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Sustainability in the Pet Food Industry: Turning Waste into Premium Pet Food Ingredients

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What are Potential Wastes?

Rice Husk and Straw:

High in fiber, these can aid in digestion and serve as a filler in pet food formulations

Sugarcane Bagasse:

Rich in organic matter, it can improve soil health and potentially be processed into pet food ingredients.

Cassava Waste:

Including peels and pulp, these are rich in carbohydrates and can be used as energy sources in pet diets

What are Potential Wastes?

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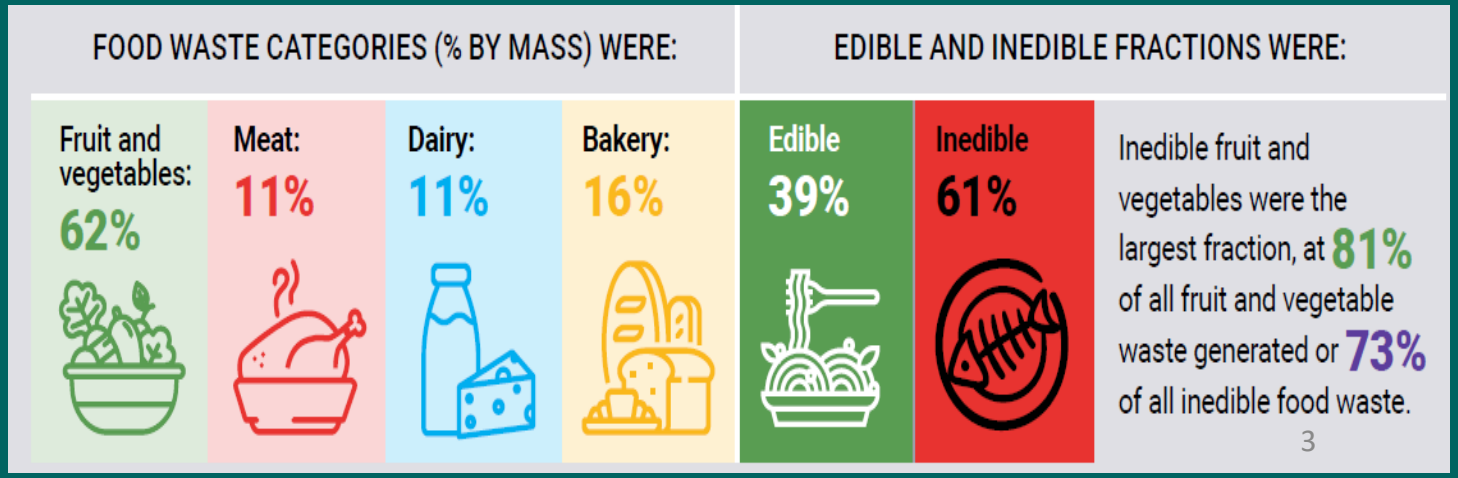
Tuna waste
Waste includes fish bones and offal. These can be processed into pet food ingredients, such as broths or meals, enhancing protein content and palatability.

Okara (Soy Pulp)
Okara is a byproduct of soy milk and tofu production. Rich in protein and fiber, it is commonly used as animal feed and has potential as an ingredient in pet food.



What are Potential Wastes?

Waste	Source	Benefits
Dried poultry/pig blood	Sourced from slaughterhouses	Very high in protein (>80%), highly palatable
Ground bones / rendered fat	By-product of meat cutting	Good source of calcium and energy
Liver, heart, lungs (organ meat)	Edible organs not used for human food	Rich in vitamin B12, iron, and minerals
Fish heads and bones	From fish processing plants	High in protein, calcium, and omega-3
Ground shrimp shells and heads	From shrimp processing	Source of collagen and chitin (immune-boosting)
Fermented cassava pulp	By-product from tapioca industry	High energy content (must ensure cyanide safety)
Rice bran, broken rice	From rice milling	High in energy, fiber, Vitamin-B
Soybean/green pea/pigeon pea meal	After oil extraction or food processing	Excellent plant-based protein
Brewer's spent grain	From beer production (malted barley residues)	High in protein and fiber; suitable for dogs
Stale bread / rejected biscuits	Bakery waste	Good energy source after drying and processing
Carrot/apple/pumpkin pomace	From juice or food factories	High in fiber, beta-carotene, prebiotics

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OBJECTIVE

- To encourage the transformation of waste into pet food for sustainability

Pet owners are interested in sustainable pet food, driven by growing awareness of environmental issues.

37% of Thai pet owners are trying to give their pet a diet that is better for the environment (eg. plant-based).

Transforming Waste into Opportunity

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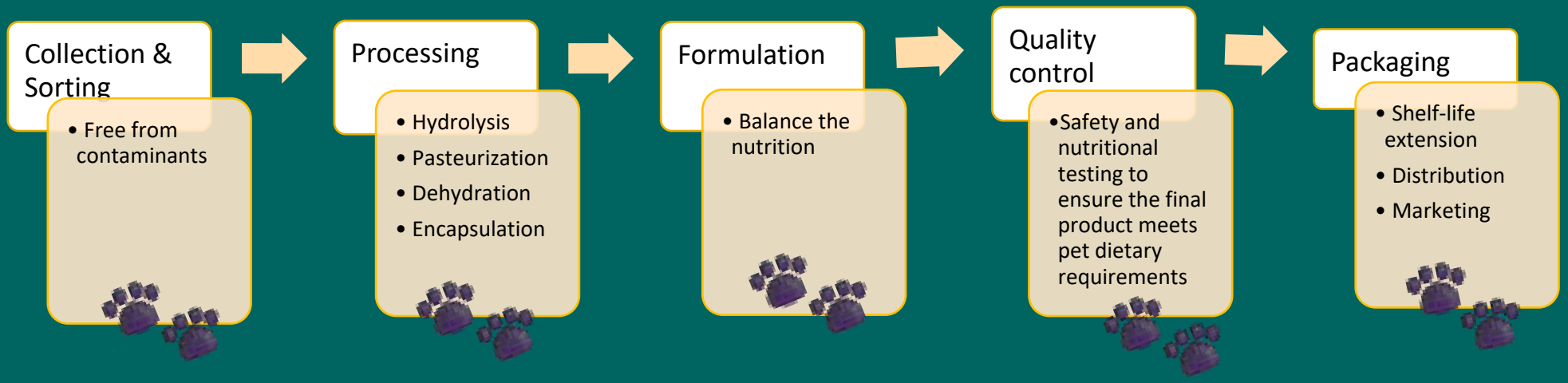
Steps in the Conversion Process



Sustainability has been defined as….

