

# Upcycling Overripe Pawpaw (*Asimina triloba*) Into Plant- based Meat Alternatives

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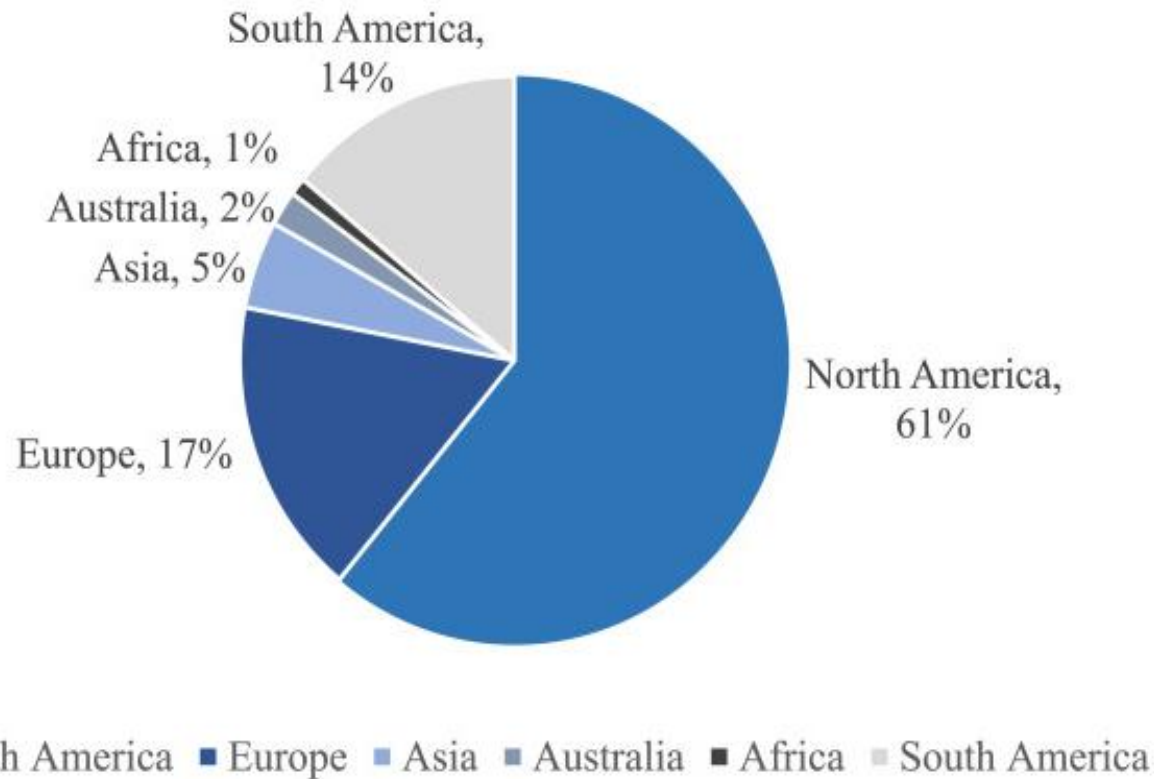


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# Market Demands and Challenges



The area distribution of second-generation plant-based meat market. Data Source: Choudhury et al. (2020)

**Demands:** Demand for PBMA is increasing due to sustainability, ethical, and health motivations.

**Challenges:** Current PBMA face persistent challenges: texture, mouthfeel, juiciness, clean-label requirements, ingredient diversity.

# PAWPAW



- Native to Eastern United States; often underutilized and highly seasonal.
- Overripe fruit is commonly discarded, though still nutritious and functional.
- Contains phenolics, flavonoids, vitamins A & C, magnesium, and potassium.
- Creamy texture can improve plant-based formulations requiring moisture retention and binding abilities.
- Strong alignment with sustainability and regional agriculture.

# RESEARCH GAP



Limited scientific research on using pawpaw as a primary PBMA ingredient.



Very few studies explore its functional roles in texture, moisture, and flavor properties within structured food matrices.



No prior research evaluating consumer acceptance of pawpaw-based patties or nuggets.



