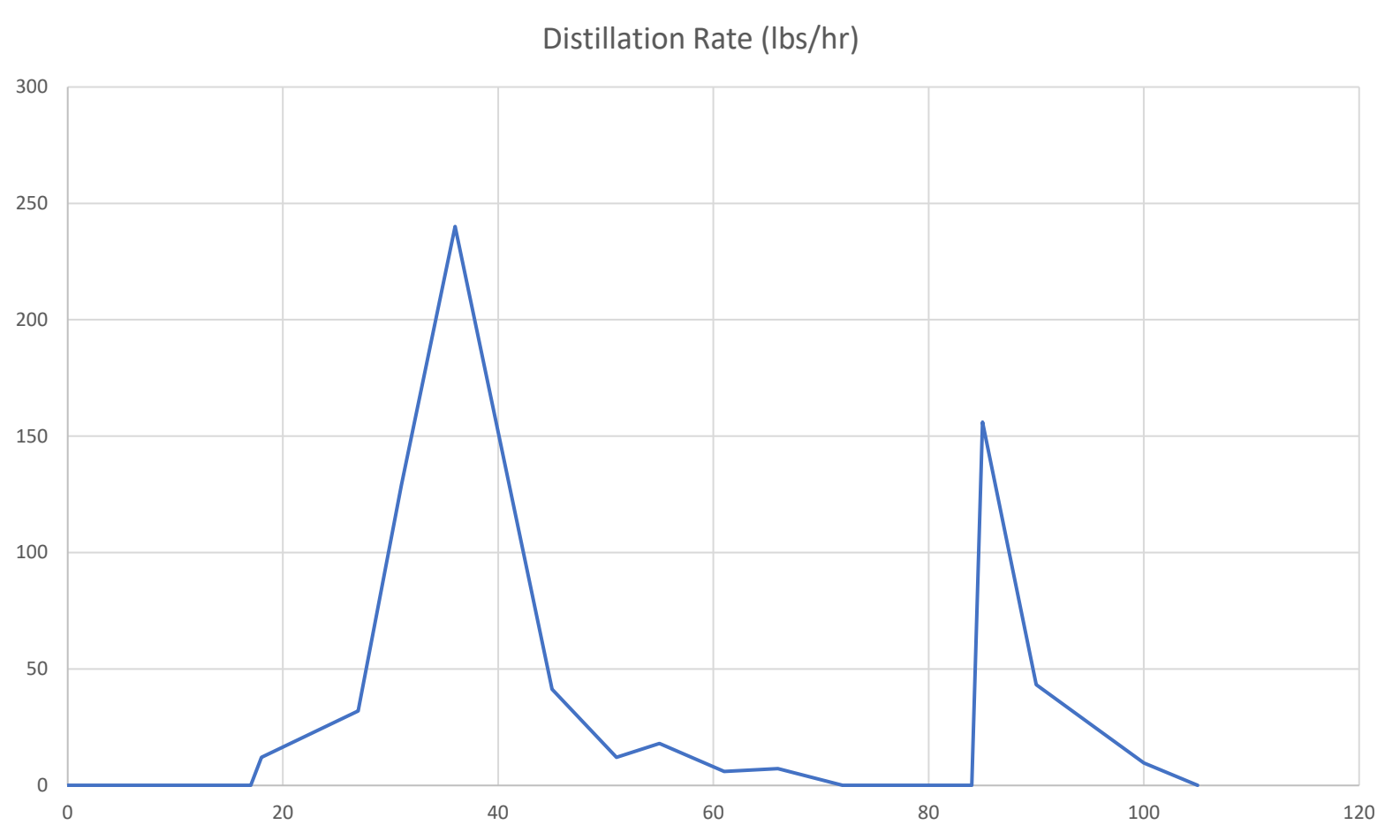

Menthol and Menthone Production Rates (lbs/hr)
60
50
40
30
20
10
0
8:52
9:07
9:21
9:36
9:50
10:04
10:19
lbs/hr menthol
lbs/hr menthone


Total Menthol and Menthone (lbs)
40
35
30
25
20
15
10
5
0
8:52
9:07
9:21
9:36
9:50
10:04
10:19
Total Menthol
Total Menthone