"Ability to produce pet food in adequate amounts while providing sufficient essential nutrients required to maintain optimum health and viability now and in the future, with the smallest environmental footprint."

Pasteurization/ Sterilization

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Thermal processing for microbial inhibition and preventing contamination

Pasteurization

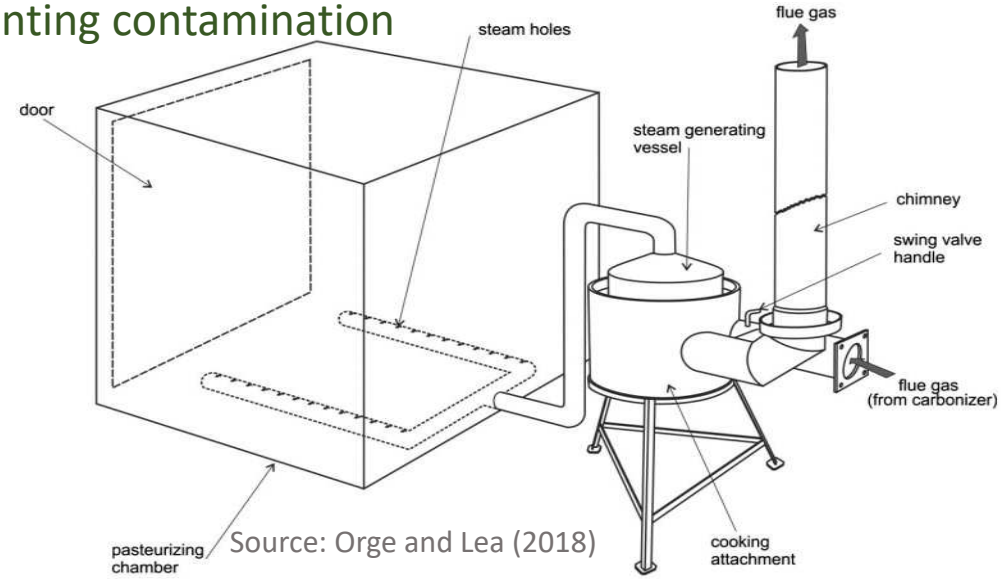
Temperature not more than 100^0C

- Hot water
- Steam
- Hot air

Sterilization

Temperature above 100^0C

- Hot water
- Steam
- Combination



Source: Orge and Lea (2018)

Table 1
Thermal inhibition of microorganisms in eggshell.

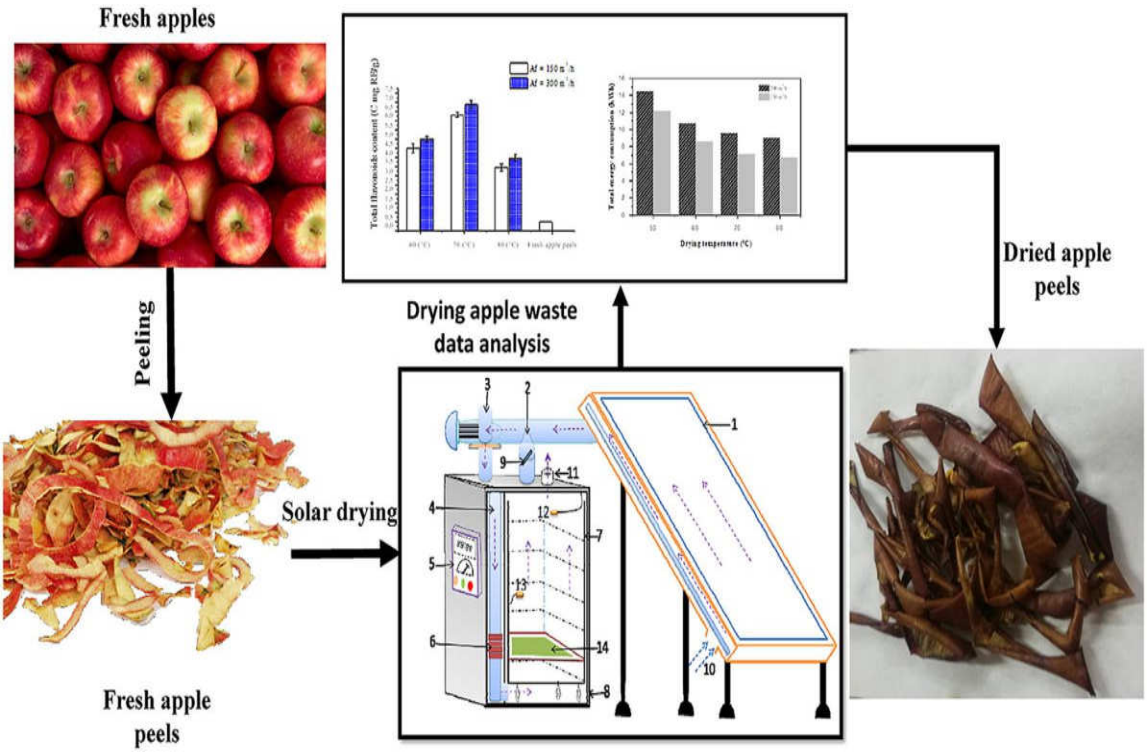
Eggshell sample	Total plate count (CFU/g)	Yeast and mold (CFU/g)	*Salmonella* sp. (per 25 g)	*Escherichia coli* (MPN/g)
Fresh	$3.3 \pm 0.2 \times 10^7$	$2.5 \pm 0.3 \times 10^3$	Detected	1100
Sterilized at 121 °C for 15 min	<10 est.	<10 est.	Not detected	<3
Pasteurized at 95 °C for 15 min	90 est.	<10 est.	Not detected	<3
Pasteurized at 95 °C for 30 min	20 est.	<10 est.	Not detected	<3
Pasteurized at 95 °C for 45 min	10 est.	<10 est.	Not detected	<3
Pasteurized at 95 °C for 60 min	<10 est.	<10 est.	Not detected	<3

Note: est. = estimated, because the number of microbial counts was less than 25 CFU per plate for each dilution.