Nutritional characterization of PBMA systems incorporating pawpaw remains largely undocumented

# Research Objectives

- Evaluate preliminary sensory data for pawpaw pulp incorporation into PBMA's to assess the upcycling potential of overripe pawpaw pulp as a functional ingredient in the development of nutrient-rich and sustainable PBMA's.
- Establish preliminary formulation benchmarks of the levels of pawpaw pulp, TVP, oats, and coconut oil to optimize sensory qualities of PBMA burgers and nuggets.

# Formulation Strategy for PBMA



## Ingredient Selection

- Formulate with 20–40% pawpaw pulp
- Combine with TVP, oat fiber, coconut oil, and seasonings



## Mixing Process

- Pre-mix dry ingredients for uniformity.
- Thaw and hold overripe pawpaw pulp separately



## Forming

- Blend under optimized processing parameters.
- Shape into nuggets and patties



## Cooking Methods

- PBMA are cooked by baking followed by frying for nuggets and pan-frying for patties to improve texture and flavor.



## Storage

- Cool to room temperature for immediate sensory testing.
- Store at 4 °C (short-term) or –18 °C (long-term)

# Pawpaw Incorporated PBMA

- NUGGETS



- BURGER PATTIES



# Sensory Evaluation



## Two locations:

- Ohio Pawpaw Festival (Preliminary)
- Ohio University Campus (Ongoing)

**Consumer panel (untrained), ages 18+.**

**9-point hedonic scale used to evaluate:**

- Appearance
- Flavor
- Texture
- Overall acceptability

**Randomized sample presentation.**

# Optimization Of Burgers

## Modified Box Behnken Design

Sample	Factor 1 Pawpaw Pulp (%)	Factor 2 Texturized vegetable Protein (TVP) (%)	Factor 3 Coconut Oil (%)
1	20	5	1.5
2	20	5	3.5
3	20	7	2.5
4	30	3	1.5
5	30	3	3.5
6	30	5	2.5
7	40	3	3.5
8	40	5	1.5
9	40	7	2.5

# BURGER PATTY SENSORY DATA

## Pawpaw

(20% | 30% | 40%)

No Differences

Appearance mean = 5.8

Flavor mean = 6.4

Texture mean = 6.4

Overall Acceptability mean = 6.3

## TVP

(3% | 5% | 7%)

No Differences

Appearance mean = 5.8

Flavor mean = 6.4

Texture mean = 6.4

Overall Acceptability mean = 6.3

## Coconut Oil

(1.5% | 2.5% | 3.5%)

No Differences

Appearance mean = 5.8

Flavor mean = 6.4

Texture mean = 6.4

Overall Acceptability mean = 6.3

**All sensory scores in the acceptable range;  
highest Pawpaw, lowest TVP and coconut oil can be used**

# Key Findings and Implications

## Burger Formulations

- **No significant sensory differences** across formulations — all variants were well-liked.
- **40% pawpaw inclusion** did not compromise acceptability.

**Implication:** High pawpaw incorporation is feasible without perceptible change.

**Strategic Insight:** This opens the door for stealth nutrition and sustainability; a win for both health and formulation flexibility.

# Optimization Of Nuggets

## Box Behnken Design

Sample	Factor 1: Pawpaw Pulp (%)	Factor 2: Ratio of TVP to Oats (%)	Factor 3: Coconut Oil (%)
1	20	5 to 2 (low to low)	2.5
2	20	10 to 4 (med to med)	1.5
3	20	10 to 4 (med to med)	3.5
4	20	15 to 6 (high to high)	2.5
5	30	5 to 2 (low to low)	1.5
6	30	5 to 2 (low to low)	3.5
7	30	10 to 4 (med to med)	2.5
8	30	10 to 4 (med to med)	2.5
9	30	10 to 4 (med to med)	2.5
10	30	15 to 6 (high to high)	1.5
11	30	15 to 6 (high to high)	3.5
12	40	5 to 2 (low to low)	2.5
13	40	10 to 4 (med to med)	1.5
14	40	10 to 4 (med to med)	3.5
15	40	15 to 6 (high to high)	2.5