Example cumulative Income from cooperator 3. Spearmint



Example cumulative Income from cooperator 3. Peppermint



Defining Terms

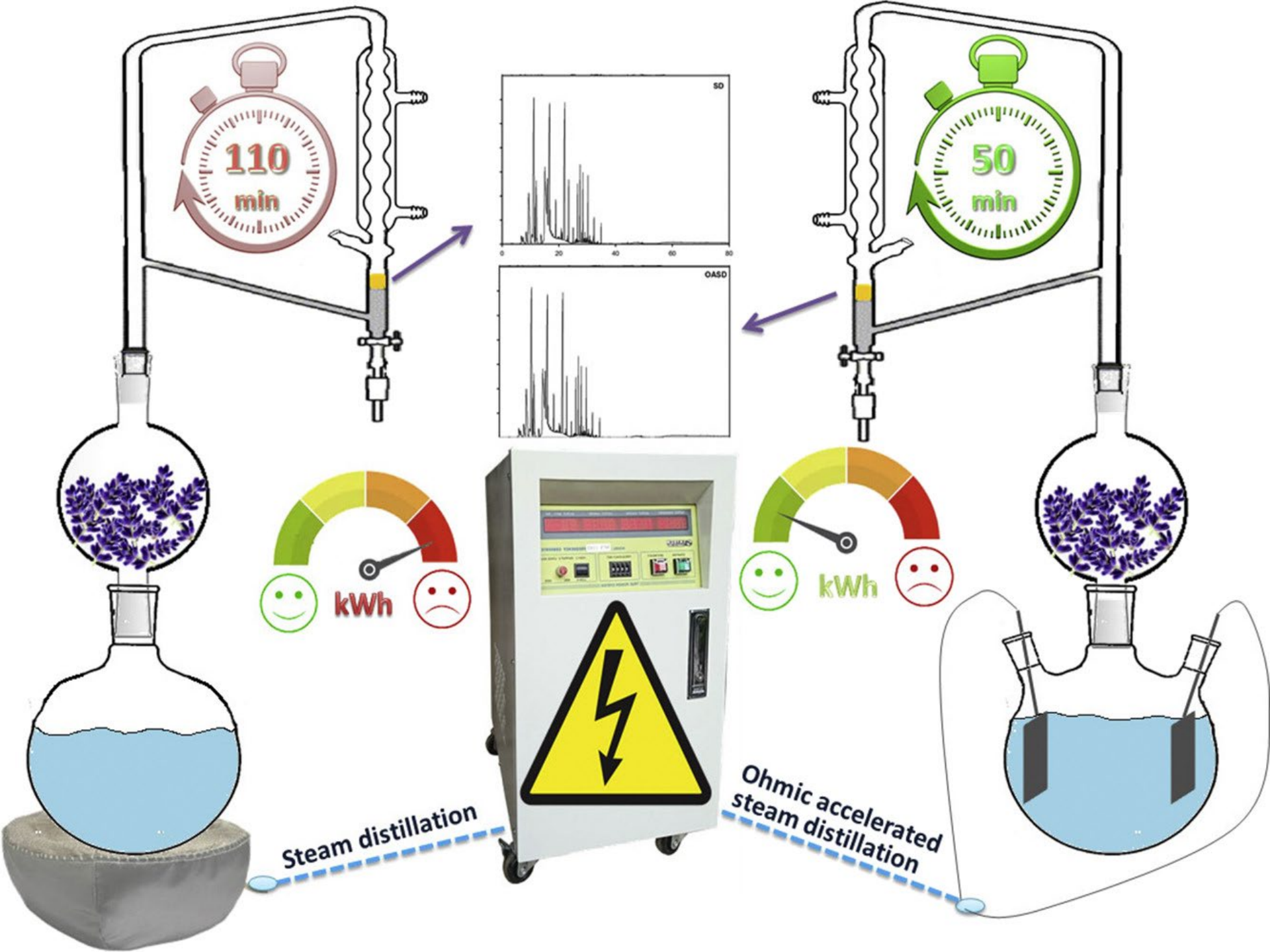
- Volatilization: Turn into a vapor (gas)
- Hydrodistillation: The mint hay is immersed in water and boiled.
- Ohmic accelerated: Electric current is run through the water to help heat
- Solar distillation: Sun's energy used to preheat water
- Microwave extraction: Microwaves used to heat the hay directly to volatilize the mint oil

Relevant Literature Review Findings

- Steam distillation is more efficient than hydrodistillation
- Distillation time affects the oil composition
- Productivity of distillation is affected by the change in heat transfer, oil mass flow rate, inlet water mass flow rate, and batch size of peppermint
- Indications that slow steam flow rate is more efficient than fast steam flow rates
- Ohmic accelerated steam distillation works faster with lower energy costs than electric resistance heating for steam distillation with the same oil quality.