Source: Therdthai et al. (2023)

Drying

Drying for water removal and extending the shelf life



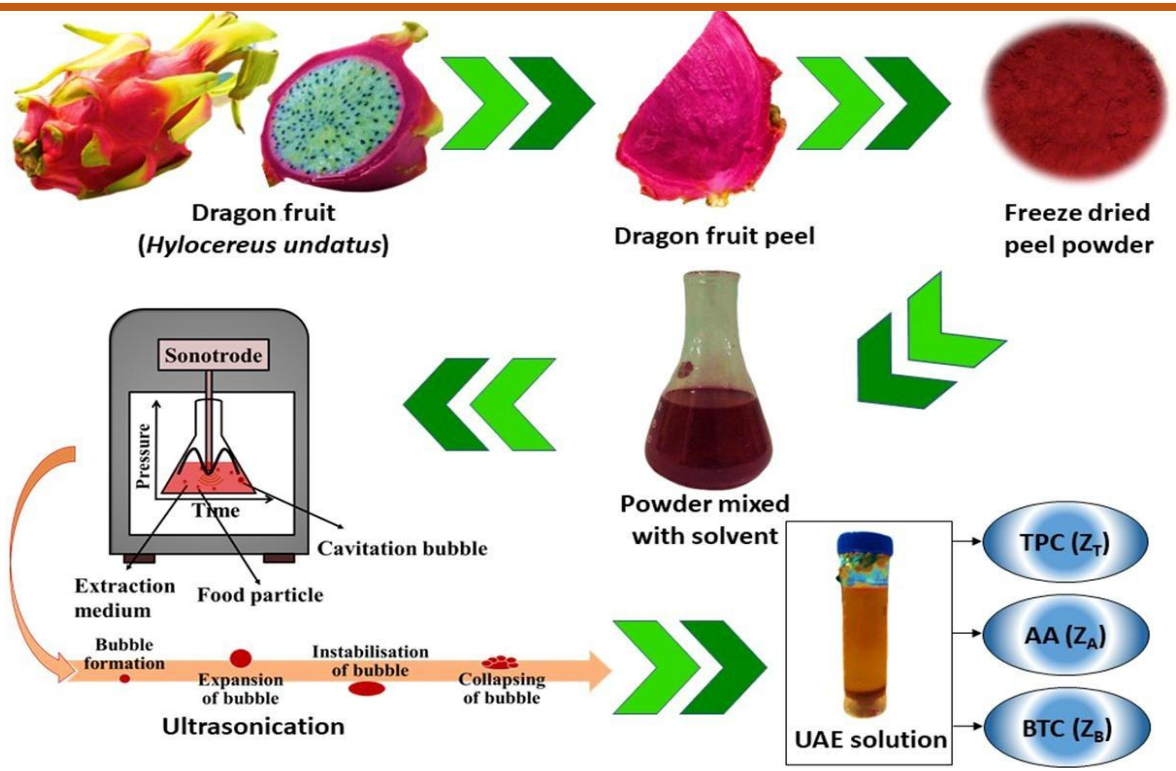
- Sun drying
- Solar drying
- Vacuum drying
- Hot air drying
- Drum drying
- Spray drying
- Fluidized bed drying
- Freeze drying

Source: Moussaoui et al. (2021)

Extraction

Extraction for bio-active compounds

Maceration | Supercritical CO2 extraction | Ultrasonic extraction | Microwave extraction



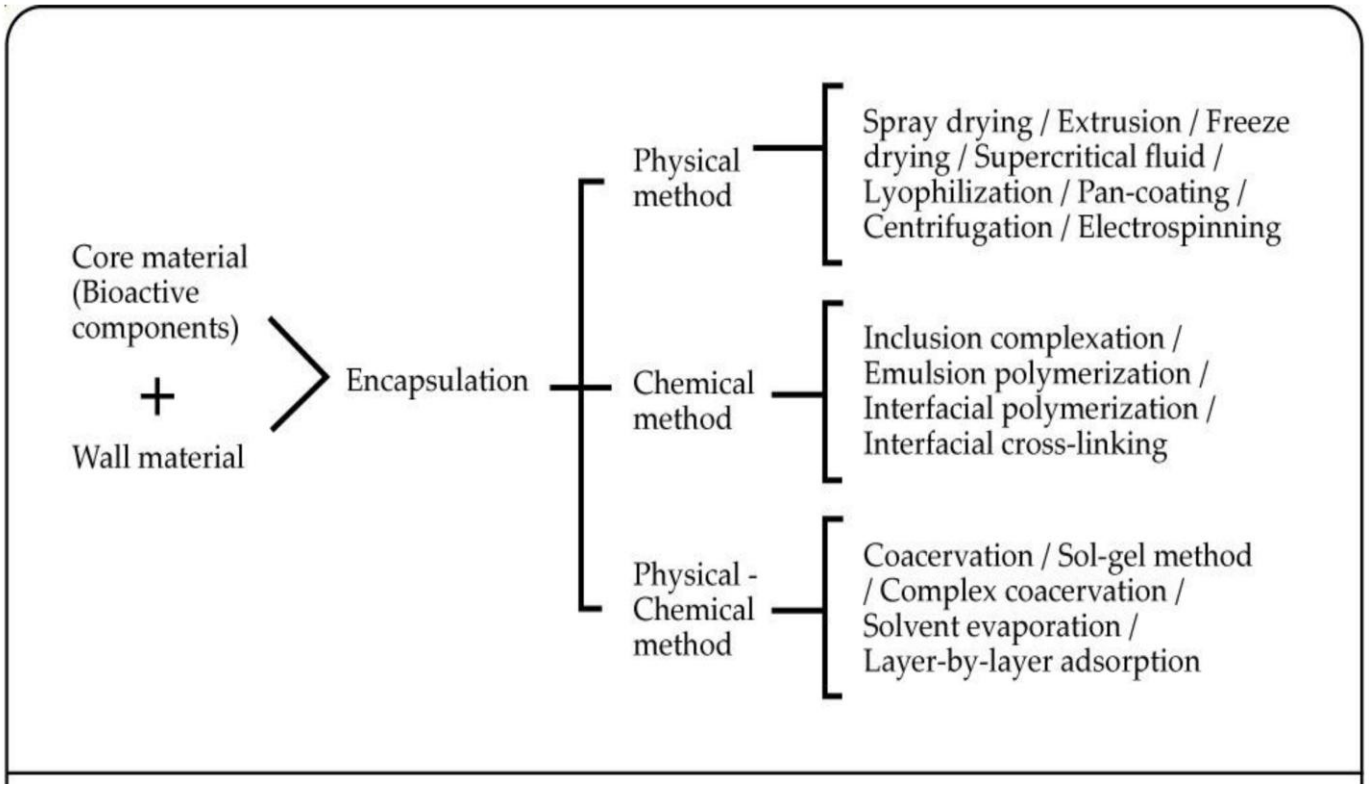
Source: Bhagya Raja and Dash (2020)

Bio-activity

- Anti-oxidant
- Anti-inflammation
- Anti-microbial

Encapsulation

Encapsulation for protection and controlling the release



Source: Zabot et al. (2022)

https://www.greenagribio.com/news/pet-food-ingredient-supplier-wet-dry-nutrition-solutions.html

