Case study: when food & data sciences make peace with meat....

iNewtrition
FOOD SCIENCE EXPERTISE

👤 **Raphaëlle O'Connor**

📱 +353876765112

✉ info@inewtrition.com

Content

- Formulation by design – Raw materials & ingredients
- Finished product characterisation & benchmarking
- Processing & technology
- Market research & consumer insights
- Compliance by design – Regulatory landscape
- Next steps

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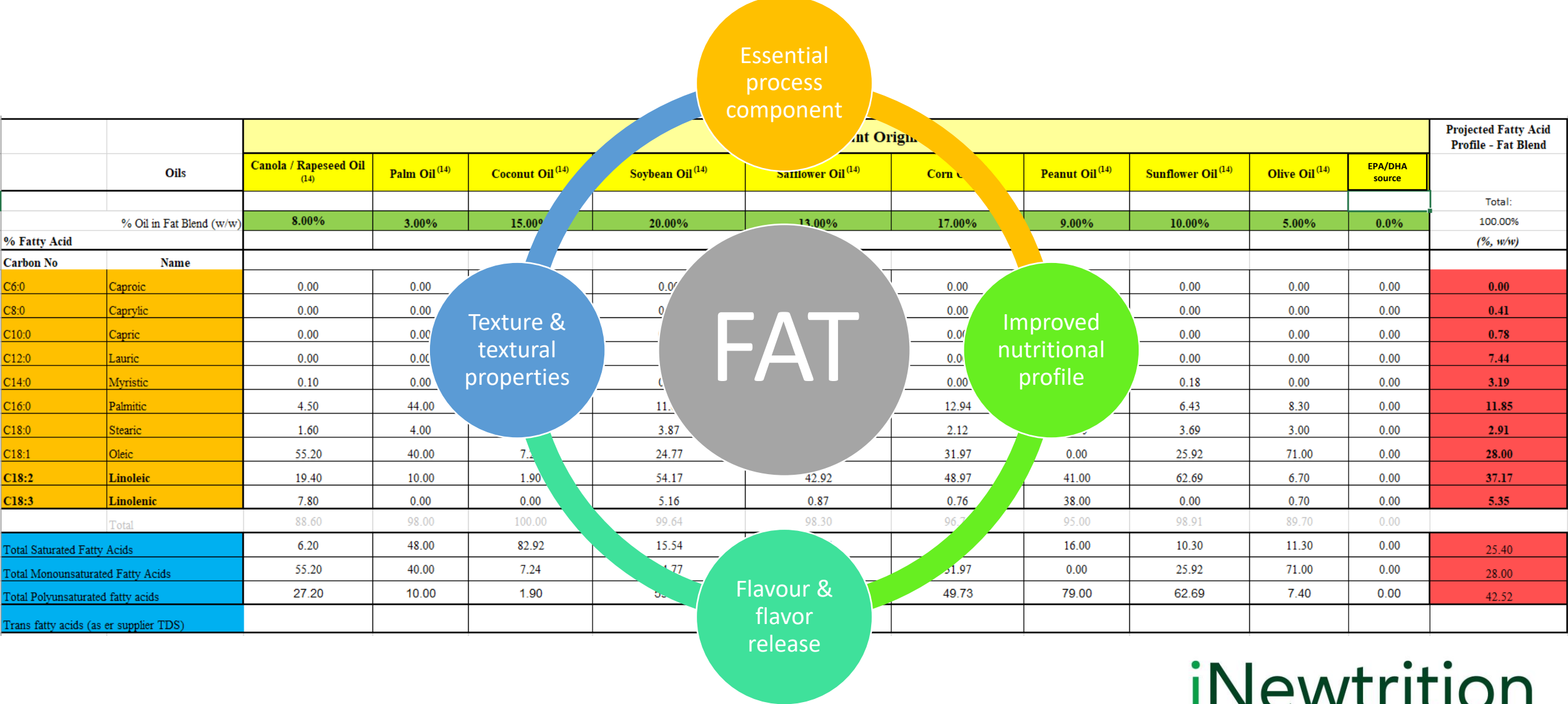
Formulation by Design

- Nutritional profile: protein content (include profile: EAA), Fat (SFA, TFA, USFA, PUFA), total sugars, fiber, sodium, Vits. B12 and D, Iron and Zinc content

- Ingredients list to be defined

- Do we understand current composition of the medium including minerals (Ca^{++} and K^+ specifically)?

- Formula fits. Fortification as required with focus on sensitive (heat, oxygen, chemical degradation, etc.) nutrients. Mass balance calculations (recovery key nutrients)

- Projections (nutritional) and simulation (functionality) focused by focused experimentation leads to rapid product development.

- Food model system to use: meat analogue or margarine?

