A life cycle assessment of biosolarization as a valorization pathway for tomato pomace utilization in California

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Biosolarization

Biosolarization uses soil amendments to induce microbial activity.

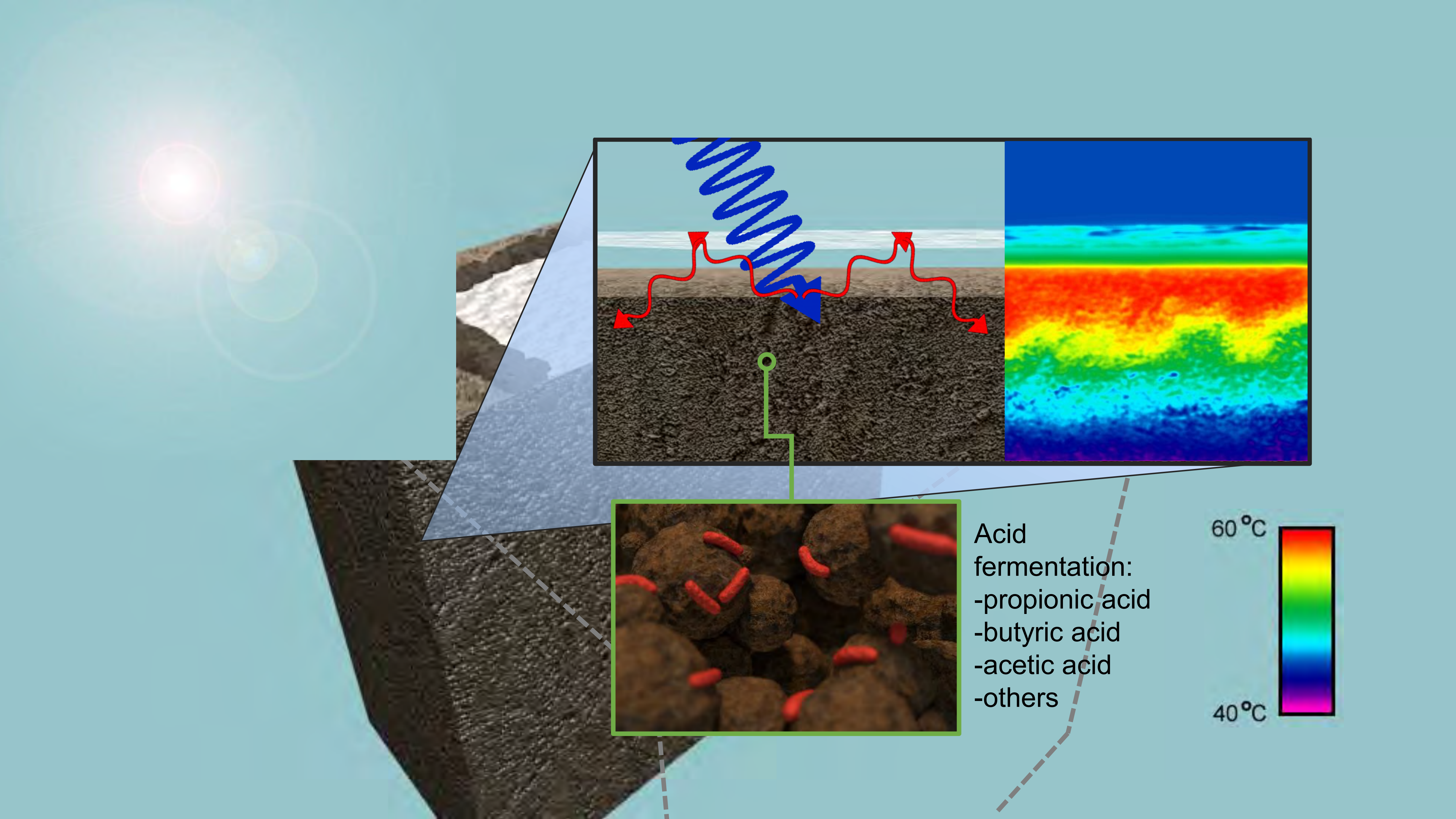
Field soil

+

Stable green waste compost

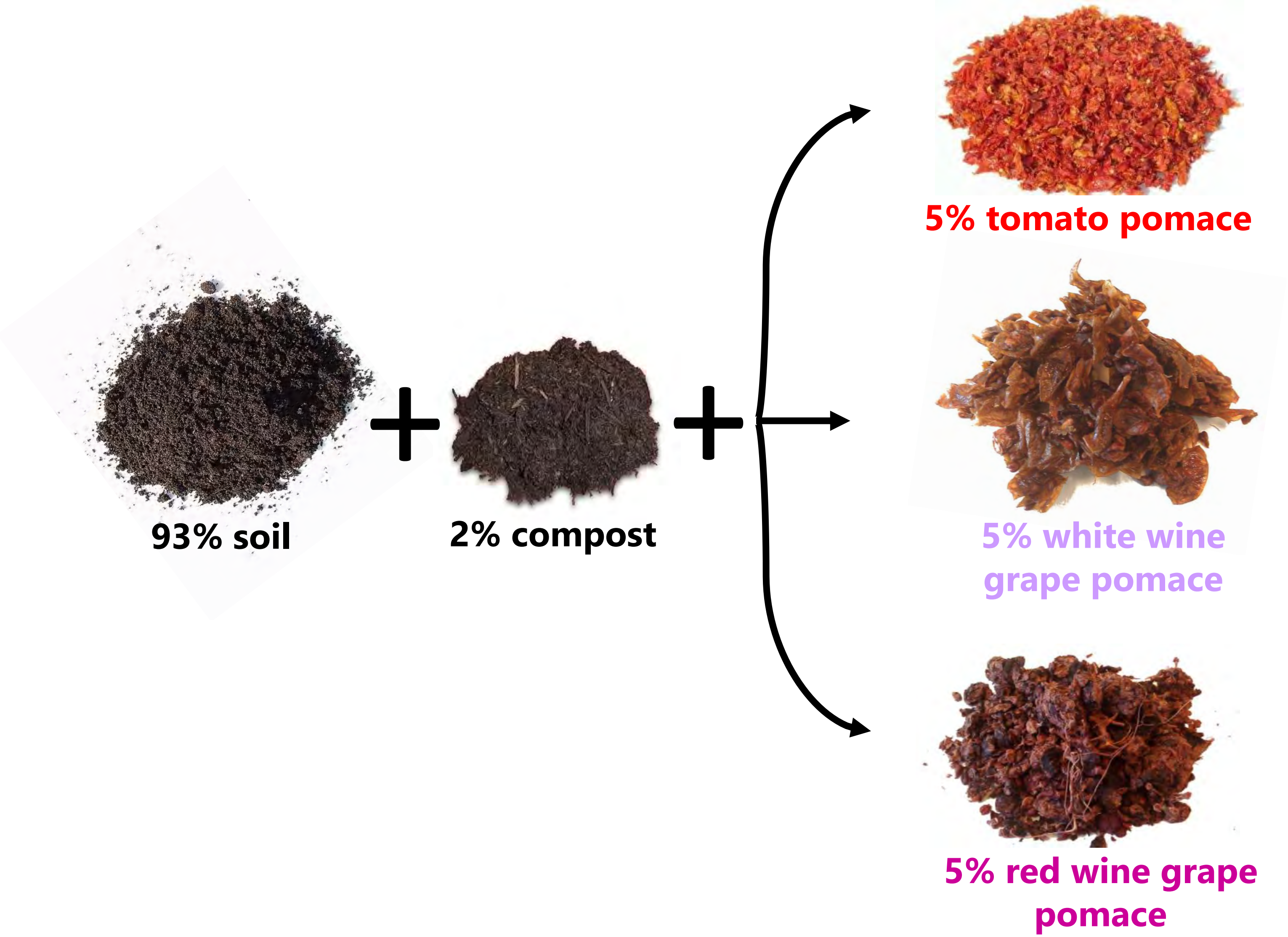
+

Agricultural or food processing organic residues

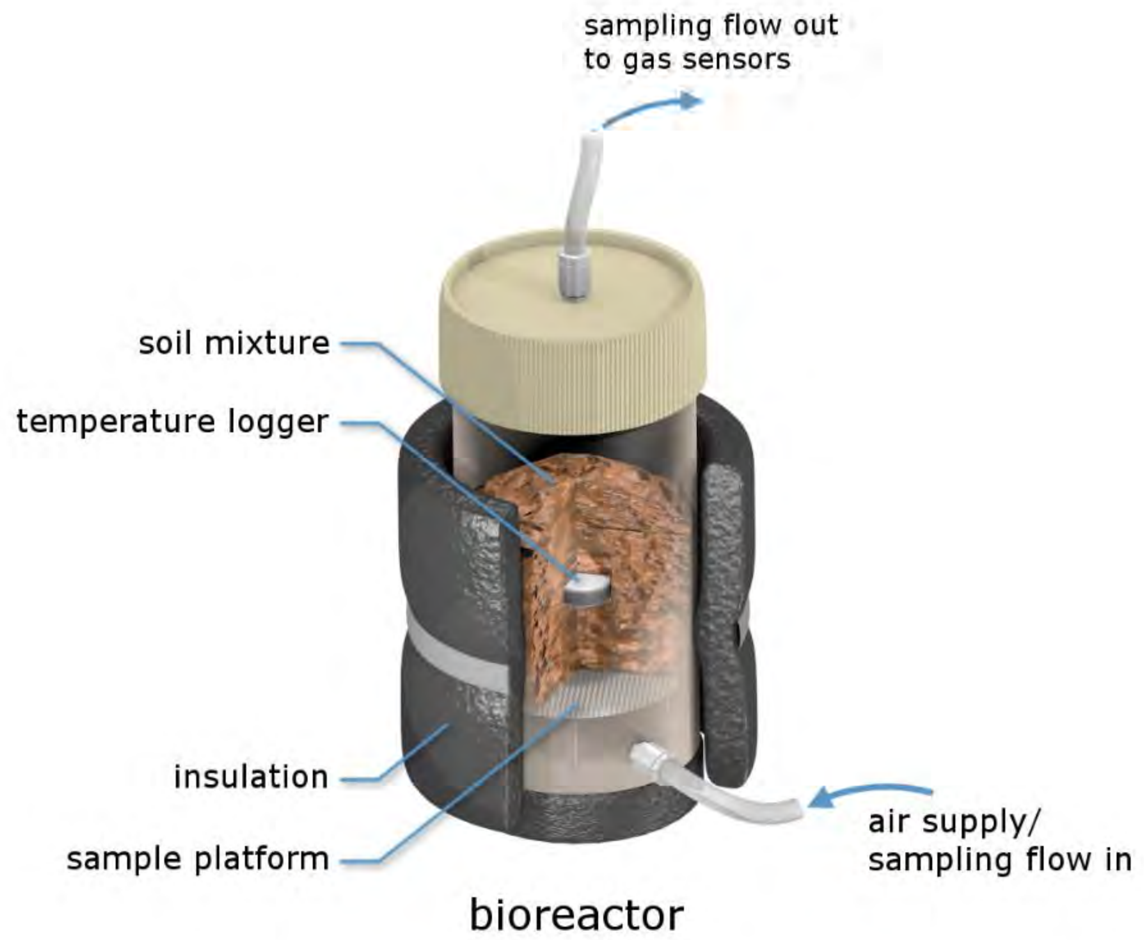

Acid
fermentation:
-propionic acid
-butyric acid
-acetic acid
-others
60 °C
40 °C

Can CA fruit processing residues be used in biosolarization?

Pomaces from tomato and wine processing are the most abundant solid waste streams in California fruit processing.