Hydrolysis

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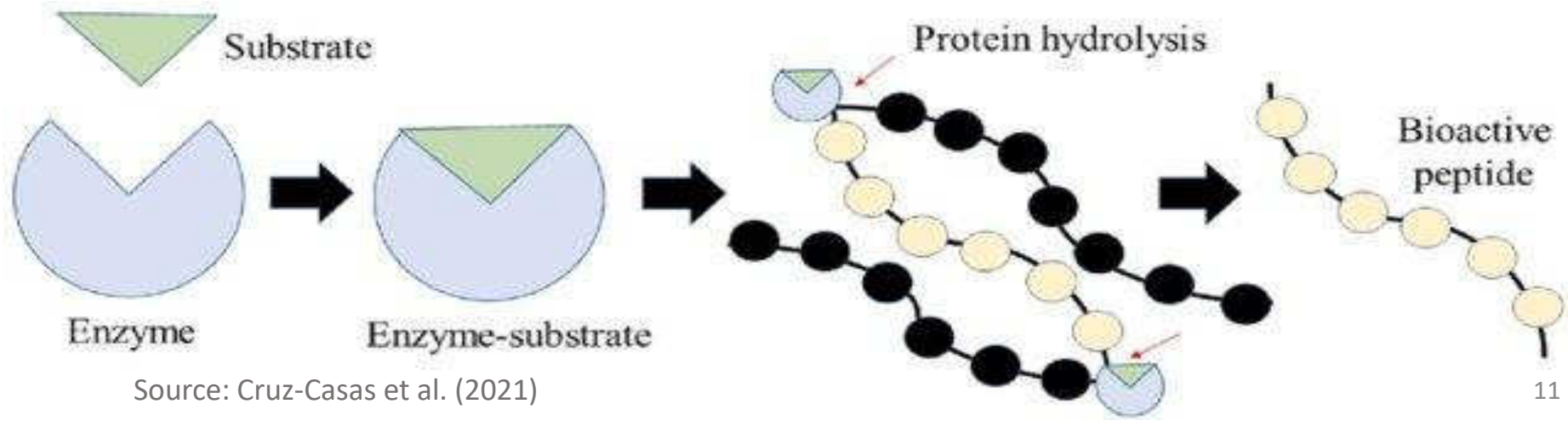
Hydrolysis for improving the functional, nutritional, and physiological properties

Limited hydrolysis	Intermediate hydrolysis	Extensive hydrolysis
• Hydrolysate with functional properties such as gelling, emulsion, foaming capacity, and stability.	• Hydrolysate with organoleptic properties such as flavoring, texturing agents.	• Bio-active compounds with unique physiological properties for supplement.



Source: Cruz-Casas et al. (2021)

Innovations in Pet Food

The majority of granted patents relating to pet food innovation are from South Korea, China, and the US.

Despite economic pressures and rising prices, 32% US pet owners are highly interested in treats or toppers that promise functional health benefits.

Innovations in Sustainability

- Claim for “Environment”

Source: Sparacino et al. (2025)

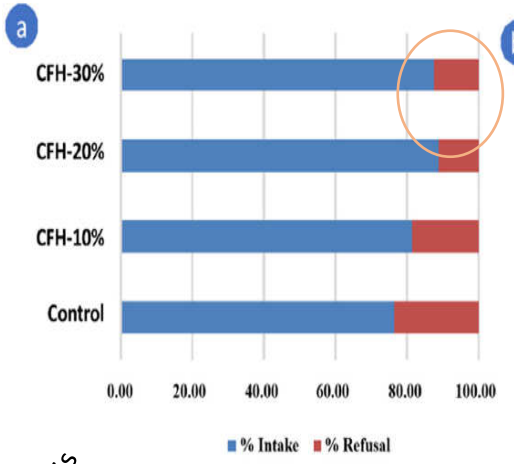
Superior code	ID	Sub-code	Description of sustainability Sub-code
Environment	18	Reducing ingredient footprints	Use of local products or ingredients with low footprints, short supply chains or from Km 0 sources.
	1	Water saving	Water conservation, making irrigation systems efficient, improving water stewarding and water quality with a focus on preserving water resources.
	9	Energy efficiency	Optimising energy usage. Preference for renewable energy sources vs fossil fuels.
	3	Reducing missions	Everything related to CO_2 emissions. Reductions in pollutant emissions as a future goal or in the short term.
	2	Soil preservation	Measures to protect soils, cropping systems that respect the life-forms present in the soil and the need for rest periods from cultivation to allow for soil restoration.
	10	Minimizing waste	Reducing waste in the supply chain, reducing the use of packaging materials.
	7	Recycling systems	The use of recycling systems in either the packaging or the production phase.
	5	Packaging	The sustainability of packaging materials and the use of organic or sustainable materials.
	19	Organic product lines	Organic product lines, organic brands, raw materials from organic farming.
	15	Low chemical use	Reduction of chemicals and pesticides.

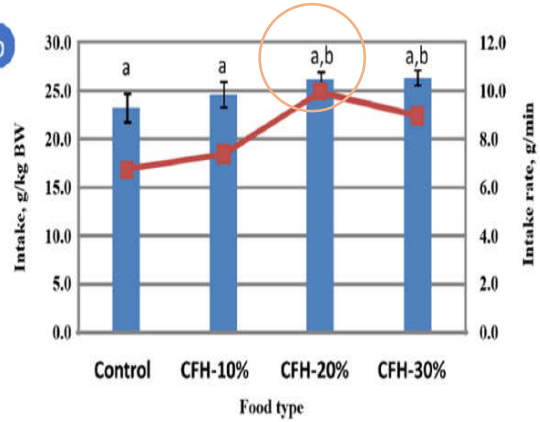
Innovations in Sustainability

Chicken feather

7 % body weight

50,000 chickens/ day = 2-3 tons of feathers/day





Broiler chickens → Cleaning → Drying → Grinding → Sterilization at 121°C 15 min → Enzymatic Hydrolysis (Papain) at pH 6.5, 55°C 120 min → Heating at 95°C 5 min → Isoelectric precipitation, HCL at pH 4.0 → Centrifugation at 4500g → Drying at 60 °C 24h

One bowl test with Labrador dogs (2 - 4 Y)

Addition in pet food

Source: Faslu Rahman et al. (2024)

Innovations in Sustainability

Table 3

Physicochemical characteristics and proximate composition of control and standardised pet foods, standard recommendations of pet food for adult maintenance.