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Fats and Fatty-acids Profile

		Fatty acid content (g/100 g fatty acids)	
Nomenclature	Denomination	Fat of *foie gras*	Duck fat
C14:0	Myristic A.	0.9 ± 0.00	0.6 ± 0.01
C14:1	Myristoleic A.	0.1 ± 0.00	0.1 ± 0.00
C16:0	Palmitic A.	28.1 ± 0.05	26.1 ± 0.20
C16:1	Palmitoleic A.	2.9 ± 0.00	3.2 ± 0.01
C18:0	Stearic A.	10.6 ± 0.06	6.5 ± 0.00
C18:1 9t	Elaic A.	0.2 ± 0.01	0.2 ± 0.00
C18:1 9c	Oleic A.	54.9 ± 0.10	53.0 ± 0.17
C18:1 11c	Cis-Vaccenic A.	1.0 ± 0.00	1.0 ± 0.05
C18:2	Linoleic A.	0.9 ± 0.00	9.0 ± 0.04
C18:3	Linolenic A.	-	0.3 ± 0.00
C20:1	Gondoic A.	0.1 ± 0.06	0.2 ± 0.00
Unknown		0.5 ± 0.06	0.4 ± 0.00
Total saturated		39.6	33.2
Total monounsaturated		59.1	57.6
Total polyunsaturated		0.9	9.3

polyunsaturated lipids (in our studies, values of 33.2 g/100 g for saturated fats, 57.6 g/100 g of monounsaturated, and 9.3 g/100 g of polyunsaturated lipids were obtained).

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Example: Fatty acid profile & projections for fat blend

	Oils	Canola / Rapeseed Oil [14]	Palm Oil [14]	Coconut Oil [14]	Soybean Oil [14]	Safflower Oil [14]	Corn Oil [14]	Peanut Oil [14]	Sunflower Oil [14]	Olive Oil [14]	EPA/DHA source	Projected Fatty Acid Profile - Fat Blend
	% Oil in Fat Blend (w/w)	8.00%	3.00%	15.00%	20.00%	13.00%	17.00%	9.00%	10.00%	5.00%	0.0%	Total: 100.00%
% Fatty Acid												(%, w/w)
Carbon No	**Name**											
C6:0	Caproic	0.00	0.00	0.0			0.00	0.00	0.00	0.00		0.00
C8:0	Caprylic	0.00	0.00				0.00	0.00	0.00	0.00		0.41
C10:0	Capric	0.00	0.00				0.00	0.00	0.00	0.00		0.78
C12:0	Lauric	0.00	0.00				0.00	0.00	0.00	0.00		7.44
C14:0	Myristic	0.10	0.00				0.00	0.18	0.00	0.00		3.19
C16:0	Palmitic	4.50	44.00	11.			12.94	6.43	8.30	0.00		11.85
C18:0	Stearic	1.60	4.00	3.87			2.12	3.69	3.00	0.00		2.91
C18:1	Oleic	55.20	40.00	7.2	24.77		31.97	0.00	25.92	71.00	0.00	28.00
C18:2	**Linoleic**	19.40	10.00	1.90	54.17	42.92	48.97	41.00	62.69	6.70	0.00	37.17
C18:3	**Linolenic**	7.80	0.00	0.00	5.16	0.87	0.76	38.00	0.00	0.70	0.00	5.35
	Total	88.60	98.00	100.00	99.64	98.30	96.7	95.00	98.91	89.70	0.00	
Total Saturated Fatty Acids		6.20	48.00	82.92	15.54			16.00	10.30	11.30	0.00	25.40
Total Monounsaturated Fatty Acids		55.20	40.00	7.24	.77		31.97	0.00	25.92	71.00	0.00	28.00
Total Polyunsaturated fatty acids		27.20	10.00	1.90			49.73	79.00	62.69	7.40	0.00	42.52
Trans fatty acids (as er supplier TDS)												

Essential process component

Improved nutritional profile

Flavour & flavor release

Texture & textural properties

FAT

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Same principles apply to proteins (essential amino acids), carbohydrate, fibers, minerals & vitamins….

Functional Ingredients

- High-water holding capacity

- Intrinsic / innate nutritional value

- Emulsification properties

- Gelling (condition specific)

- Heat, pH, freeze/thaw and shear stability

- Natural and smooth texture

- Balanced flavour

- Clean-declaration

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Processing & manufacturing

Relevant Technologies

- High shear mixing / homogenization
- Biotechnology / fermentation
- High Pressure Processing
- High hydrostatic pressure
- Heat processing - Canning / Sterilisation (up to 130C)
- Tailored texturisation of proteins if needed
- Molecular gastronomy
- Enzymatic hydrolysis

Parameters & Criteria

- Texture / Visco-elastic properties of the gel
- Heat-induced aggregation & colloidal stability
- Aw
- Characteristics of the emulsion (w/o, o/w) and double-emulsions
- Texture and taste throughout 24 months shelf life (non-refrigerated storage)

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Finished Product characterization & specifications

- Evaluate throughout shelf-life

- Contaminant testing / Anti-nutritional factors

- Nutritional profile optimized by design based on DRA / EU guidelines: protein content (include profile: EAA), Fat (SFA, TFA, PUFA, EPA/DHA), total sugars, fiber, sodium, Vits. B12 and D, Calcium, Iron and Zinc content. Targeted health benefit platforms. For example Omega 3 and 6 and EPA/DHA

- Texture profile at room temperature throughout shelf life and upon cooking at home (i.e. culinary experience)

- Develop unique sensory & culinary experience and expertise. Mouthfeel & flavour

- Sensory analysis and profiling with trained panel

- Flavour profile optimization with flavor house / strategic partner. In-process flavor generation + controlled release (delight consumer through enhanced culinary experience) & microencapsulation.