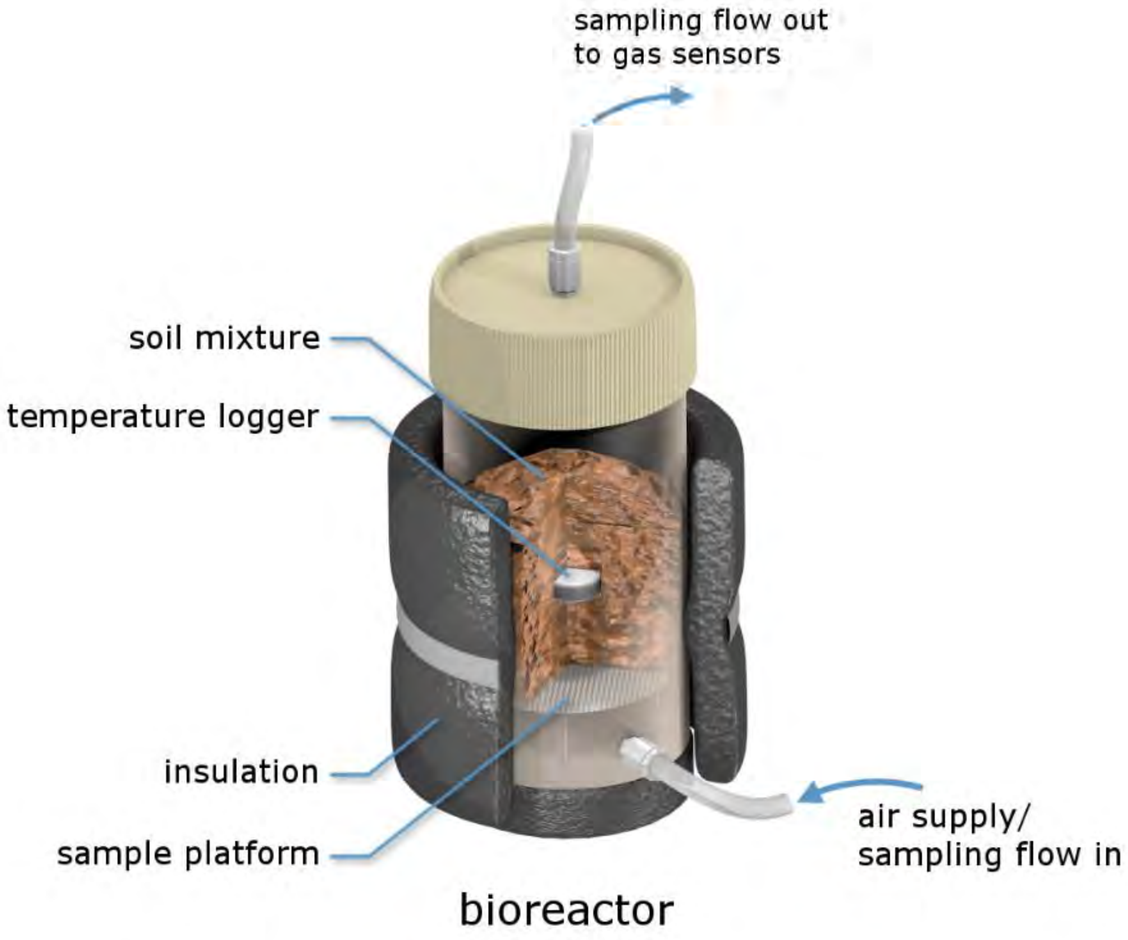

93% soil
2% compost
5% tomato pomace
5% white wine grape pomace
5% red wine grape pomace

Screening pomaces using simulated biosolarization in soil bioreactors

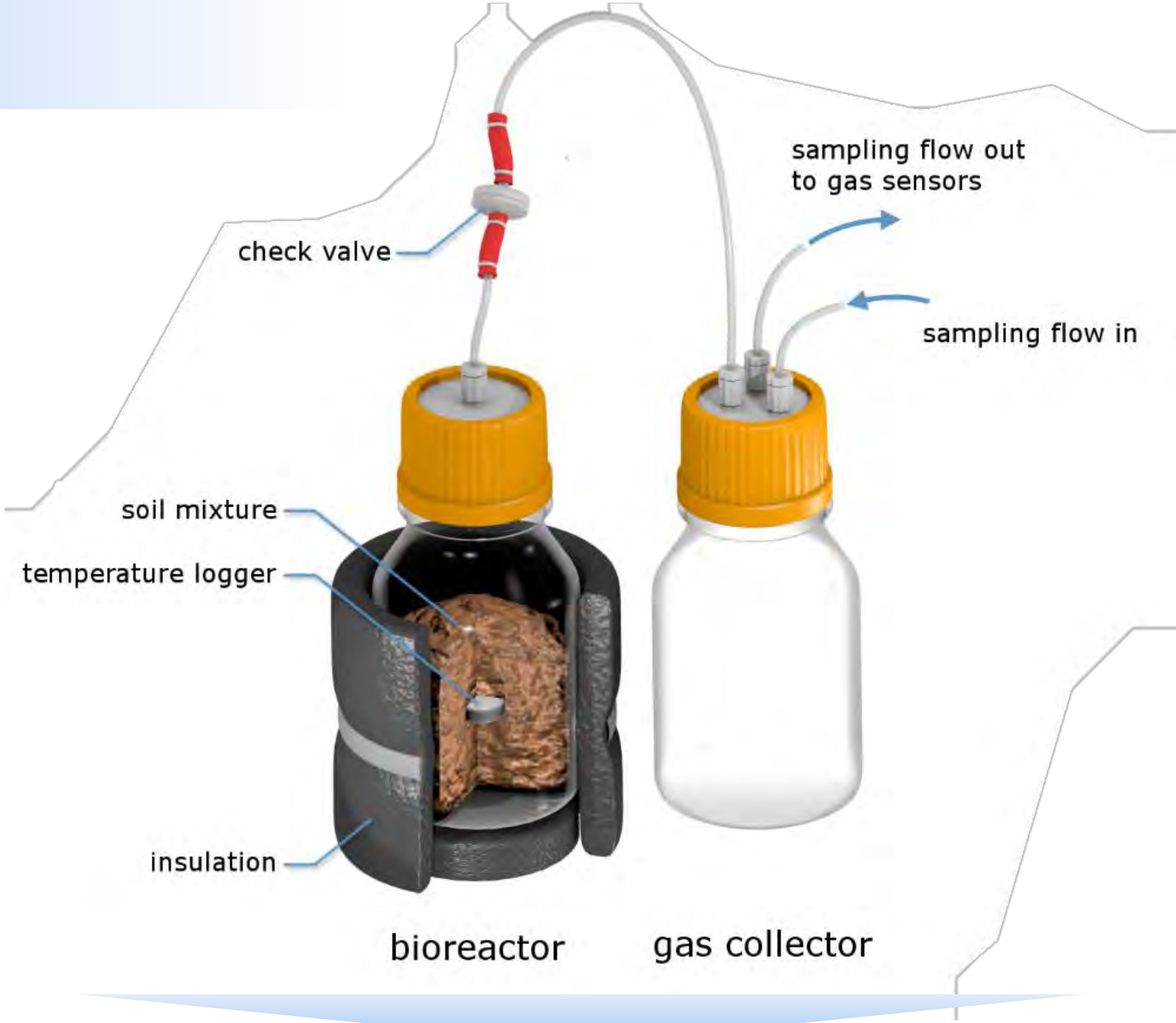


Aerobic conditions, 55 °C

Screening pomaces using simulated biosolarization in soil bioreactors



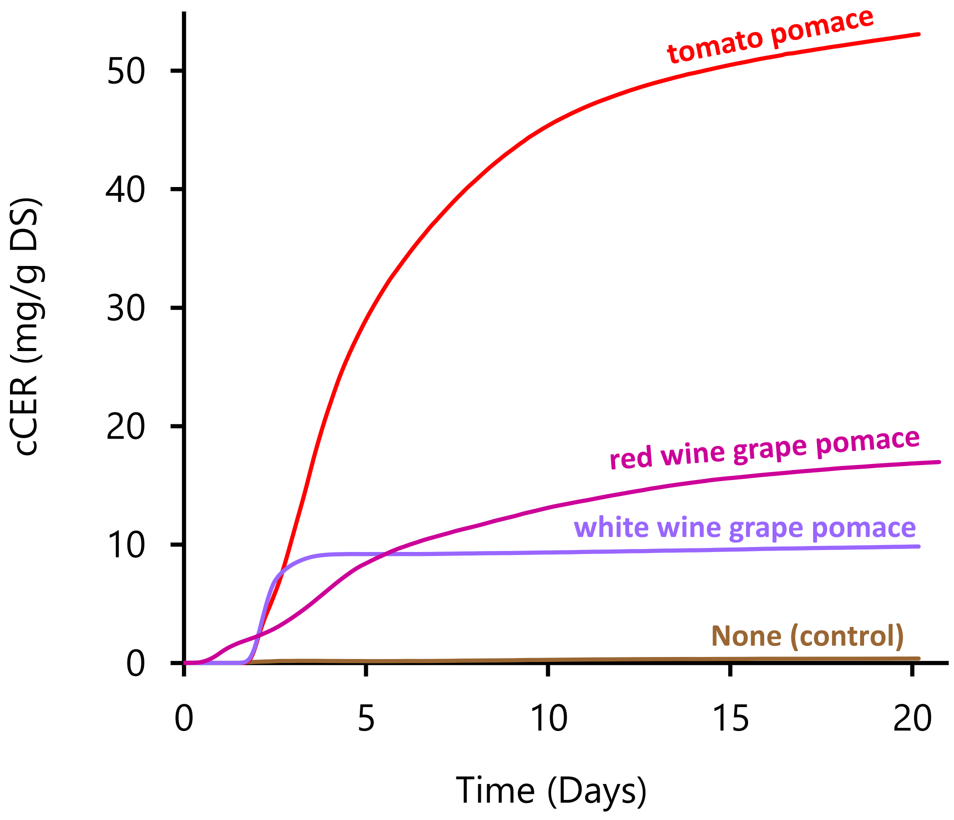
Aerobic conditions, 55 °C



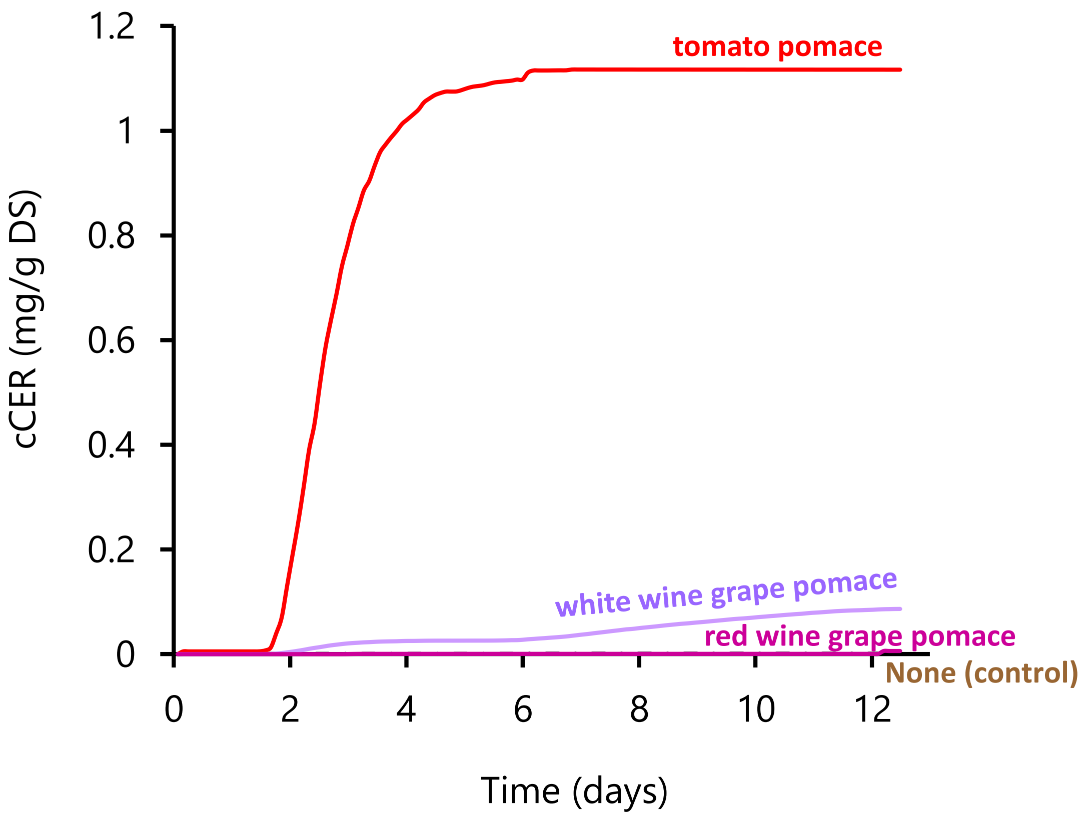
Anaerobic conditions, 55 °C

Tomato pomace amendment yields high microbial activity under biosolarization conditions