Parameter	Control	CFH-20	NRC	AAFCO
Moisture (%)	4.71±0.18[a]	4.70±0.15[a]	6–10	
Dry matter (%)	95.39±0.18[a]	95.40±0.15[a]	90–94	
Crude Protein (%)	20.07±0.18[a]	21.09±0.22[b]	16–30	18
Crude Fat (%)	7.60±0.14[a]	8.01±0.20[b]	7–20	5.5
Ash (%)	5.07±0.14[a]	5.00±0.07[a]		
Crude fibre (%)	3.71±0.10[a]	3.87±0.15[a]		
NFE (%)	58.60±0.26[a]	57.31±0.29[b]		
Total carbohydrate (%)	47.96	44.80	41–70	
GE (Kcal/kg)	4426.8 ±0.51[a]	4464.1 ±1.04[b]	2800–4050[#]	
Calcium (%)	1.67±0.05[a]	1.63±0.05[a]		0.5
Phosphorus (%)	1.31±0.01[a]	1.29±0.01[a]		0.4
Ca:P	1.29:1	1.24:1		1:1–1:2

NFE- Nitrogen Free Extract, GE - Gross Energy, CFH-20 – Selected pet food containing 20 % protein replaced by feather hydrolysate, NRC- National Research Council recommendations on adult dog food, AAFCO- Association of American Feed Control Officials recommendations on adult dog food. [#]Metabolisable energy.

Source: Faslu Rahman et al. (2024)

Two bowls test with Labrador dogs (2 - 4 Y)

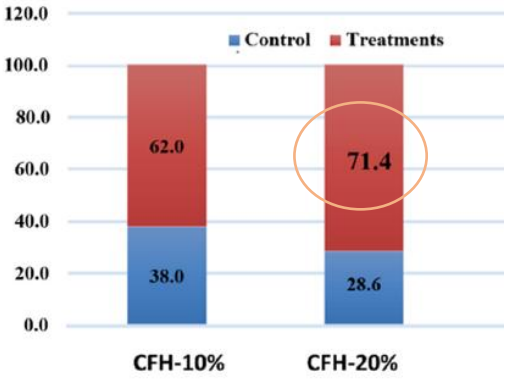


Table 4

Water activity, Instrumental colour analysis, cooking yield, and spoilage indices of control and selected pet foods.

Parameter	Control	20 % CFH- Pet food
a_w (Water Activity)	0.52±0.01[a]	0.50±0.01[a]
L*	24.64±0.62[a]	24.01±0.52[a]
a*	5.96±0.19[a]	5.56±0.16[a]
b*	9.03±0.19[a]	7.33±0.18[b]
Cooking Yield (%)	91.32±0.17[a]	92.54±0.26[b]
Free Fatty Acids (% oleic acid)	0.35±0.01[a]	0.30±0.01[b]
TBARS (mg Melonaldehyde/kg)	0.69±0.07[a]	0.80±0.48[a]
Tyrosine Value (mg/100 g)	8.14±1.0[a]	10.37±0.16[b]

Mean±S.E with different superscripts in the same row differ significantly ($p<0.05$), a_w- Water activity, L*- Lightness, a*- redness, b*- yellowness TBARS- Thiobarbituric acid reactive substances. [a, b] mean values within column with different superscripts are significantly different ($P<0.05$).

Innovations in Sustainability

Bread crumb
12.1% protein
64.6% carbohydrates

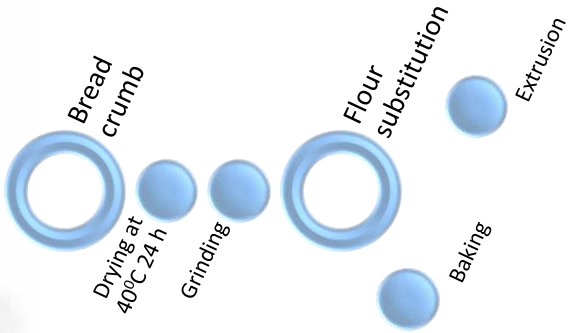
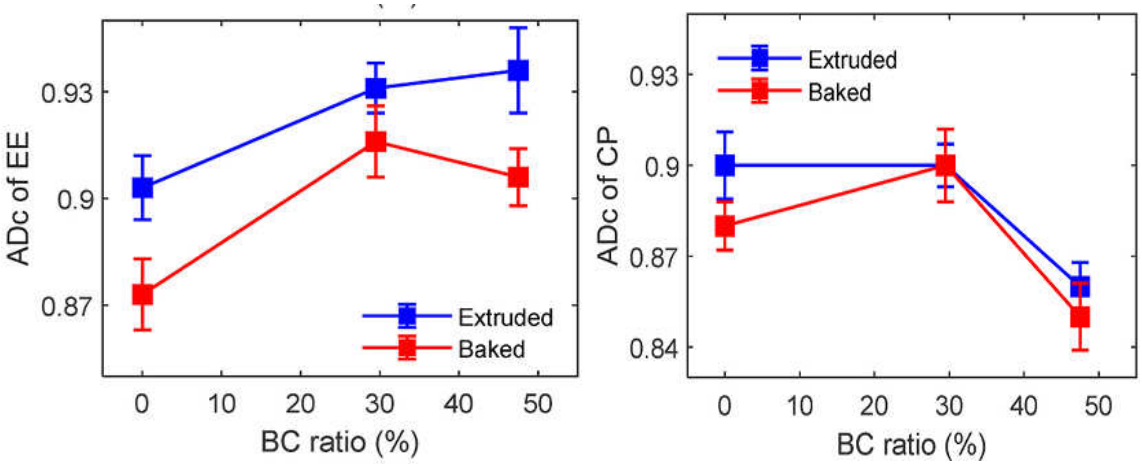


Table 1
Ingredients of the experimental diets.

Ingredients g/100 g	F1	F2	F3
Rice	21.5	12.0	10.0
Maize	21.0	12.0	6.0
wheat	21.0	11.0	0.0
BC	0.0	29.5	47.5
Beet pulp	3.0	4.0	5.0
Poultry meal	22.0	22.0	22.0
Poultry fat	4.0	4.0	4.0
CGM	5.0	3.0	3.0
Calcium Carbonate	0.8	0.8	0.8
Potassium Chloride	0.4	0.4	0.4
Sodium Chloride	0.4	0.4	0.4
Dicalcium Phosphate	0.9	0.9	0.9
GE (MJ/kg) as tested	19.1	19.4	19.6

Abbreviations: F1, F2, F3: diet formulations, BC: Bread crumps obtained from regular white bread, CGM: Corn gluten meal, GE: Gross energy.

Source: Mevliyaogulları et al. (2023)



Apparent digestibility coefficients (ADc) of extruded (20% feed moisture) and baked (40% feed moisture) products with varying BC ratios.