- Focus group with target segment

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Physical characteristics of 125g Burger (10% fat) made from beef and plant protein isolate
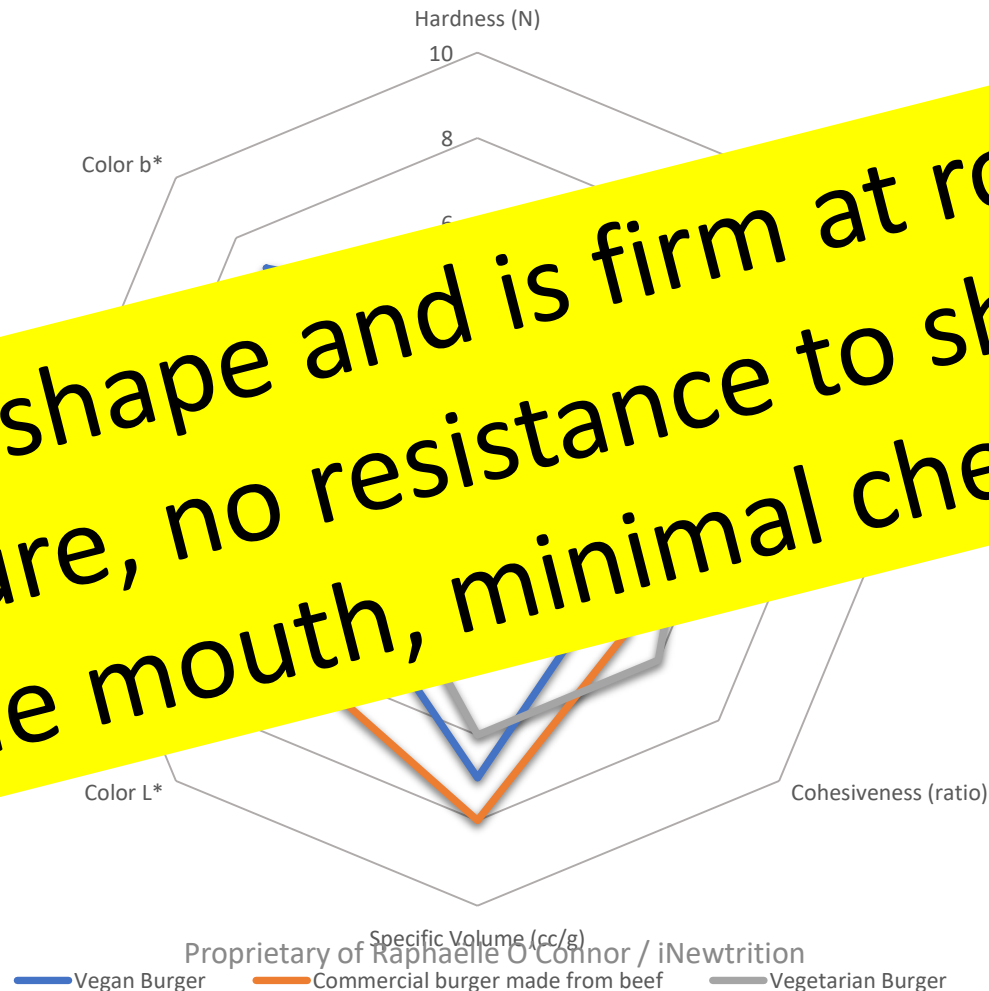
Holds shape and is firm at room temperature, no resistance to shear, melt in the mouth, minimal chewing