# Nuggets Sensory Data: Main Effects

Ingredient	Attribute	p-value	Factors		
			20%	30%	40%
Pawpaw 20% 30% 40%	Appearance	.222	overall mean = 6.6		
	<b>Texture</b>	<b>.055</b>	<b>7.1 b</b>	<b>6.8 b</b>	<b>6.7 b</b>
	Flavor	.108	overall mean = 6.6		
	<b>Overall</b>	<b>.026</b>	<b>7.0 a</b>	<b>6.7 b</b>	<b>6.7 b</b>
TVP and Oats low   low med   med high   high			low/low	med/med	high/high
	Appearance	.374	overall mean = 6.6		
	Texture	.840	overall mean = 6.8		
	<b>Flavor</b>	<b>.031</b>	<b>6.8 a</b>	<b>6.6 ab</b>	<b>6.3 b</b>
	Overall	.319	overall mean = 6.7		
Coconut Oil 1.5% 2.5% 3.5%	Appearance	.096	overall mean = 6.6		
	Texture	.215	overall mean = 6.8		
	Flavor	.813	overall mean = 6.6		
	Overall	.641	overall mean = 6.6		

# Key Findings and Implications

## Nugget Formulations

- **20% pawpaw** scored significantly higher than 30% and 40% for **texture and overall liking**.
- **Challenge:** Higher pawpaw levels may disrupt texture - requires reformulation or binding optimization.

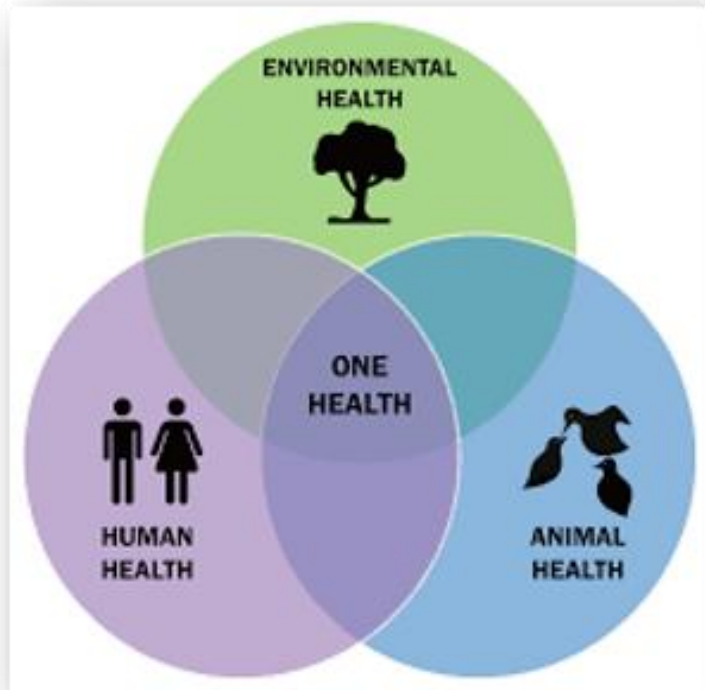
**TVP/Oats:** Lower levels yielded **better flavor** without affecting texture. Minimal TVP/Oats is sufficient for binding and enhances flavor.

**Coconut Oil:** No significant differences across levels. Use the lowest level to reduce cost and saturated fat.

# 40% Pawpaw Incorporation in Burgers & Nuggets is Possible: Strategic Relevance

- Pawpaw's unique properties support its role as a **functional ingredient** in fruit-based meat alternatives.
- Aligns with **One Health goals**, promoting human health, environmental sustainability, and ethical food innovation.
- Expands the frontier of **fruit-forward protein systems**, offering novel textures and nutritional profiles for conscious consumers.

# One Health Context



## Human Health

- Nutrient-dense pawpaw enhances dietary quality and addresses micronutrient gaps.

## Animal Health

- Reduced demand for livestock-based proteins lowers reliance on industrial animal systems and zoonotic disease exposure.

## Environmental Health

- Upcycling overripe pawpaw reduces post-harvest waste and greenhouse gas emissions.
- Plant-based proteins generally have lower land, water, and energy footprints.

## Economic Sustainability

- Adds value for local growers and supports circular food systems by redirecting “waste fruit” into novel products.

# Thank you!

Pawpaw-powered possibilities are just beginning.

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