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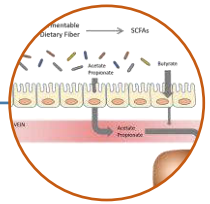
25–30 % of carrot residues are generated during Processing.

Pectin-rich fiber source: Enhances digestive health



Increase fecal short-chain fatty acids, particularly acetate. A crucial role in gut health and metabolic regulation.

High carotenoid content in carrots provides antioxidant properties. Contribution to immune system support and well-being

2.74 g/100 g for total fiber
3.68 mg/100 g for carotenoid content

Pasteurization at 60^{0}C °C for 15 min

Carrot bagasse 60%

Water 20%

Gelatine 20%

Carrot gummies

68% dog acceptance (n=90)

91% dog acceptance (n=90)

Pasteurization at 60^{0}C °C for 15 min

Carrot bagasse 70%

Water 23.5%

Cornstarch 6.5%

Carrot sauce

Carotenes 6.66 mg/L of sauce

Source: Londono Valencia et al. (2025)

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Raw Materials from Food Waste:
Eggshells

"BiskyBone"

Ca-fortified Dog Biscuits with Eggshells

Associate Professor Nantawan Therdthai and Assistant Professor Aussama Soontrunnarudrungsri

Department of Product Development, Faculty of Agro-Industry, Kasetsart University

This pet treat contains:

- High protein
- High calcium
- Good balance of Ca:P
- Natural calcium from eggshells
- Ideal for dogs especially small breeds

วช. NRCT

TRL4

References:

- Therdthai, N., Soontrunnarudrungsri, A. and Khotchai, W. 2023. Modified eggshell powder using thermal treatment and its application in Ca-fortified dog biscuits. Heliyon. e13093. https://doi.org/10.1016/j.heliyon.2023.e13093
- นันทวัน เทอดไทย, อุศมา สุนทรนฤรังสี และ วลัยลักษณ์ โคตรชัย. 2566. ผลิตภัณฑ์บิสกิตโปรตีนสูงเสริมแคลเซียมสำหรับสุนัข อนุสิทธิบัตร เลขที่คำขอ 2303003181
- โครงการวิจัย ระบบการดัดแปลงเปลือกไข่จากโรงฟักไข่แบบครบวงจร เพื่อลดปริมาณขยะภาคการเกษตร และการสร้างมูลค่าสินค้าเกษตรและอุตสาหกรรมเกษตร โดยการสนับสนุนจาก สำนักงานการวิจัยแห่งชาติ (วช) ประจำปีงบประมาณ 2564

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Commercial products

Nutrition Facts	
Per 100.00g	
Crude Protein ≥ 13.50 %	
Crude Fat ≥ 8.50 %	
Crude Fibre ≤ 6.00 %	
Crude Ash ≤ 8.50 %	
Moisture ≤ 32.00 %	
Energy (kcal) 330.00 kcal	

Ingredients On Pack Standard form
seafood (tuna, fish meal), breadcrumbs, wheat flour, other sugars, vegetable oil, silvervine powder (gall fruit), seasoning, glycerin, dietary fibre (cellulose), sorbitol, minerals (sodium), preservative (sorbic acid, sodium dehydroacetate), sodium polyphosphate, taurine

Nutrition Facts	
Per 1.00kg	
Crude Protein Min 26.00 %	
Crude Fat Min 10.00 %	
Crude Fiber Max 8.00 %	
Moisture Max 10.00 %	
Linoleic Acid Min 1.30 %	
Calcium Min 1.20 %	
Phosphorus Min 1.00 %	
Potassium Min 0.60 %	
Manganese Min 15.00 mg	
Zinc Min 150.00 mg	
Selenium Min 0.35 mg	
Vitamin A Min 5000.00 IU/UI	
Vitamin D Min 500.00 IU/UI	
Vitamin E Min 100.00 IU/UI	
Niacin Min 15.00 mg	
Omega-6 Fatty Acids Min 1.40 %	
Omega-3 Fatty Acids Min 0.20 %	
Metabolizable Energy... 3189.00 kc	

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Claim: Plant Based + Banana Low-Fat Dog Jerky Treats

Upcycled ingredients

Claim: Fiber-rich for digestion support

Upcycled Beet, Sunflower meal

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Claim: 100% Natural

Natural chews are made from animal parts that would normally go to waste, and upcycling these parts as treats for pets.

Thin Sliced Beef Tongue for Dog

Nutrition Facts	
Per 100.00g	
Crude Proteins ≥ 44.00 %	
Crude Fat ≥ 12.00 %	
Crude Fibre ≤ 1.00 %	
Crude Ashes ≤ 4.00 %	
Moisture ≤ 25.00 %	
Energy (kcal) 410.00 kcal	

Thin Sliced Chicken Cockscomb for Dog

Nutrition Facts	
Per 100.00g	
Crude Protein ≥ 50.00 %	
Crude Fat ≥ 13.50 %	
Crude Fibre ≤ 2.00 %	
Crude Ashes ≤ 4.00 %	
Moisture ≤ 25.00 %	
Energy (kcal) 410.00 kcal	

Pig's Ears

Nutrition Facts	
Per Serving	
Crude Protein 65.10 %	
Fat 22.40 %	

Cow's Pizzles

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Personal Care Products

100% all natural and made from the rice husk, an agricultural byproduct, that is usually burned as a waste generating air pollution

100% all natural and made from biodegradable cassava

100% recycled paper
40% transport emissions reduction

Made from 95% post-consumer recycled (PCR) paper

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Personal Care Products

Made of 65% post-consumer recycled (PCR) plastics, giving a second life to more than 2.2 million kilograms of waste plastic every year.

The dispenser is made from wheat straw.

Poo bag is made from 100% corn starch

Benefits of Upcycled Ingredients

- Reduction in waste and emissions of CO_2
- Adopt sustainable and alternative ingredients
- Appeal to environmentally conscious
- Economic efficiency for manufacturers

Economic efficiency for manufacturers

- Cost breakdown of pet food

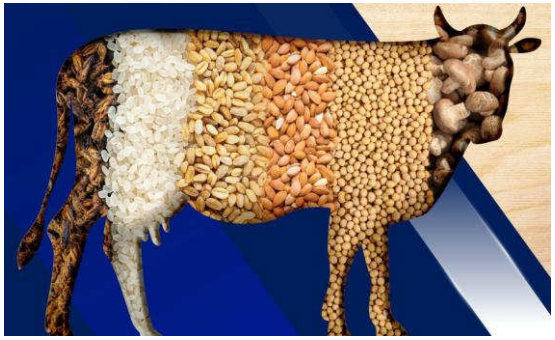
Ingredient Type	Average Cost per Ton (USD)
Chicken Meal	$1,200
Fish Meal	$1,500
Organic Meat	$2,500
Specialty Additives	$5,000
Standard Grains	$300–$400
Vegetables & Carbohydrates	$800–$1,600

Protein content significantly influences the retail price of pet food.