Finished Product characterization - Texture

Texture characteristics of 125g Burger (10% fat) made from beef and plant protein isolate
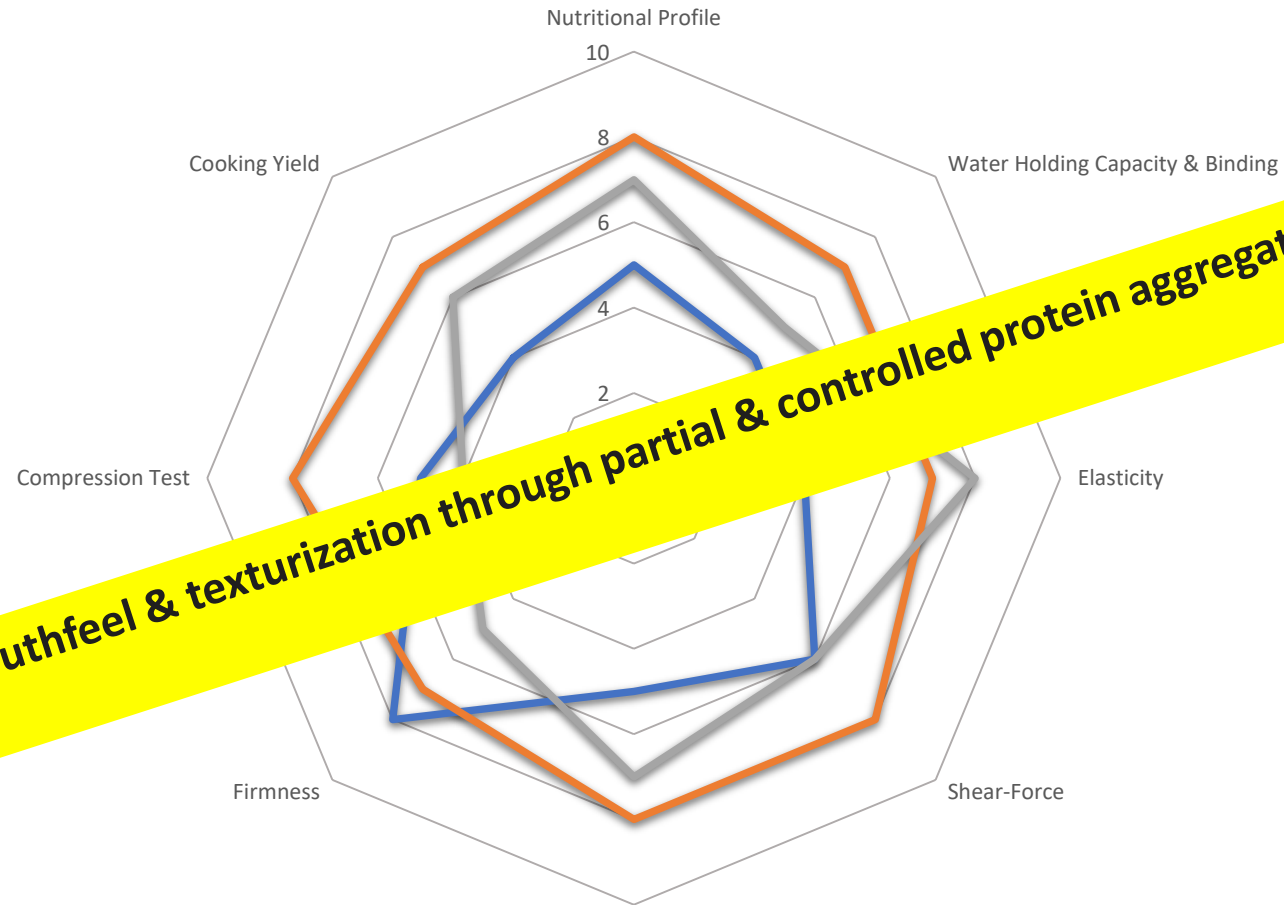
Mouthfeel & texturization through partial & controlled protein aggregation

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Nutritional Profile
Water Holding Capacity & Binding
Elasticity
Shear-Force
Penetration Test
Firmness
Compression Test
Cooking Yield

— Vegan Burger   — Commercial burger made from beef   — Vegetarian Burger

Consumer experience & culinary preparation

- Avoid separation sedimentation / syneresis

- Must perform well when fried, baked, blended

- Firm structure with minimal fat / moisture exudation

- Minimum fat loss during cooking

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Current to optimized Nutritional Profile (% w/w)

- High Calorie content
- 30% water
- 5 to 10% protein
- 55 to 60% fat
- 2% carbohydrate
- 0.9% Ash
- Cholesterol (375mg)
- Triglycerides
- Phospholipids
- Saturated fat
- Monounsaturated fat
- Sodium (732mg)
- Vitamin A (8,500 µg)
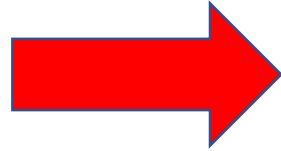
- 45 to 65% carbohydrate (total / available)
- Fiber (optimal blend soluble/insoluble)
- 30% protein
- 35% fat
- Phosphatidylcholines
- Choline
- Intake of saturated fatty acids to less than 10% of total energy intake and their intake of *trans*-fatty acids to less than 1% of total energy intake. Draft guidelines recommend using polyunsaturated fatty acids as a source of replacement energy, if needed.