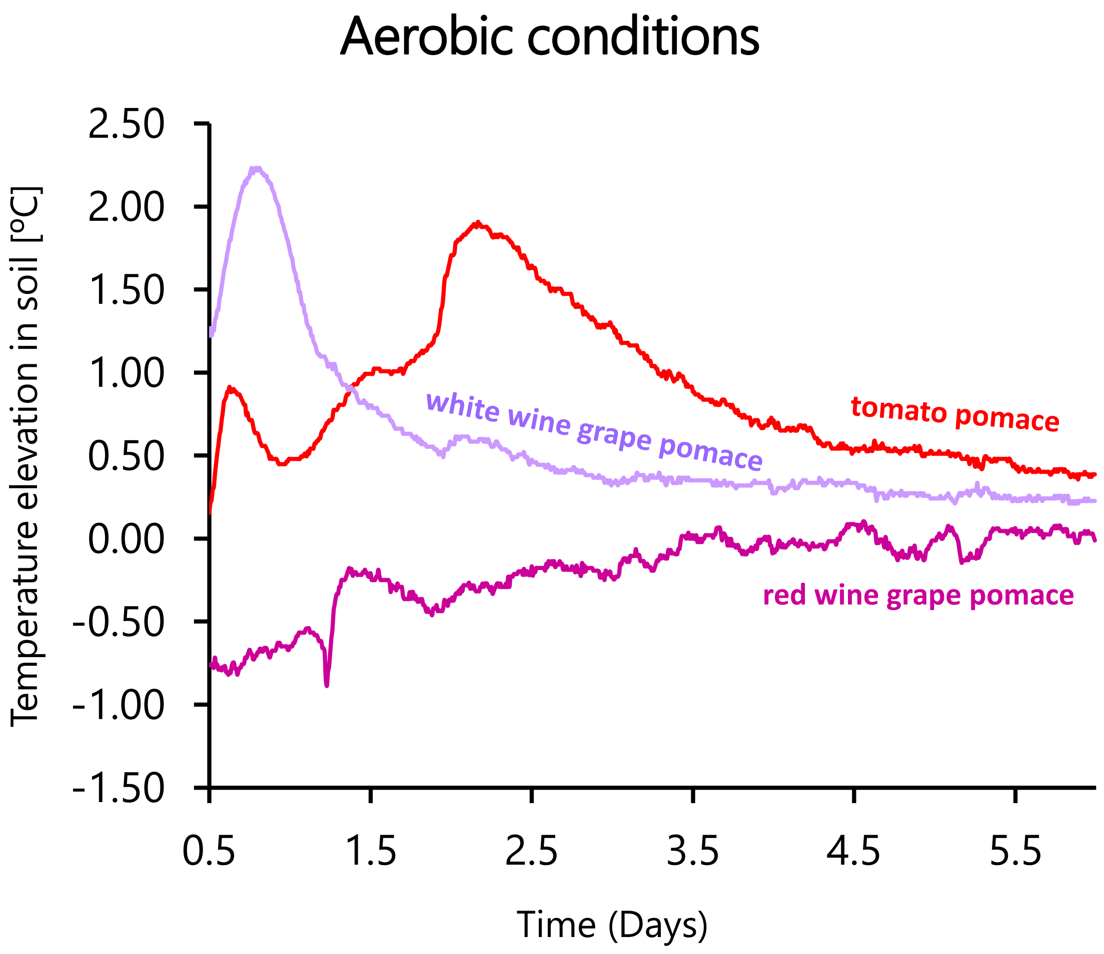
Aerobic conditions

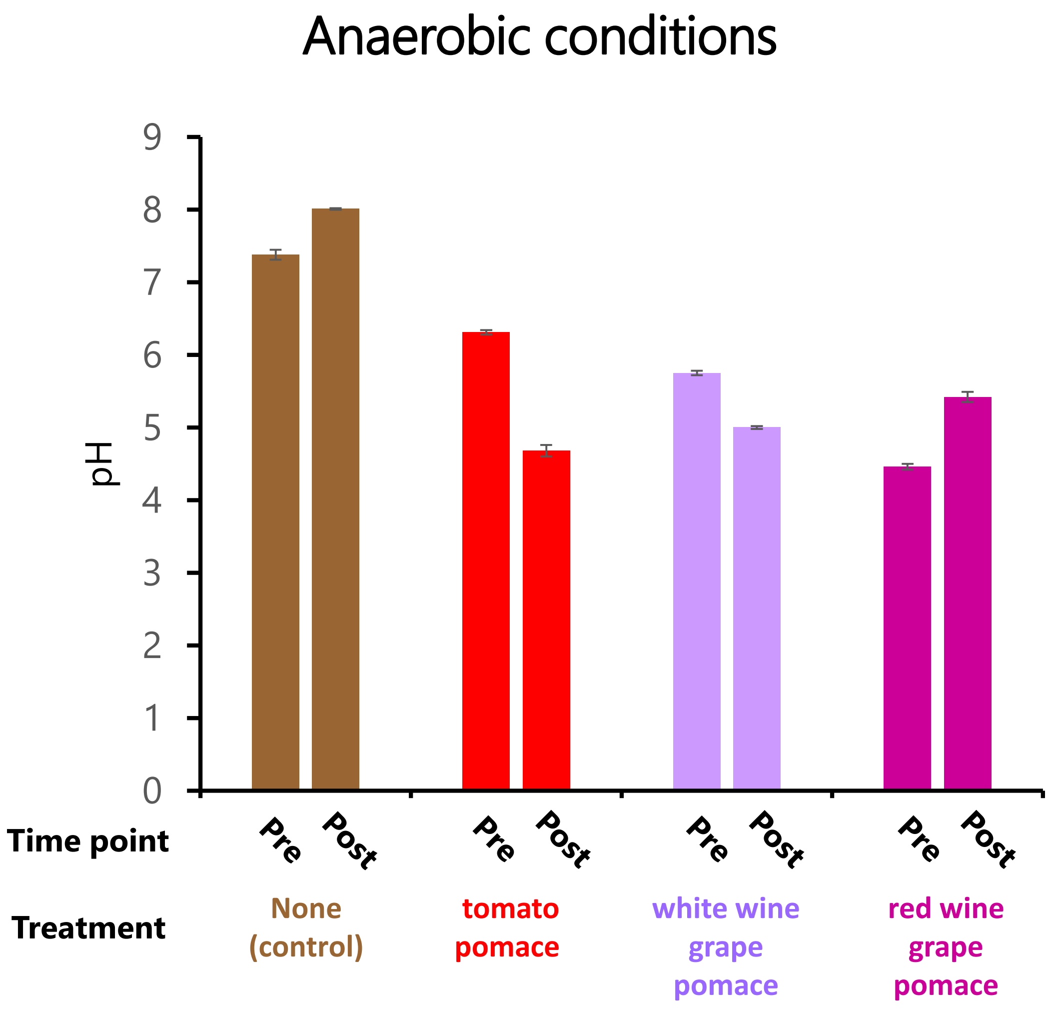


Anaerobic conditions

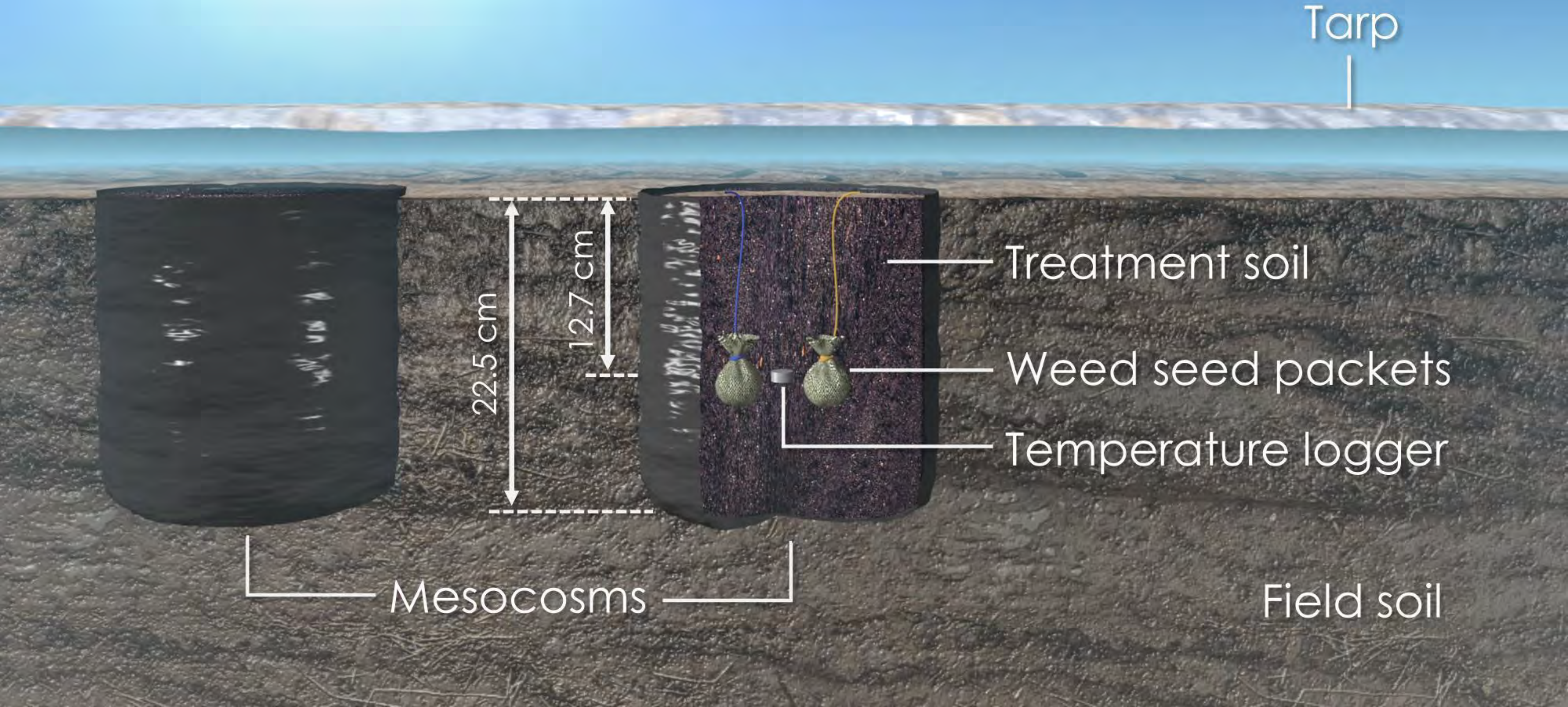


Tomato pomace amendment results in biological heating and acidification during biosolarization





Field trial


Tarp
Treatment soil
12.7 cm
22.5 cm
Weed seed packets
Temperature logger
Mesocosms
Field soil

Amended soil compared to non-amended soil under solar heated and non-heated conditions