Wet foods, which often contain higher amounts of animal-based proteins, are more expensive than dry kibble.

Utilizing animal by-products like chicken liver and pork bones can be an economical way to provide essential nutrients. Cooking these ingredients ensures safety and digestibility for pets.

Economic efficiency for manufacturers



- Protein sources

Protein Source	Approximate Cost (per kg)
Fish Meal (65% Protein)	$0.45–$0.50
Poultry By-Product Meal	$1.00–$1.50
Beef Meal	$1.50–$2.50
Lamb Meal	$2.00–$3.00
Pork Meal	$1.80–$2.80
Soy Protein Concentrate	$1.00–$1.50
Corn Gluten Meal	$0.32
Pea Protein	$2.00–$3.00
Rice Protein	$2.50–$4.00
Hemp Protein	$3.00–$5.00
Cultivated Meat (Mouse)	$4.40–$5.50
Single-Cell Proteins (SCPs)	High

Economic efficiency for manufacturers

Protein Source	Digestibility	Nutritional Value
Animal-Based	High	Rich in essential nutrients
Plant-Based	Moderate	Lower in certain nutrients
Novel Proteins	Emerging	Variable; potential for fortification

Sustainability in Packaging

During the past two decades, sustainability and sustainable packaging have continually shifted course.

- Circularity
- Recyclability
- Recycled content
- Mono-materials
- LCA (Life Cycle Analysis)
- ESG (Environment, Social, and Governance)
- EPR (Extended Producer Responsibility)
- SDG (Sustainable Development Goals)
- Total carbon footprint measurement

Packaging in any format, with any material, must be responsible for the environment throughout its lifecycle.

In Thailand, younger consumers prefer packaging that is visually appealing and tells a story about the brand.

In terms of economic consideration, packaging that offers additional value, such as durability or multipurpose use, is appealing to consumers who are cautious with their spending.

Source: https://www.gnpd.com/

Sustainability in Packaging

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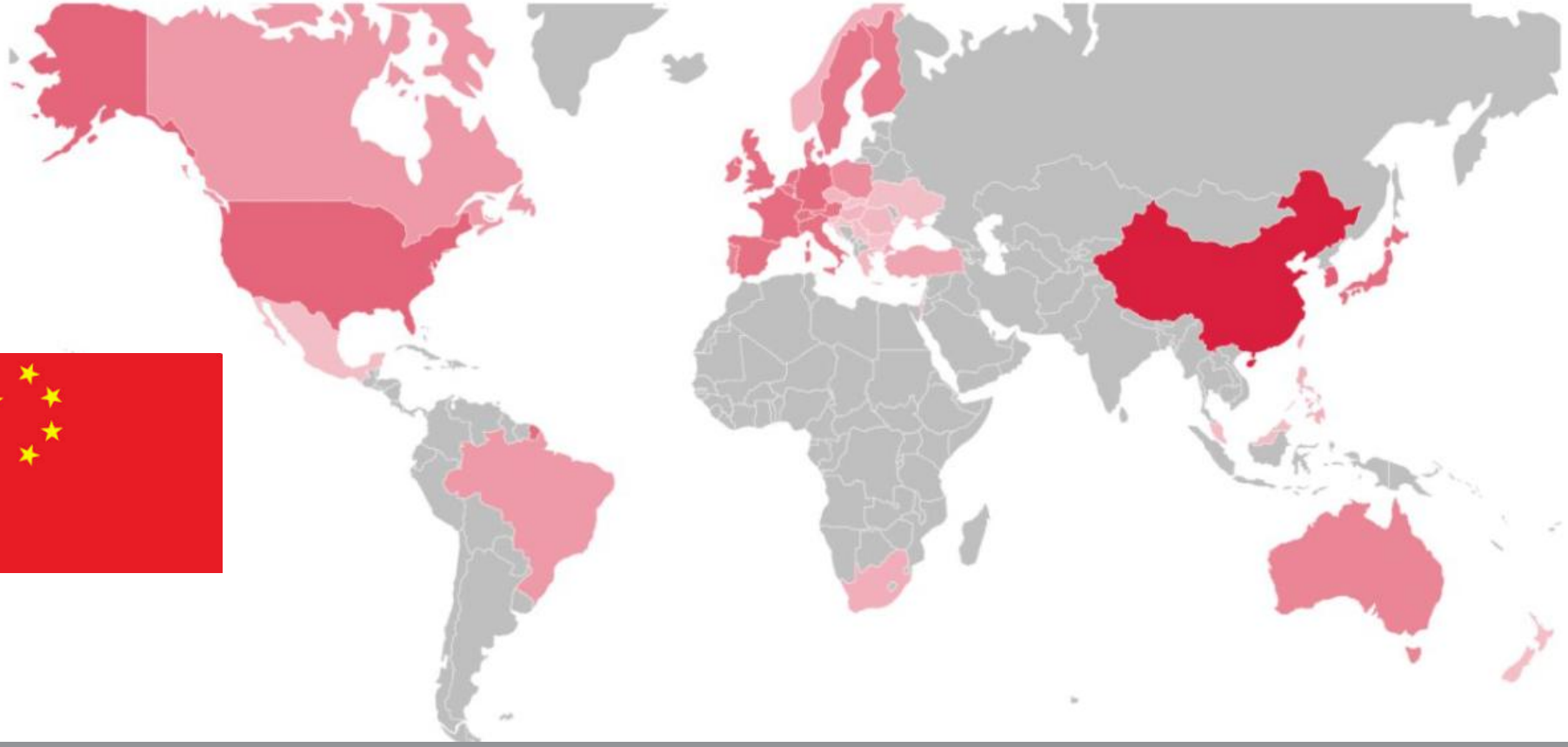
China leads granted patents relating to eco-friendly* packaging

The leading countries for granted patents are China (with 29% of all global patent grants), South Korea (9%), the US (7%), Germany (5%) and France (5%).