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Complex combination of flavours

- In-process & controlled flavor generation
- Maillard reactions
- Flavour house strategic partner
- Controlled release (served cold vs. hot)
- Encapsulation

2-acetyl-1-pyrroline ("roasty, popcorn-like")
2-acetyltetrahydropyridine ("roasty, popcorn-like")
2-acetyl-2-thiazoline ("roasty")

No.	name		strength
1	Hexanal		S
2	Heptaldehyde		
3	2- Ethylcyclohexanol	Pickles taste	
4		Grease fresh taste	
5		Slight odor	L
		Peanut flavor	L
		Seafood flavor	M
		Burning smell	S
		Sauce flavor	S
			L
			M
	n-octyl		-S

E-2 nonenal ("fatty")
E,E,2,4-decanedial ("fatty")
E,E,E,4-nonedial ("fatty")
heptanal ("fruity, fatty, sweet, oil")
E,2-heptenal ("fatty")
1-undecen ("fatty, burnt, nutty, rubbery")
2-formyl-5-methylthiophene ("sulfurous")
2-acetylthiophene ("sulfurous, sweet")
Benzothiazole ("metallic")
Alkylpurazines (Maillard reaction – "nutty, roasted")
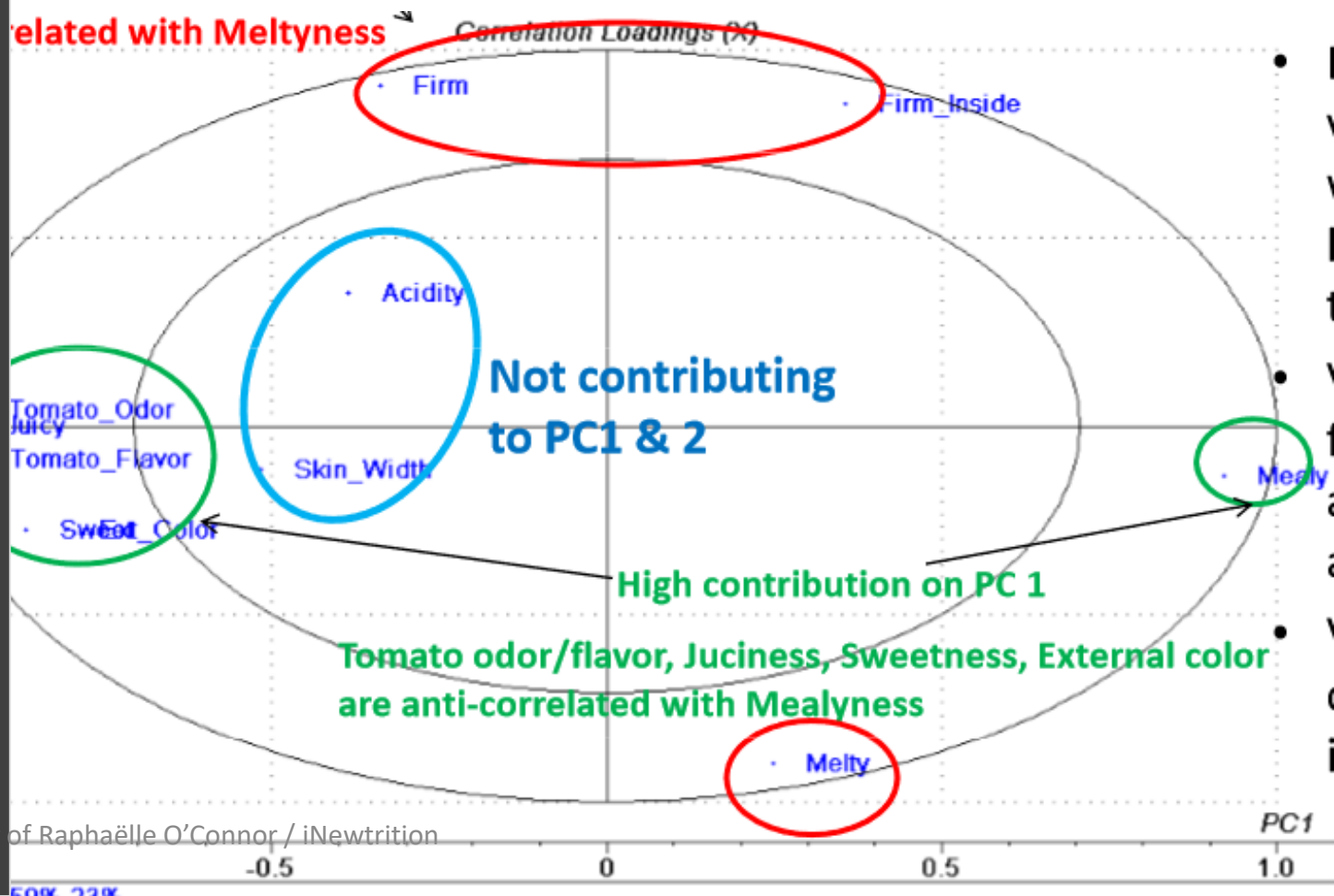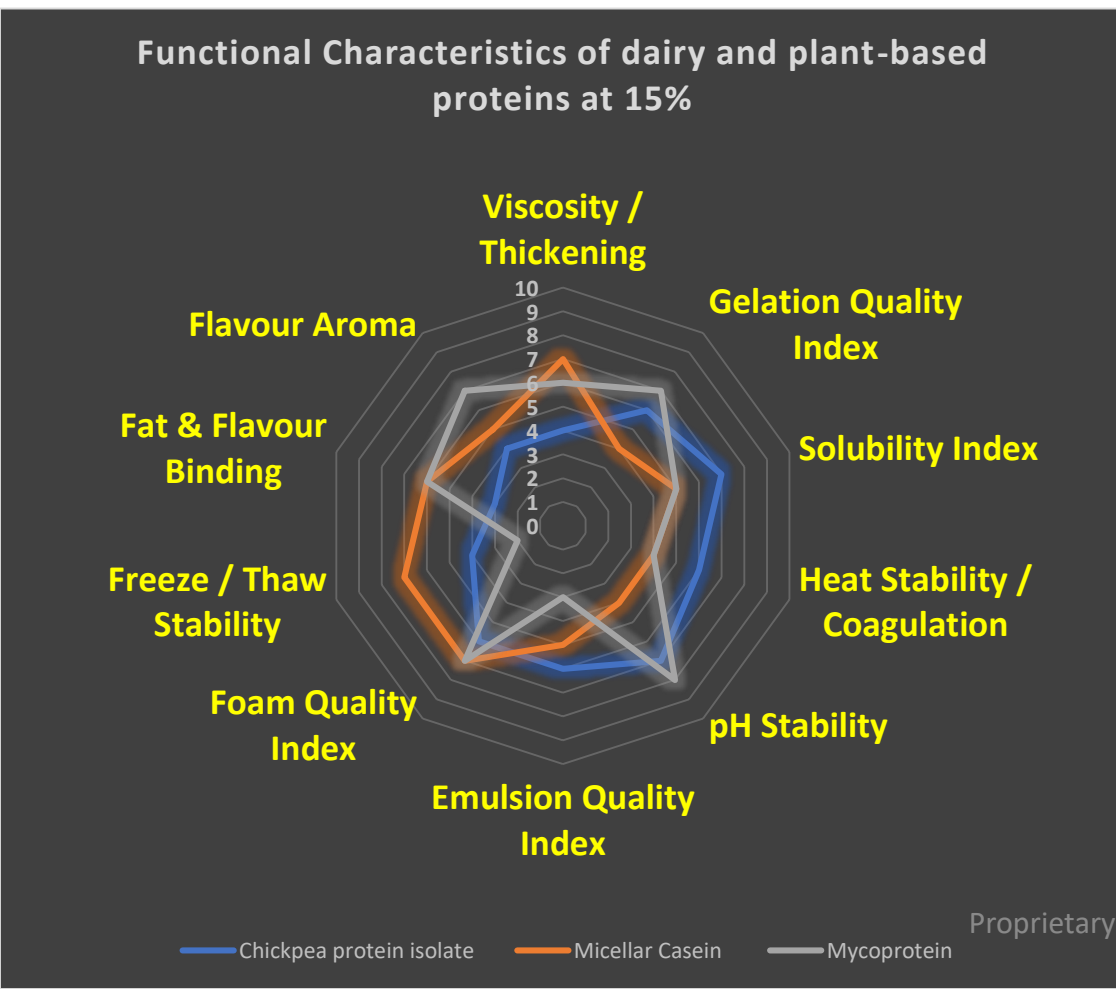Oxazoles (idem – "green, nutty, sweet")