95.5% soil

+

2% compost

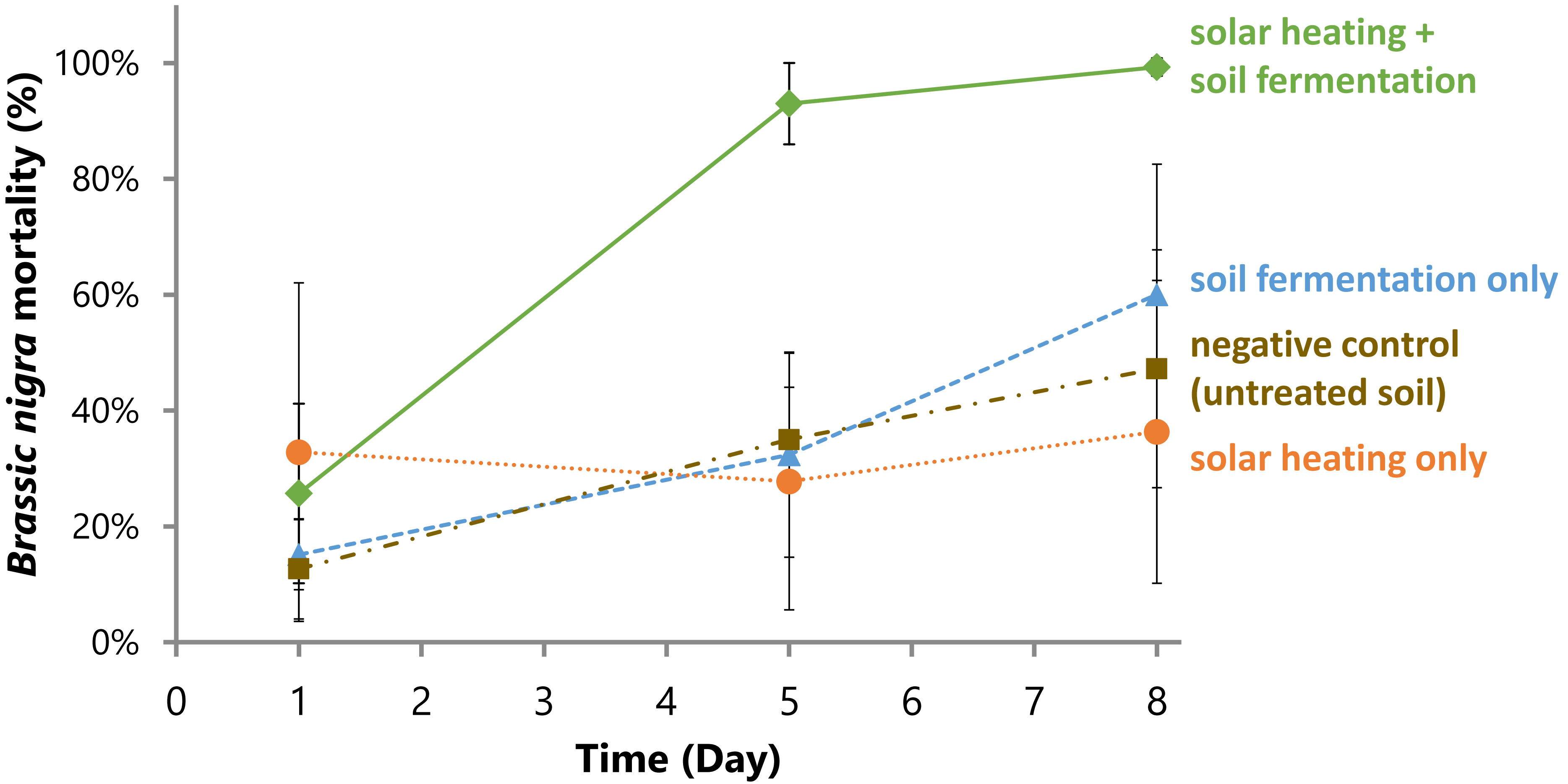
+

2.5% tomato pomace

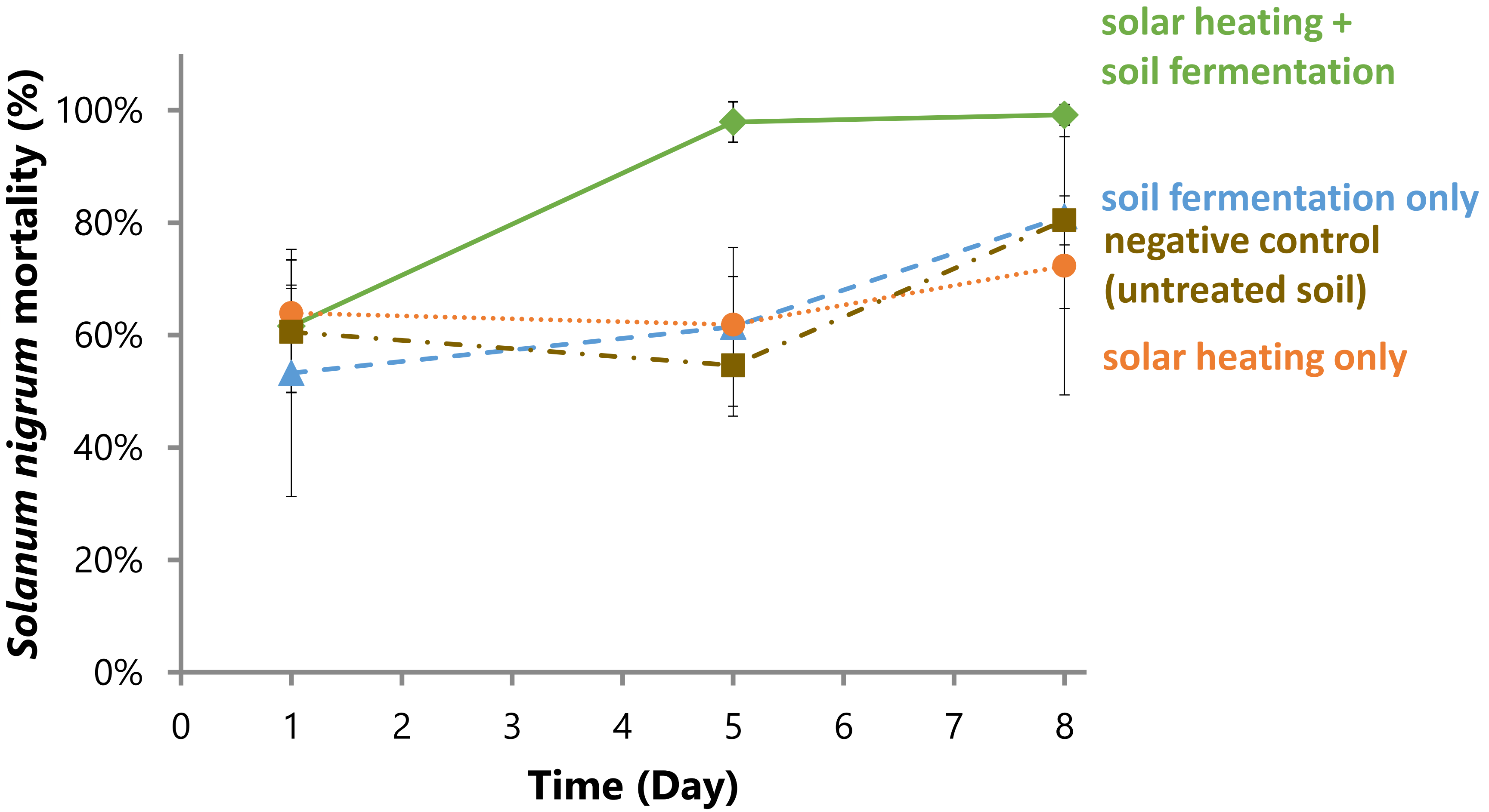
VS

100% soil (control)

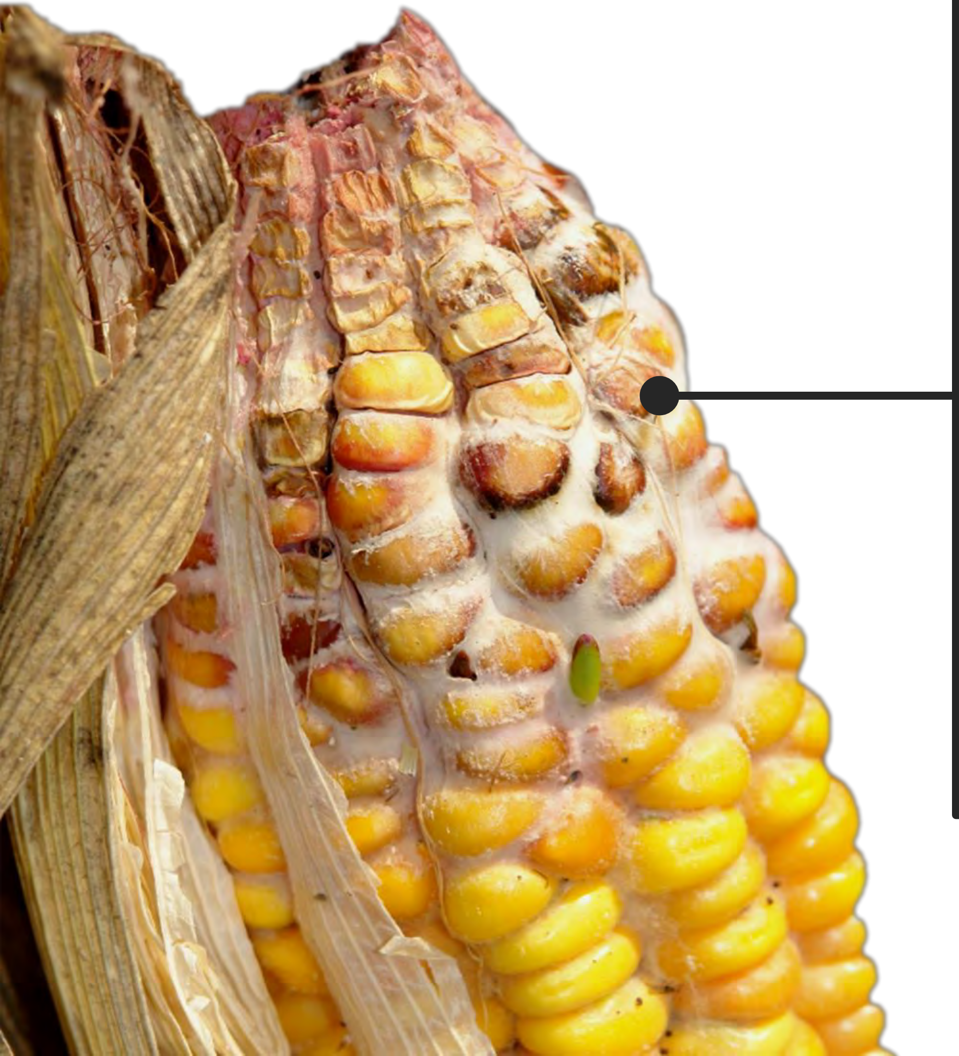
Biosolarization leads to rapid and complete inactivation of Black Mustard seeds



Biosolarization leads to rapid and complete inactivation of Black Nightshade seeds



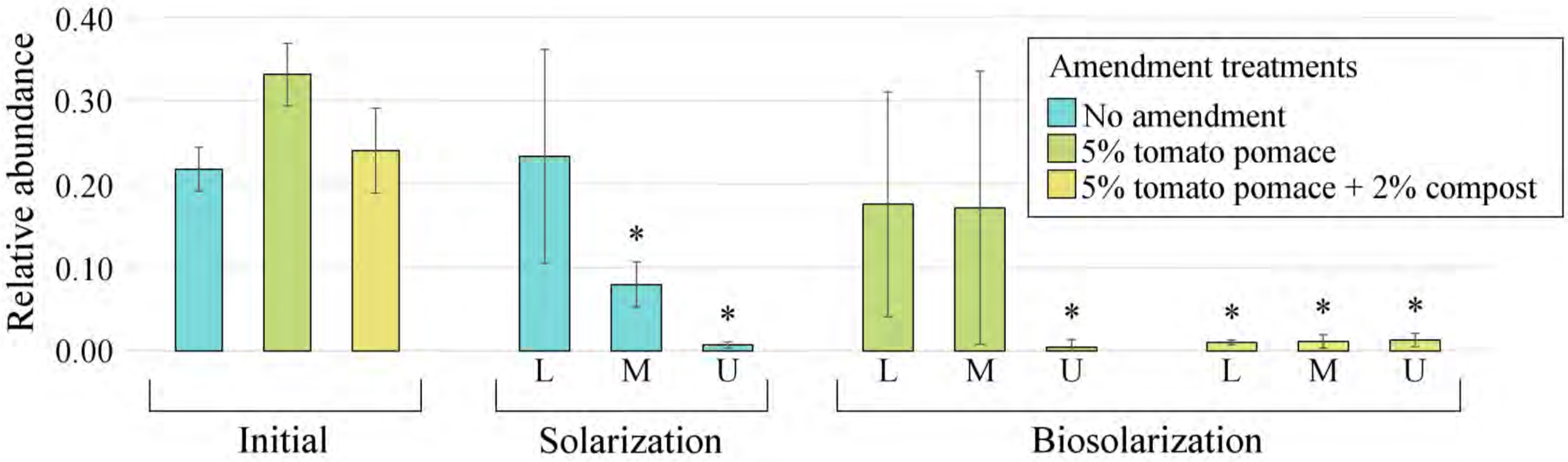
Fungal pathogen control



Gibberella – causes a variety of rot, wilt, and scab diseases

Biosolarization leads to a significant reduction in *Giberella* relative abundance in the soil

Giberella (causes rot and wilt in several crops)



Is biosolarization a more sustainable alternative to fumigation?