Source: https://www.gnpd.com/

Sustainability in Packaging

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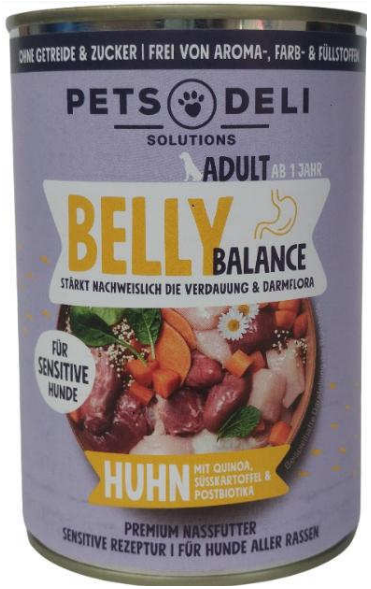
Recyclability/ Composability / Reduction



100% recyclable

100% recyclable

Use less energy to recycle VS a can

80% lower global warming potential VS a can

Eliminate plastic and now use a recyclable cardboard packaging

Sustainability in Packaging

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Composability / Reduction/ Recyclability

The package is produced from sugarcane, a raw material of renewable source that collaborates to reduce of emission of greenhouse gases.

Packaging made of 60% less plastic

Mono-material pouches with reduced carbon footprint compared to the multi-layer packaging

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Challenges

- Safety concerns:
  - Screening the food waste is important to exclude food waste that can be toxic to pets.
  - Contamination of pathogen
  - Contamination of heavy metals

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Challenges

- Safety concerns:
  - Processing Standards: Pet food must be produced under sanitary conditions, with appropriate processing to inactivate
  - Safety and quality testing is necessary to ensure that the food waste-derived ingredients are safe for animal consumption and meet the required nutritional standards.

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Challenges

- Pet food labels must be truthful and not misleading, with specific requirements for certain ingredients.
- Public perception of "by-products" and "waste.“

The Association of American Feed Control Officials (AAFCO) defines by-products as

“Secondary products produced in addition to the principal product”

- Communication has become a powerful tool to demonstrate a company’s commitment to sustainability issues and provide added value to all stakeholders.

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Challenges

Economic uncertainty/ Inflationary environment

- Economic uncertainty, coupled with rising pet food prices, has led many pet owners to opt for budget-friendly brands that may compromise on nutrition.
- 42% of US pet owners have considered switching to a lower-priced pet food brand to save money, while 65% are interested in finding ways to reduce pet care spending to save money.
- 65% of Canadian pet owners agree that the price of pet food has an impact on their choice of pet food and treats.
- Only 29% of Thai pet owners usually choose the more-expensive pet food product for its value (eg added benefits, high quality).

Compliance for Utilizing Food Waste in Pet Food Production

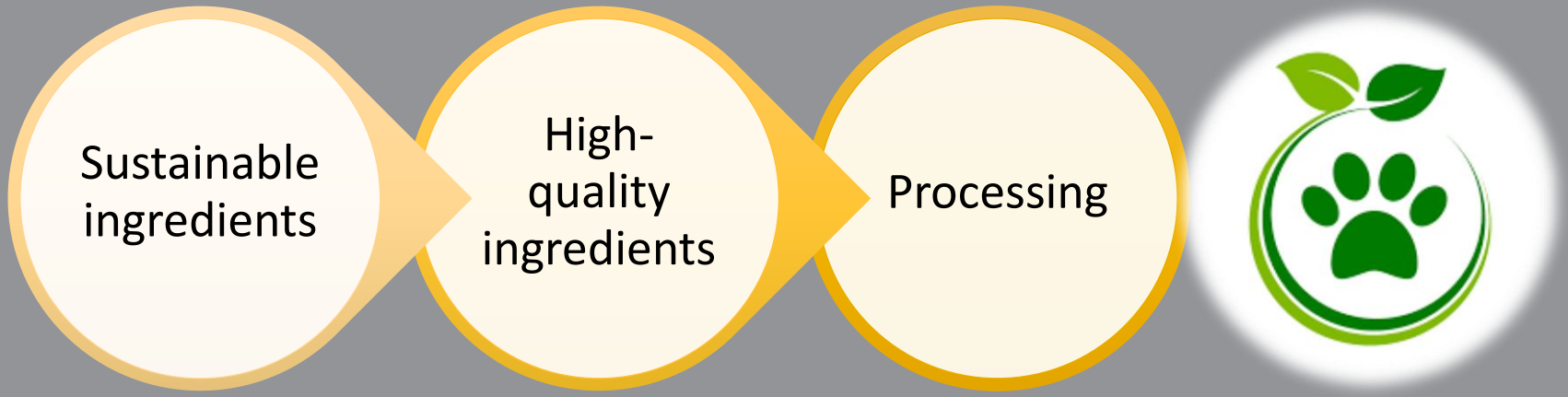
- พระราชบัญญัติอาหารสัตว์ พ.ศ. 2558 กรมปศุสัตว์ **https://legal.dld.go.th/P152.html**
- ประกาศกระทรวงเกษตรและสหกรณ์ เรื่องกำหนดวัตถุหรือวัตถุดิบที่ใช้ผสมอาหารสัตว์ควบคุม พ.ศ. 2560
- ประกาศกระทรวงเกษตรและสหกรณ์ เรื่องมาตรฐานอาหารสัตว์ควบคุมกำหนดรายละเอียดคุณภาพ
- มาตรฐานผลิตภัณฑ์อุตสาหกรรม (มอก.) อาหารสัตว์เลี้ยง
- มาตรฐานวัตถุดิบอาหารสัตว์
- **GMP/HACCP** สำหรับโรงงานผลิตอาหารสัตว์รับรองโดยกรมปศุสัตว์

Compliance Steps for Utilizing Food Waste in Pet Food Production

Country	Regulation	Description
US	Food and Drug Administration (FDA) under the Federal Food, Drug, and Cosmetic Act.	Safety, sanitary conditions, and labeling
	The American Association of Feed Control Officials (AAFCO)	Guidelines on ingredient definitions and nutritional adequacy
EU	Feeding Stuffs Act	All ingredients for pet food must be fit for human consumption. Thus, pet food containing by-products must be labeled as "Not for human consumption".
UK	Animal and Plant Health Agency (APHA) under the Animal By-Products (ABP) Regulations	Allow the use of animal by-products in pet food, provided they are derived from animals fit for human consumption and are processed to inactivate pathogens.
Canada	Canadian Food Inspection Agency (CFIA) regulates pet food under the Feeds Regulations	Pet food is safe and meets nutritional standards.
Japan	Legislation enacted in 2007	Facilitate the use of food waste in pet food production, provided it meets safety and quality standards

Future Outlook

The company can focus on…



- Producers should also consider using advanced processing techniques and technologies that deliver personalized recommendations addressing pets' specific dietary needs and health concerns.
- Lower ingredient costs and product prices will help consumers overcome price barriers.

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Summary

To turn waste into premium pet food ingredients.....

PAWS Framework

P – Potential in Waste

A – Actionable Process

W – Win-Win Solution

S – Sustainability Goal

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- GNPD database (https://www.gnpd.com/)

thank you

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