Pentanol
Hexanal
Hexanol
1-octen-3-ol
Nonanal
β-pipene
2,4-decanedienal

Note: S expressed strong; M Representation; L It indicates weak.

[XIE, Zhang-bin, Ya-wei FAN, Ze-yuan DENG, Rong LIU, Jing LI, Jiang-... DU. "Analysis of Volatile Compounds in Foie Gras by SDE, GC-MS and GC-O [J]." Fo... 24 (2011)]

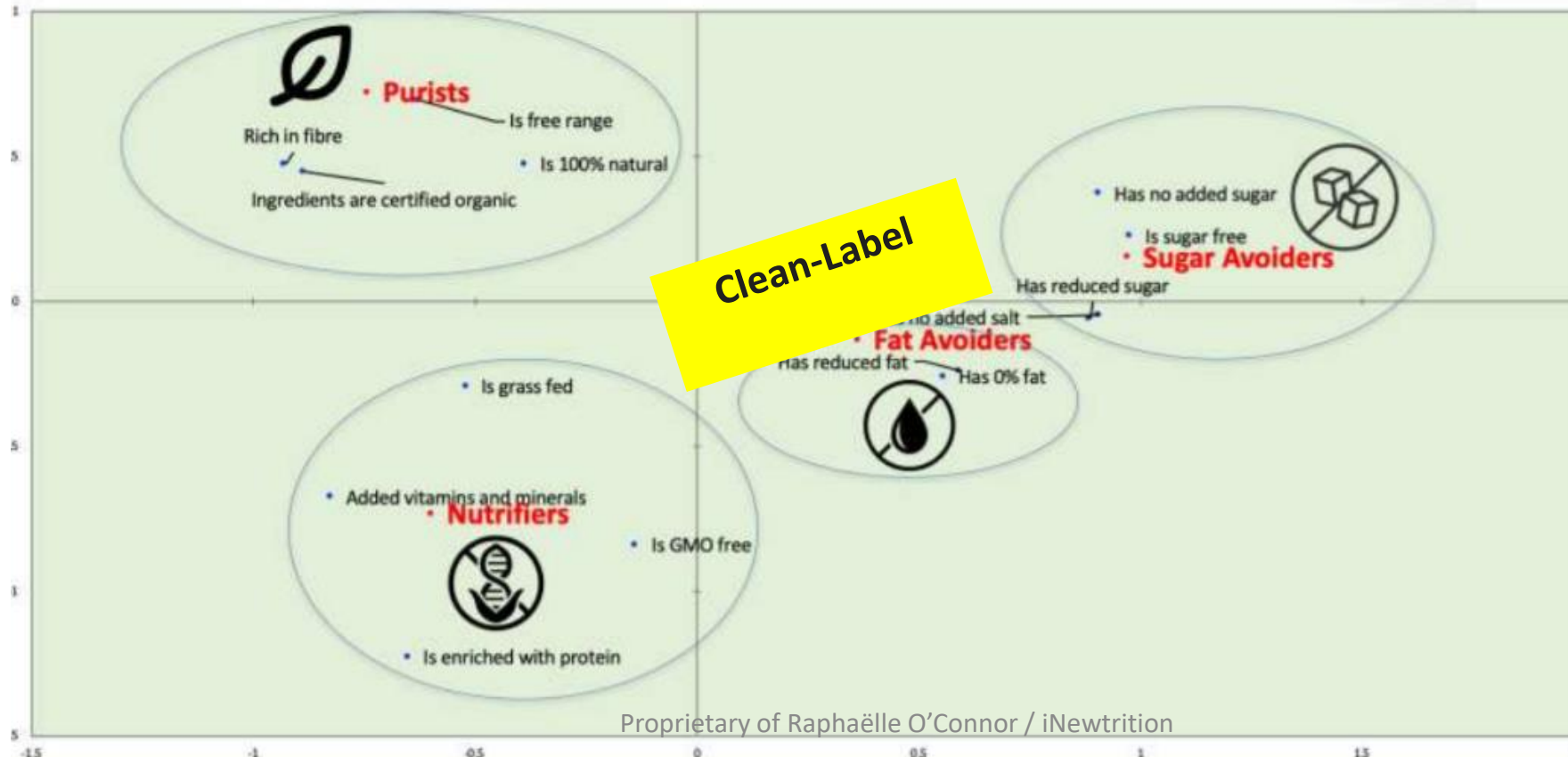# Consumer segment, profile & persona

- Confirm suitability ingredient list

- Confirm communication strategy

- Commercialisation of science

- Natural plant-based emulsifiers, stabiliser, anti-oxidants & in-process flavour generation

- Clean-label. See https://www.bordbia.ie/globalassets/bordbia.ie/industry/marketing-reports/consumer-reports/what-does-clean-mean-2019.pdf

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Food Industry: Market knowledge & consumer insights

Functional Characteristics of dairy and plant-based proteins at 15%

Viscosity / Thickening, Gelation Quality Index, Solubility Index, Heat Stability / Coagulation, pH Stability, Emulsion Quality Index, Foam Quality Index, Freeze / Thaw Stability, Fat & Flavour Binding, Flavour Aroma

— Chickpea protein isolate — Micellar Casein — Mycoprotein

Correlation Loadings (%)

...rrelated with Meltyness

Firm, Firm_Inside

Acidity

Tomato_Odor, Juicy, Tomato_Flavor, Skin_Width, Sweet, Ext_Color

Not contributing to PC1 & 2

Mealy

High contribution on PC 1

Tomato odor/flavor, Juciness, Sweetness, External color are anti-correlated with Mealyness