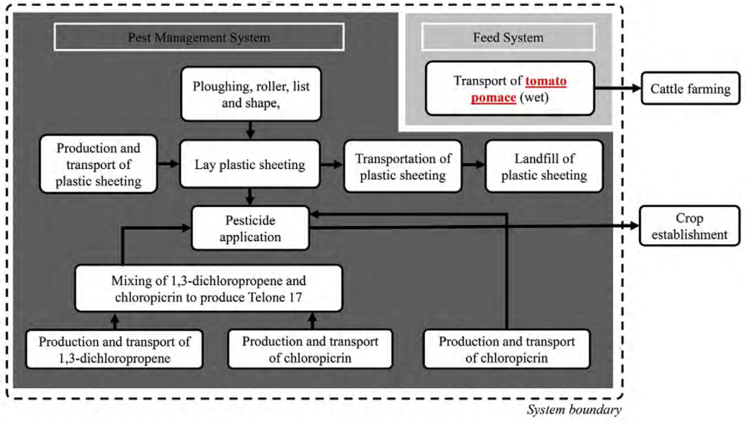
Biosolarization Life Cycle Assessment

Goals and Scope

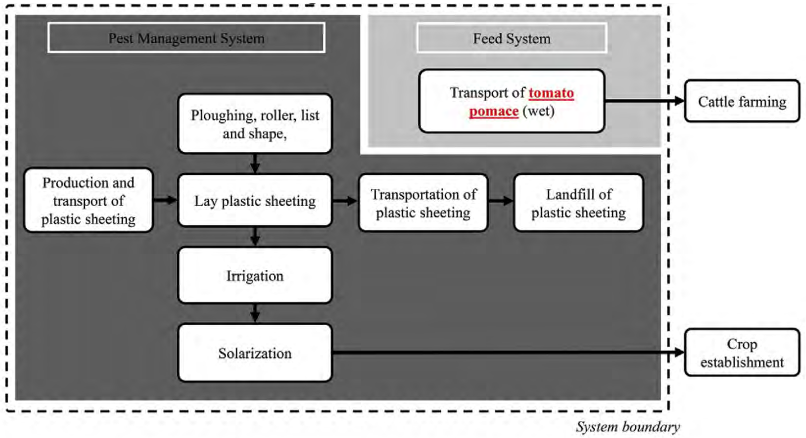
- Calculate **baseline environmental impact** data for utilizing tomato pomace in biosolarization compared to its current use as animal feed.
- Provide information for **strategic decision making** regarding pomace valorization and soil disinfestation.

Biosolarization Life Cycle Assessment
Goals and Scope

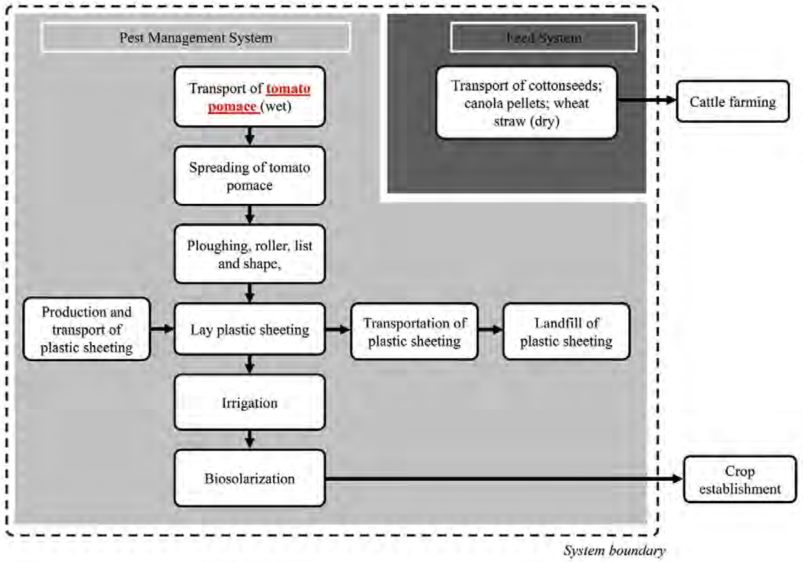
Scenario 1 (business as usual): Fumigation for disinfestation, pomace sold as cattle feed.



Scenario 2: Solarization (solar heating) for disinfestation, pomace sold as cattle feed.



Scenario 3: Biosolarization (solar heating and fermentation) using pomace for disinfestation, alternative cattle feed.



Biosolarization Life Cycle Assessment

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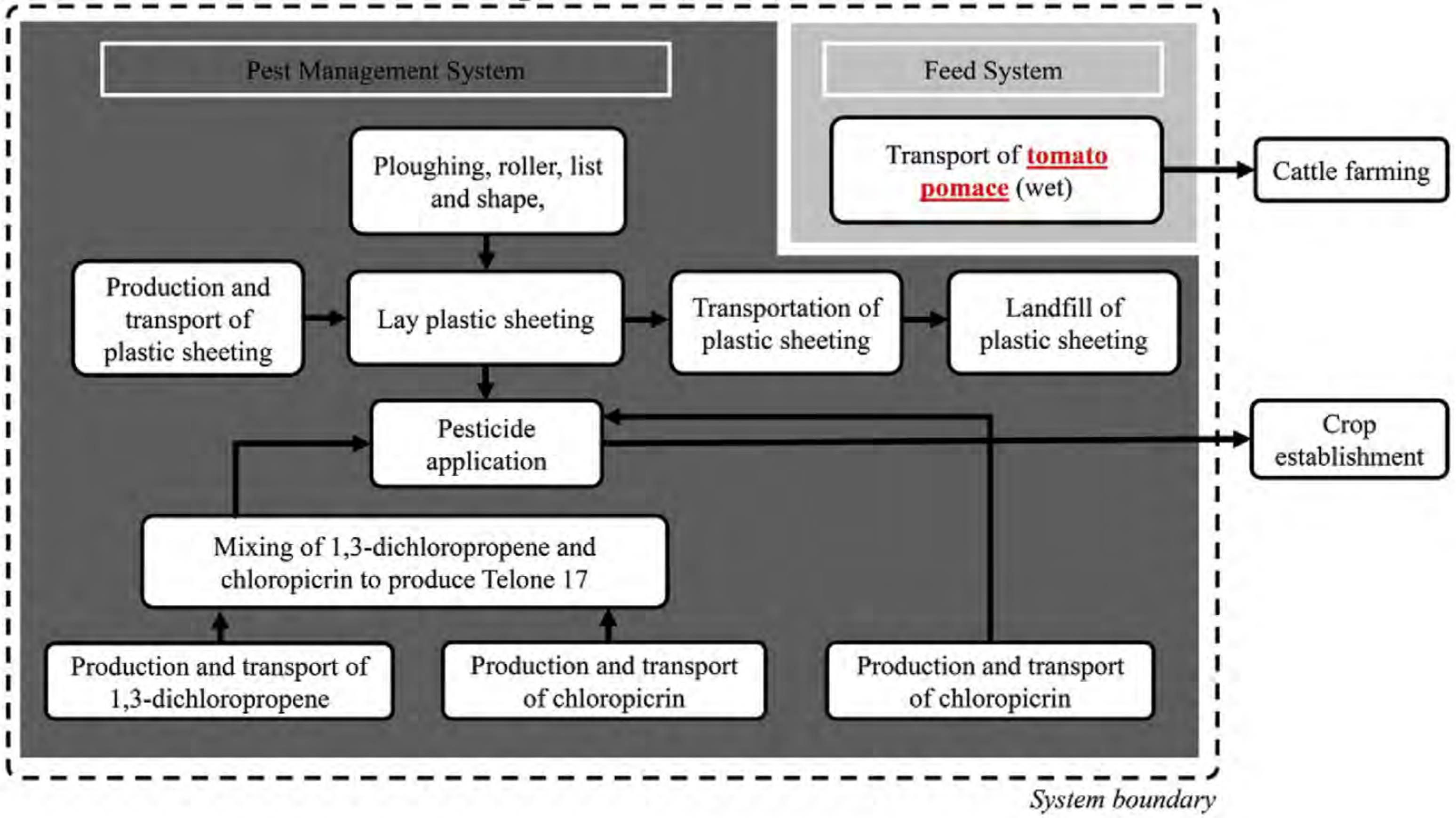

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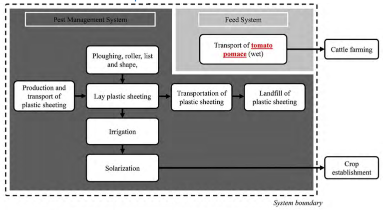

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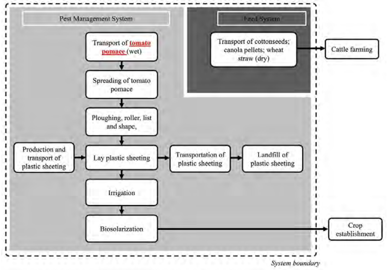

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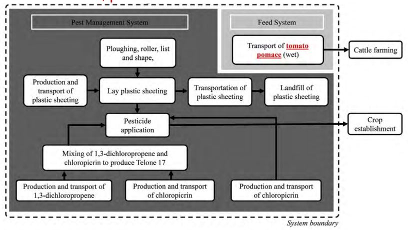

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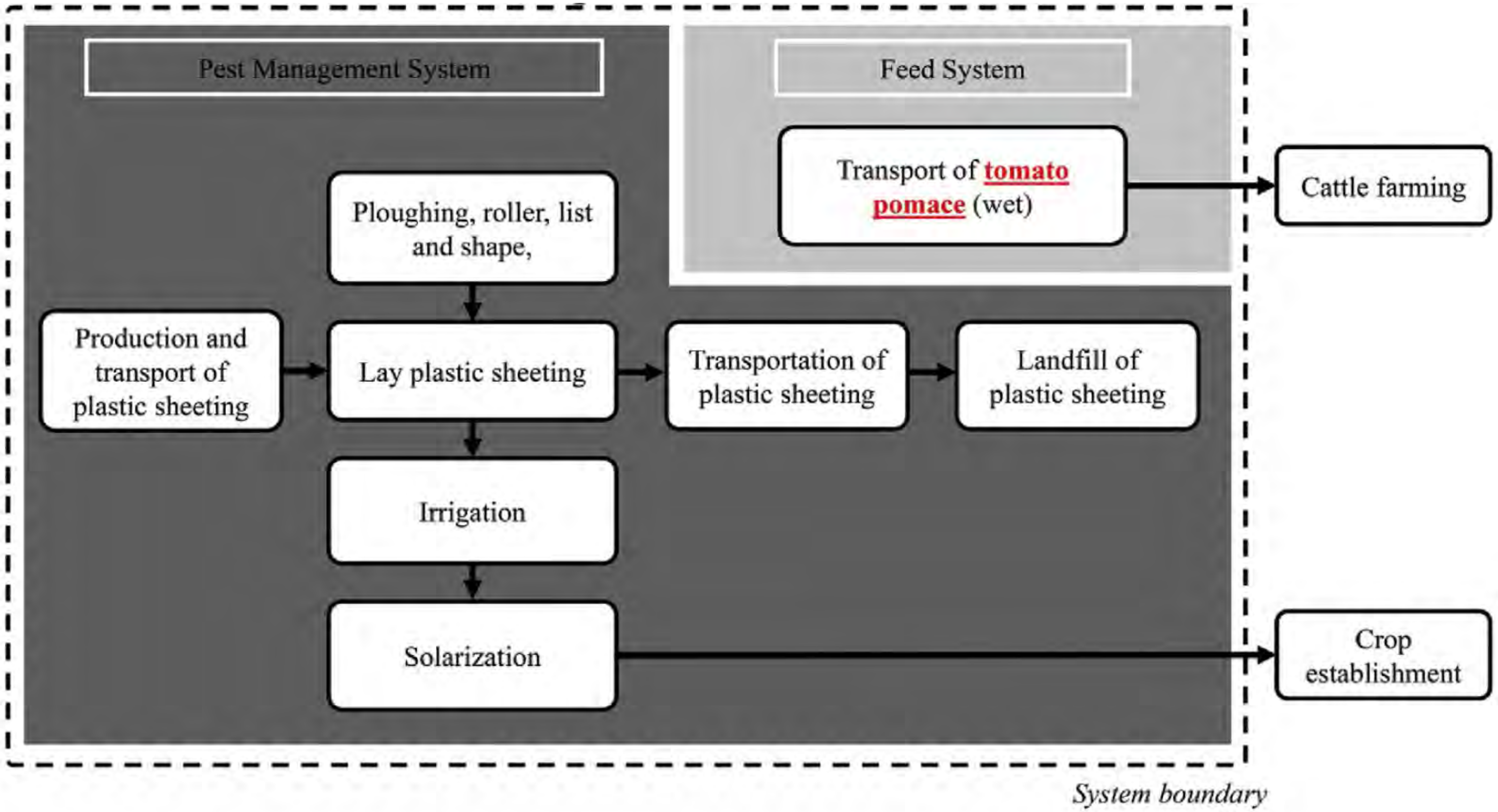