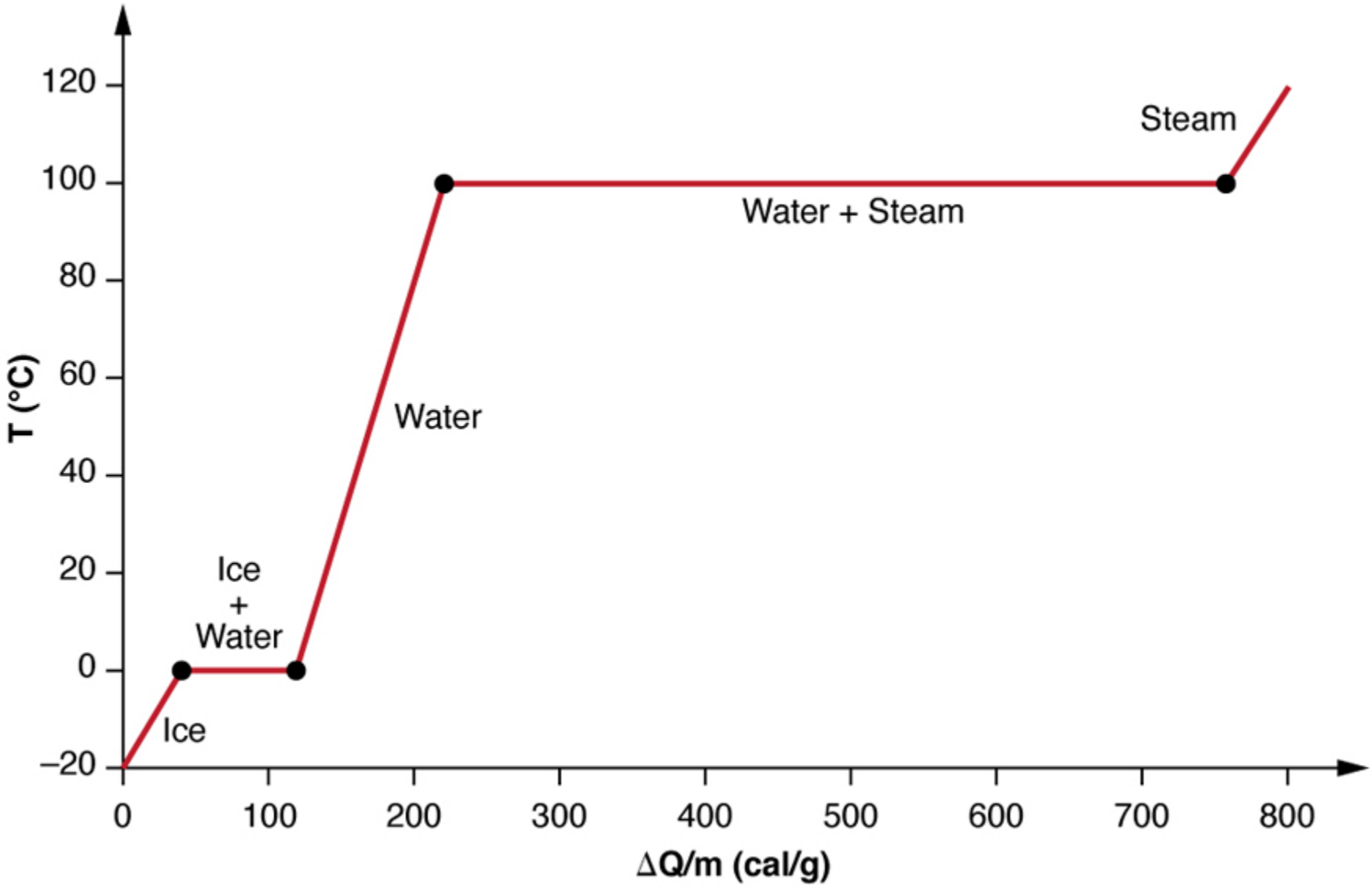
Relevant Literature Review Findings

- Different plants need different periods for the essential oils to achieve the desired quality or quantity of extract
- Hydrodistillation may be more cost effective for other plants like lavender compared to steam distillation


110
min
50
min
SD
OASD
kWh
kWh
Steam distillation
Ohmic accelerated
steam distillation

Outstanding Questions

- Fill tubs with steam quickly, then cut back?
- Cost effectiveness of insulation? On tubs? On steam lines?
- Propane vs. diesel vs. electric heat
- If electric: ohmic accelerated steam distillation (OASD) vs electric resistance heating
- Steam temperatures throughout the process
- Does the steam superheat to > 100 C (212 deg F)?
  - It's not if it coexists with water/condensate.
  - Terms such as "wet steam", or "burning the oil"


120
100
80
60
40
20
0
−20
T (°C)
Steam
Water + Steam
Water
Ice
+
Water
Ice
0
100
200
300
400
500
600
700
800
ΔQ/m (cal/g)

Levers

- Steam flow rate
  - Boiler BTU (heat input)
  - Pipe sizes (reduced friction losses)
  - Boiler energy input rate
  - Flow rate profile throughout the cook
- Steam temperature through the hay
  - 100 deg C only?
- Condenser heat removal rates
  - Cold water temperature and flow rate
- Distillation or cutoff times

Indicators

- Oil distillation rate
- Condensate temperature
  - Too hot, likely letting oil out
  - Too cold, likely using too much water
- Boiler pressure
  - Too high = too many restrictions or too much energy (heat) input
  - Too low = not enough energy (heat) input, too many tubs and likely condensing in the tubs or in the return lines instead of in the condenser, possibly not volatilizing the oil