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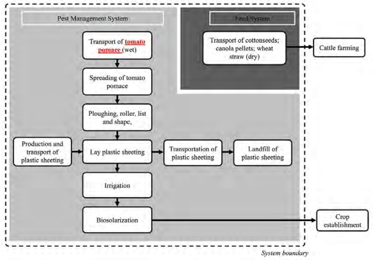

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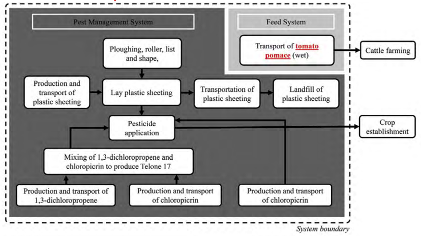

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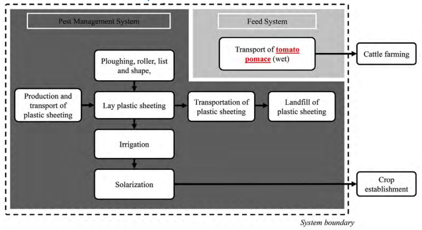

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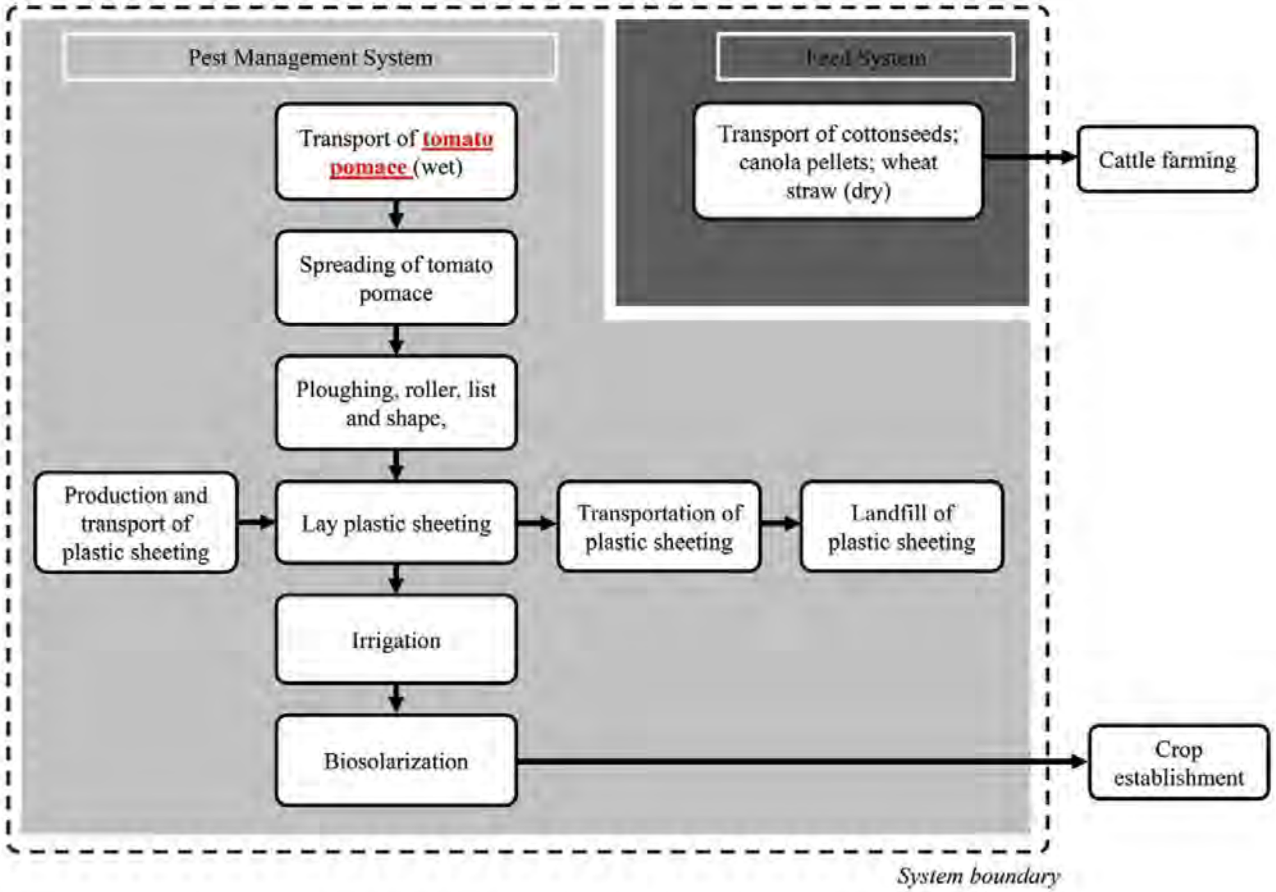


LCA scope

Soil disinfestation location:

Fresno County

- Eggplant growers use fumigation
- Weather and fallow period compatible with biosolarization

Animal feed location:

Tulare County

- Contains high concentration of dairy farms


Functional unit:
1 ton of tomato pomace

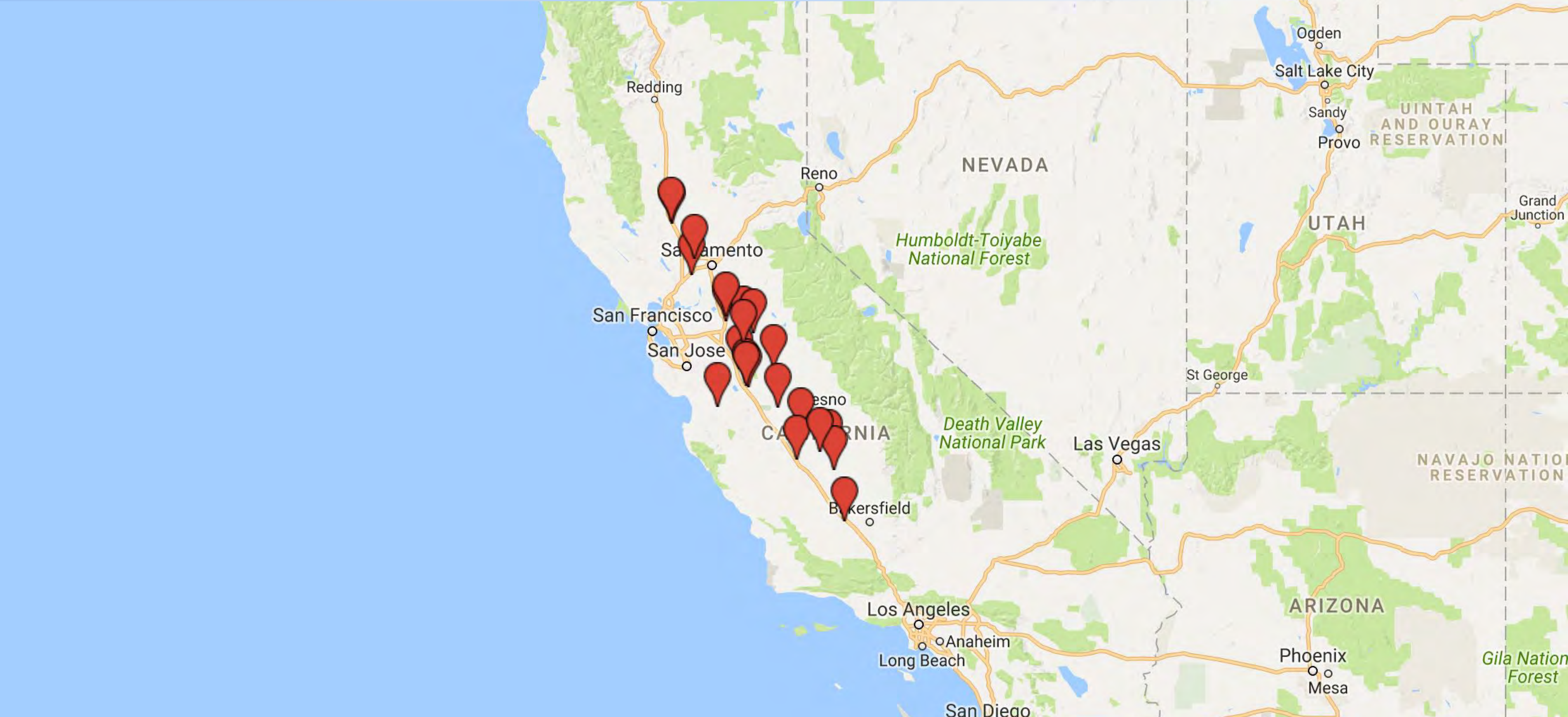
Functional unit:

1 ton of tomato pomace

Reference flow:

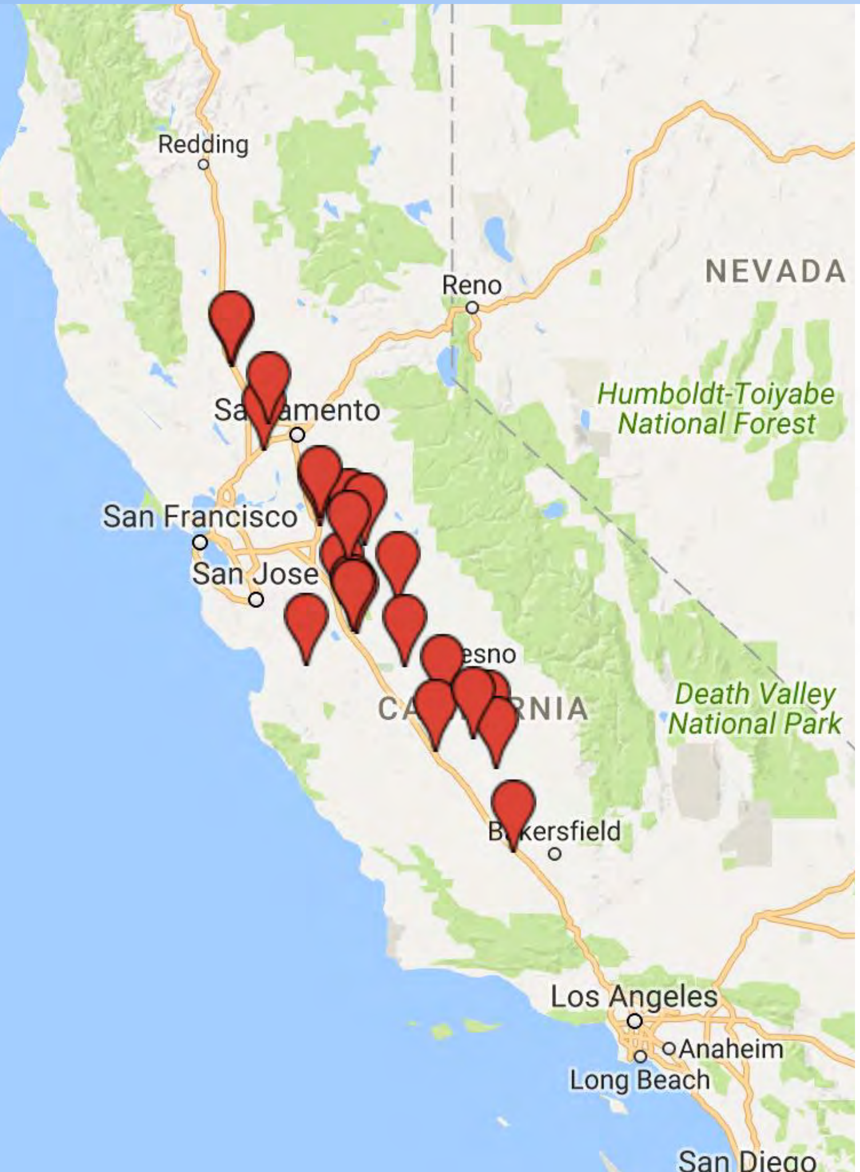
388,856 t fresh weight

Biosolarization Life Cycle Assessment
Life Cycle Inventory



Biosolarization Life Cycle Assessment

Life Cycle Inventory



Locations of tomato processing centres in California.

Location	Pomace production (metric tonnes, fresh weight)	Pomace production (metric tonnes, dry weight)	Distance to Fresno (horticulture) (km)	Distance to Tulare (feed) (km)
Santa Nella	50,808	11,686	408	476
Williams	43,245	9946	370	438
Los Banos	38,164	8778	117	185
Huron	29,561	6799	85.8	72.5
Lemoore	25,866	5949	54.1	49.4
Los Banos	23,672	5445	117	185
Bakersfield	23,383	5378	176	103
Corcoran	19,226	4422	81	29.6
Los Banos	18,995	4369	117	185
Dixon	17,436	4010	310	363
Woodland	17,090	3931	307	375
Firebaugh	14,434	3320	69.1	137
Williams	14,376	3307	370	438
Oakdale	11,894	2736	165	232
Helm	11,894	2736	47.5	90.1
Stockton	9873	2271	205	273
Stockton	9527	2191	205	273
Hanford	5081	1169	53.7	36.6
Modesto	4330	996	156	224
Total	388,856	89,437	–	–
Average	–		179.7	219.2

GaBi 6 used to obtain LCI information for diesel truck hauling of pomace to target counties.

Biosolarization Life Cycle Assessment
Life Cycle Inventory

Life cycle inventory for agricultural operations Life cycle inventory for agricultural operations (per hectare).

	Option 1	Option 2	Option 3
Pomace applied (kg)[a]	–	–	61,900
Fumigant applied (kg)	112	–	–
Herbicide applied (kg active ingredient)	0.2	–	–
Plastic sheeting consumed (t)	1	0.7	0.7
Fuel consumed (L)			
Spreading	–	–	30.2
Plough	25.3	25.3	25.3
Level	29.9	29.9	29.9
Plastic sheeting laying	15.15	15.15	15.15
Irrigation	–	201.65	201.65
Plastic sheeting removal	15.15	15.15	15.15
Emissions during soil inactivation (kg CO_2)	–	Negligible	340.5 (biotic)
Plastic sheeting disposal (t)	1	0.7	0.7

[a] Fresh weight.

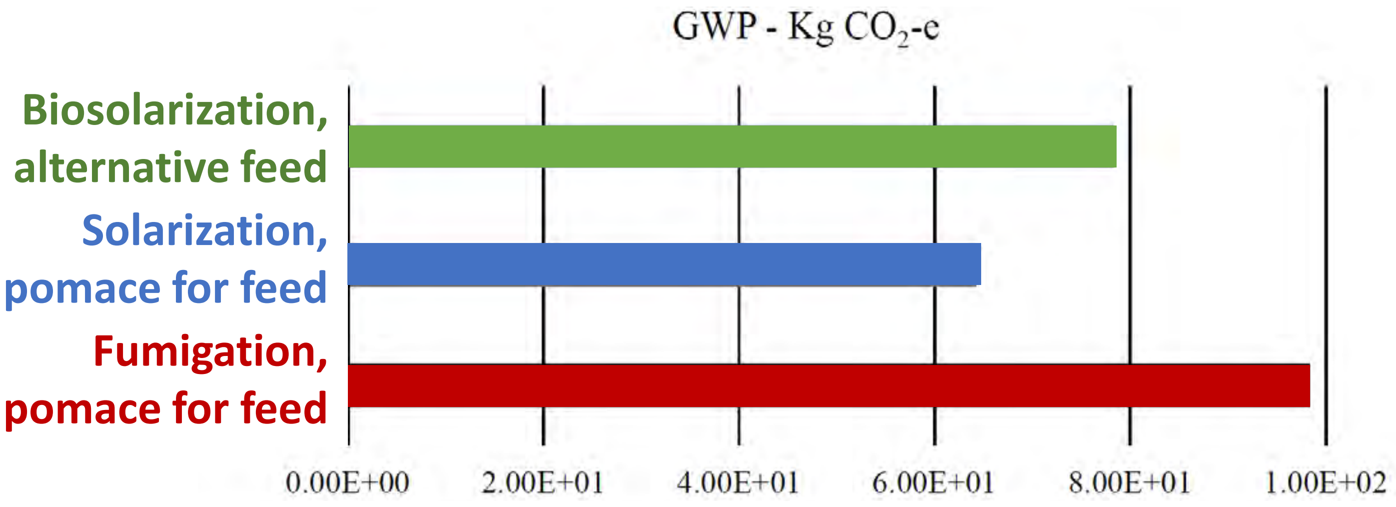
GaBi 6 and Ecoinvent used to obtain LCI information for materials and farm operations.

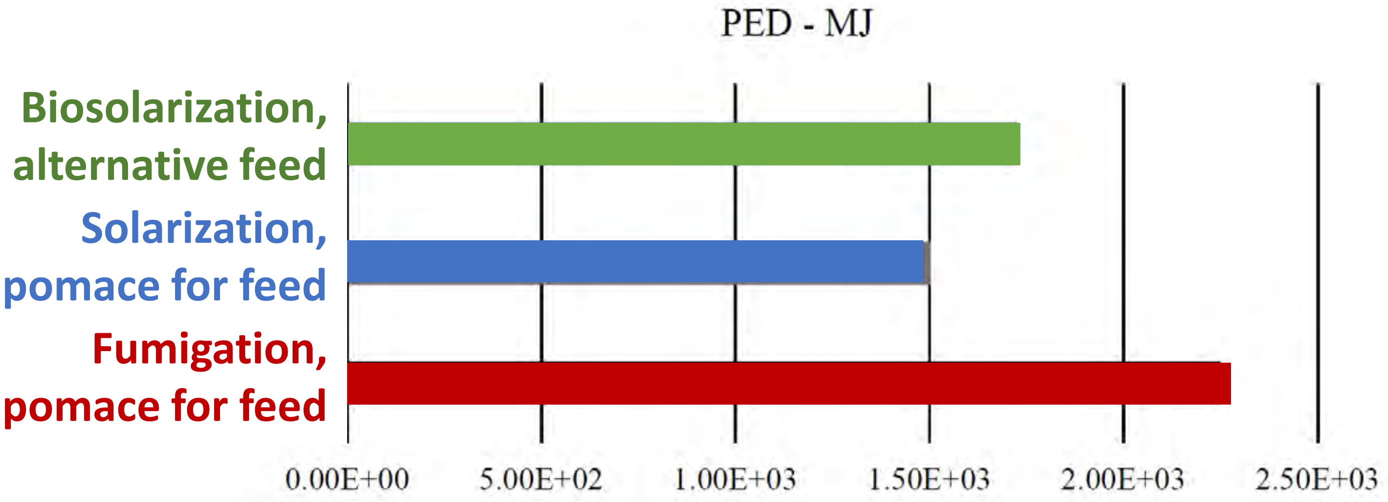
Biosolarization Life Cycle Assessment

Impact Assessment – Global warming potential and Primary Energy Demand

- Solarization and biosolarization have decreased global warming potential (GWP) and primary energy demand (PED) compared to the fumigation baseline scenario.

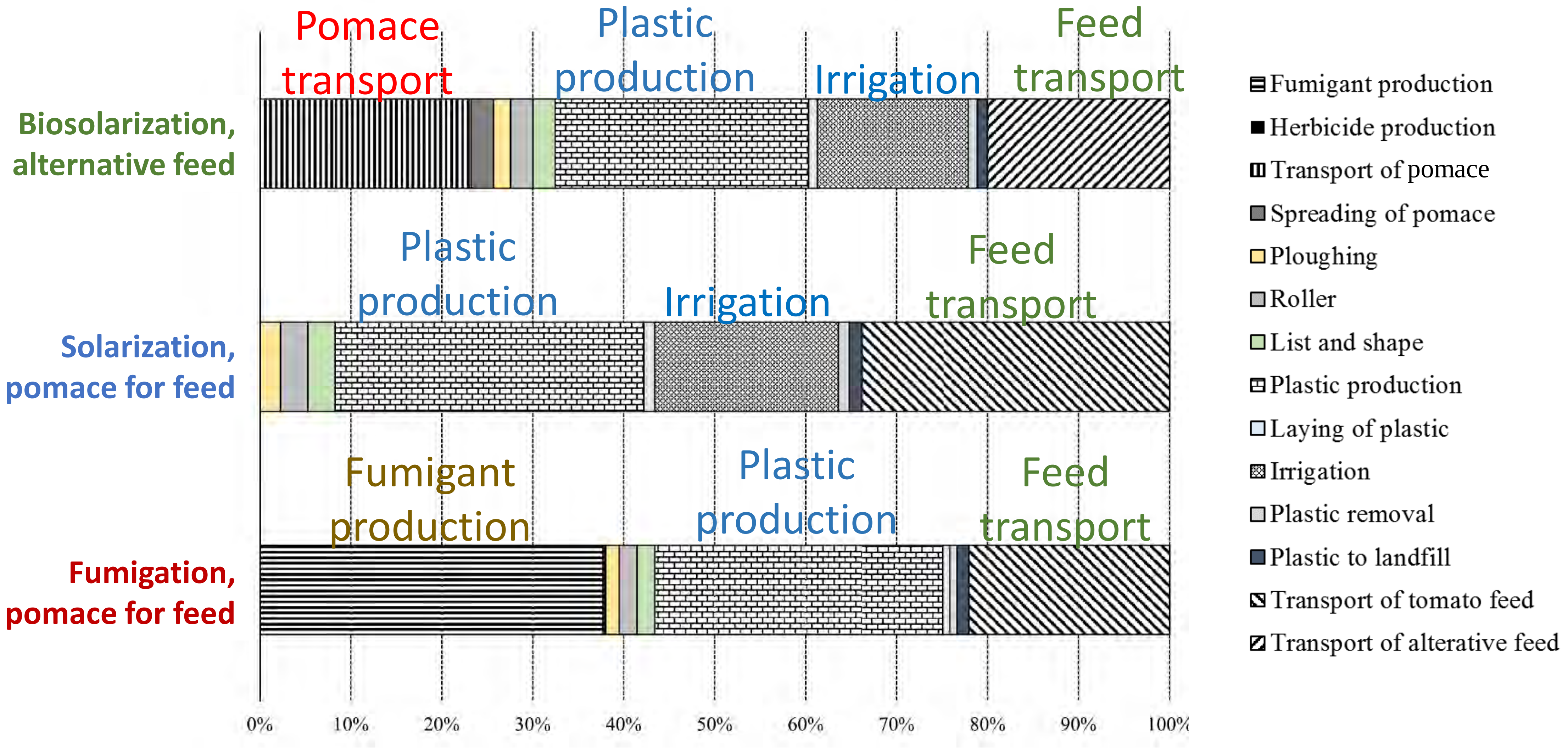
- Solarization yields decreased GWP and PED relative to biosolarization





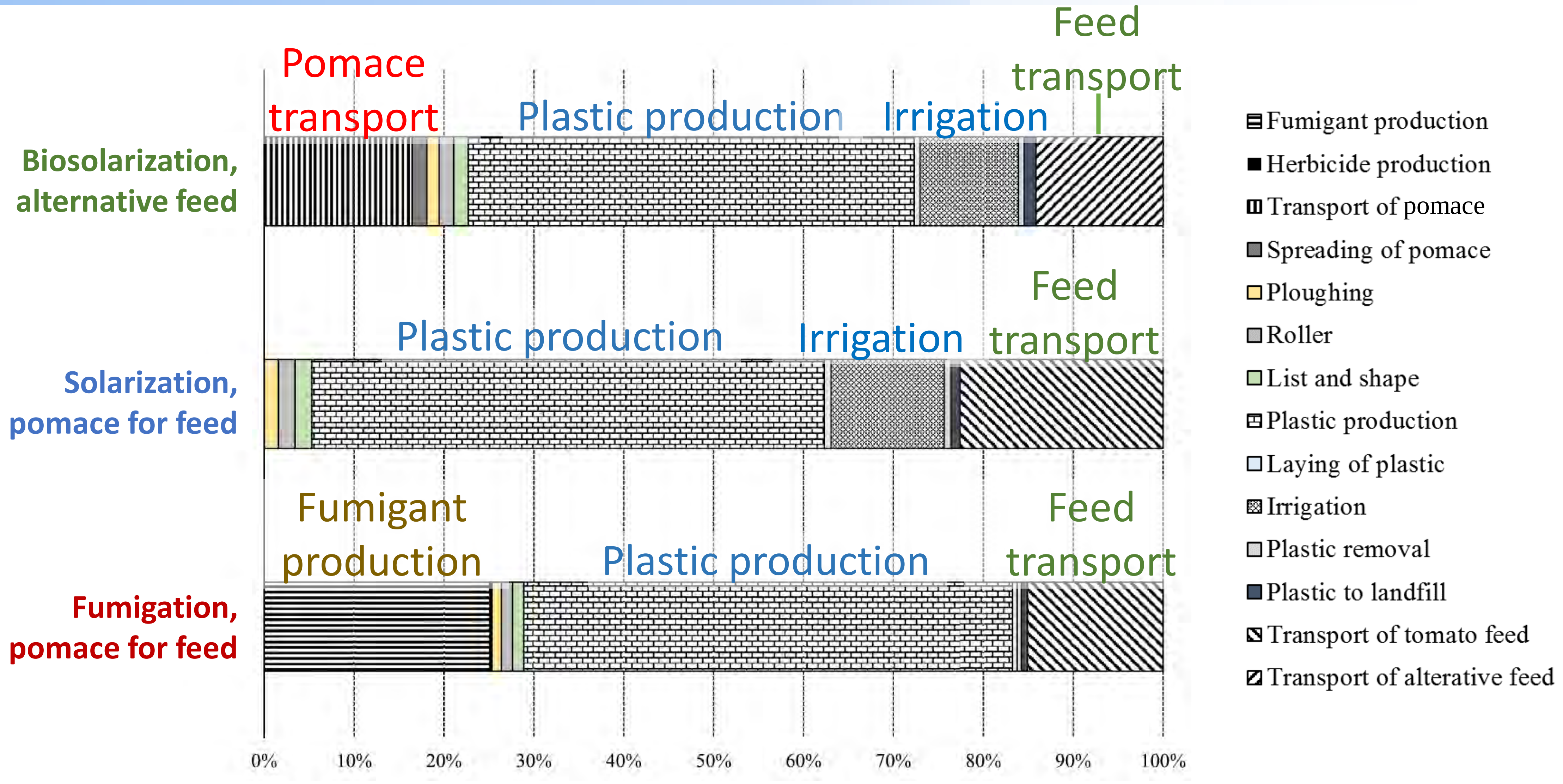
Biosolarization Life Cycle Assessment

Impact Assessment – Contributions to global warming potential



Biosolarization Life Cycle Assessment

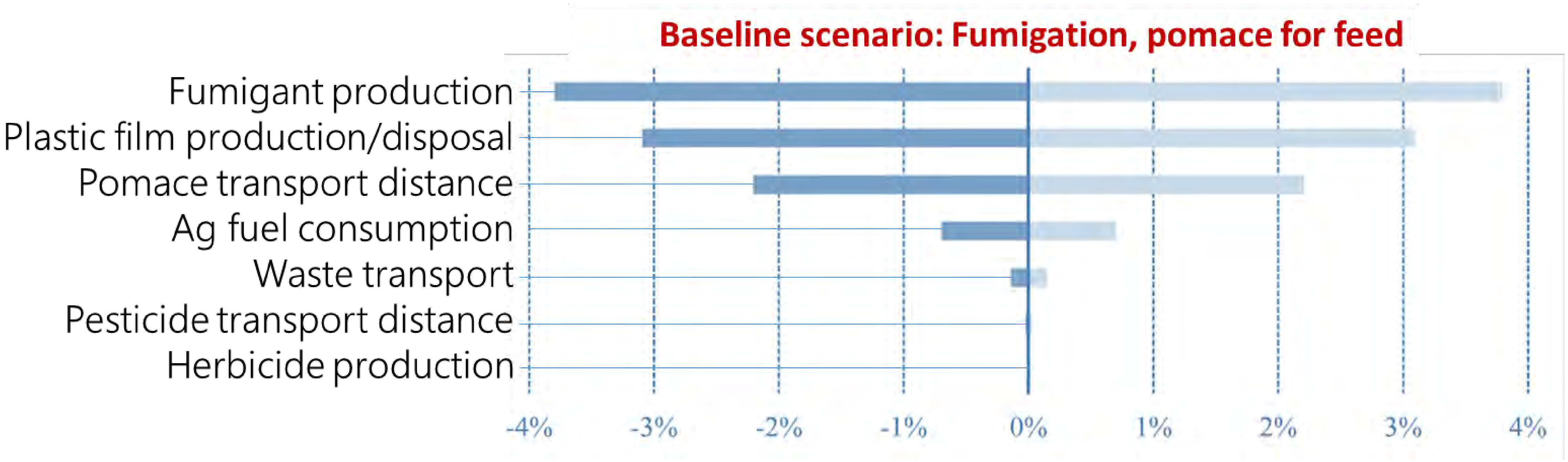
Impact Assessment – Contributions to primary energy demand



Biosolarization Life Cycle Assessment

Impact Assessment – Global warming potential sensitivity analysis

Variables adjusted +/- 10% of original value



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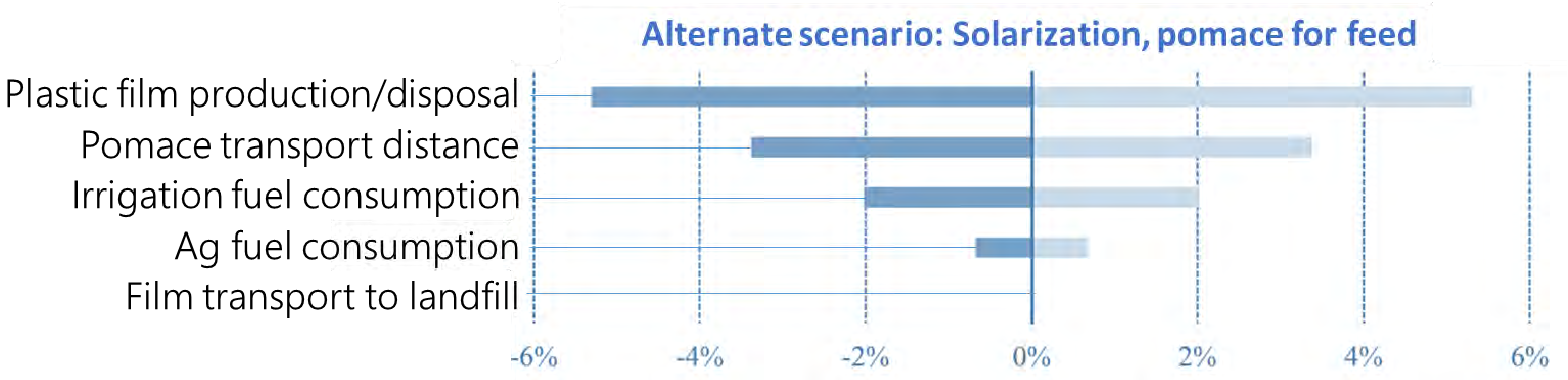

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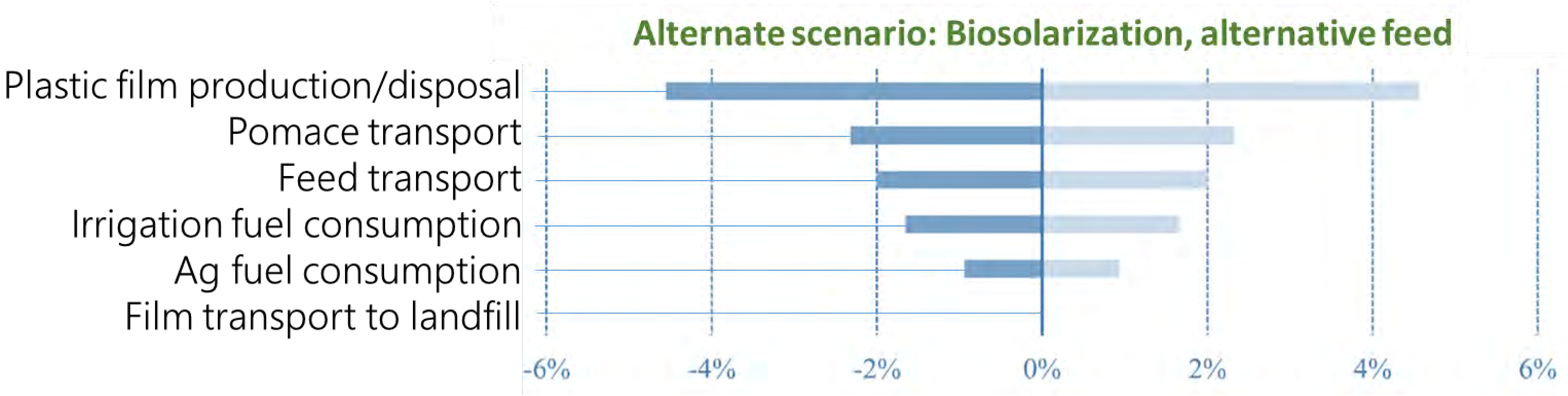

Biosolarization Life Cycle Assessment
Interpretation

- Advancements in tarp materials or production and recycling methods could reduce the GWP and PED of all scenarios examined.

- Solarization and biosolarization yield reduced environmental impact compared to fumigation by negating the impacts of fumigant production and transportation.

Biosolarization Life Cycle Assessment

Interpretation

- Solarization has lower GWP and PED than biosolarization due to fewer farm operations
- Current model does not consider differences in pest inactivation efficacy between solarization and biosolarization. Biosolarization is generally more effective.

Biosolarization Life Cycle Assessment

Interpretation

- All scenarios show a need to optimize sourcing of pomace to minimize transportation distance.

Biosolarization Life Cycle Assessment

Interpretation

Future studies should consider additional impacts:

- Water consumption and water sourcing
- Eco-toxicity
- Human toxicity and exposure risk

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ABSTRACT

The California tomato processing industry produced circa 388,856 t of tomato pomace in 2014. While currently used for animal feed, tomato pomace could be utilized for biosolarization. Primary Energy Demand (PED) and Global Warming Potential (GWP) equivalent emissions were calculated for two valorization pathways: (i) feed for cattle; and (ii) biosolarization. In order to make these two valorization pathways comparable three management options were analyzed whereby each part of the system was satisfied, i.e. a pest management sub-system and a cattle feed sub-system. The management options were (1) tomato pomace used for cattle feed and soil pest control using fumigant Telone II and herbicide glyphosate; (2) tomato pomace used for cattle feed and soil pest control using solarization; (3) alternative cattle feed (cottonseed, canola pellets and wheat straw) and soil pest control using biosolarization with tomato pomace. Options 2 and 3 result in a reduction of GWP and PED. Among management options, the GWP ranged from 64–98 kg CO_2-e and 1502–2250 MJ for PED per t of pomace. The majority of impacts were beyond the tomato processors' immediate control, therefore encouraging the diversion of tomato pomace to biosolarization may be desirable. Total savings per annum for biosolarization could be [...] M kg CO_2-e and 203,000 GJ annually.

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UNITED STATES DEPARTMENT OF ENERGY

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DIAMOND DEVELOPERS

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