Melty

PC1

-0.5   0   0.5   1.0

Consumer health goals influence choice of food

Dependant on what the consumers health goals are, they will be pulled towards products that contain certain ingredients and likewise will be pushed away from products that contain ingredients that are not aligned with their health goals.
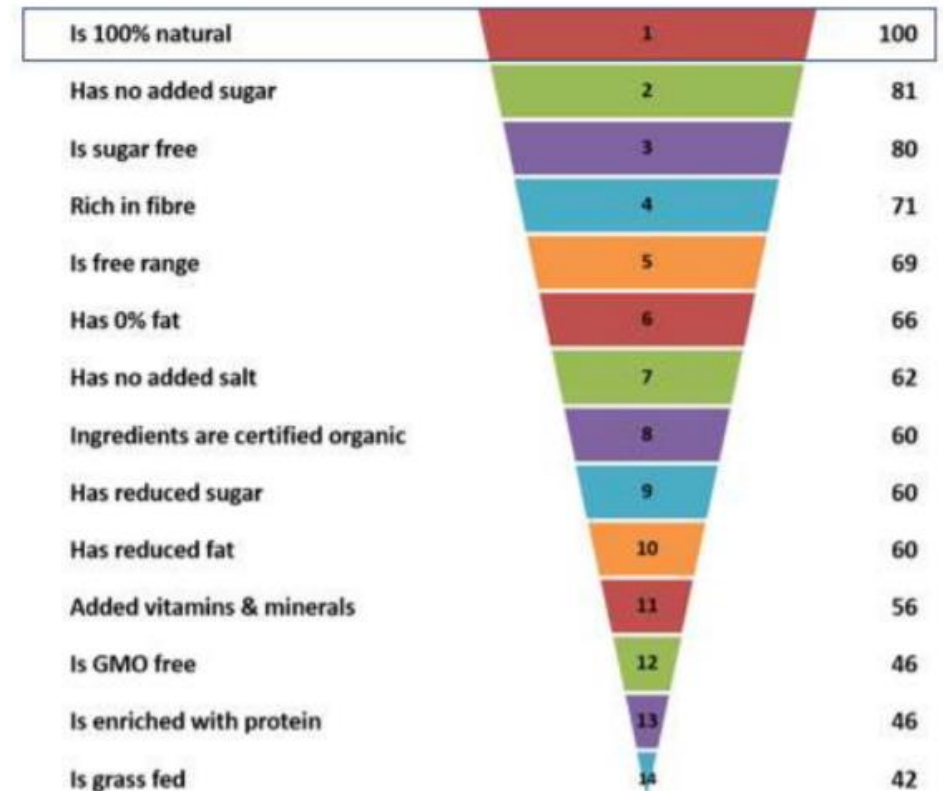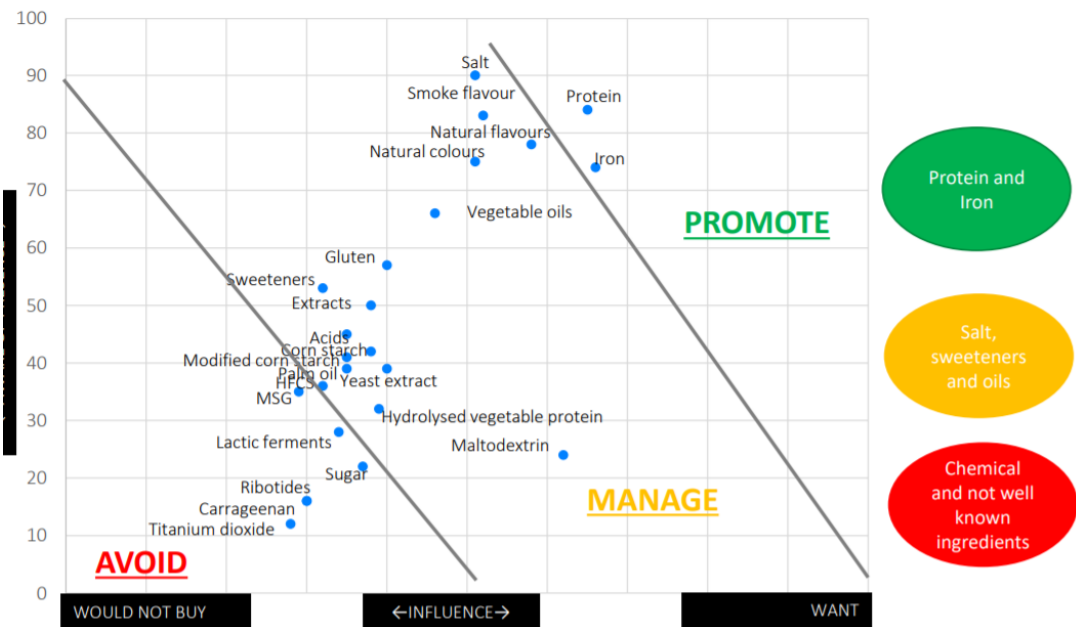
Claims that influence

Consumer Insights

Brands will make claims about the physical product's ingredients, nutrients, production and sourcing. Typically, these claims are not contained in the finer points of a product's label. Rather, they form part of the brand itself and are presented via badges that are highly visible on packaging.

Consumers want to see such badges on the front of packaging to avoid friction. Consumers admit to these claims exerting influence over their buying decision. Of course, there will be some claims that exert greater influence than others, depending on brand, on product type and familiarity. Yet it is essential to understand the hierarchy of influence on the basis of the claim itself.

From a broad range of claims, "100% natural" is by far the claim that exerts most purchase influence across the five markets. Thus it is preferable to have nothing added or naturally

| Claim	Rank	Score
Is 100% natural	1	100
Has no added sugar	2	81
Is sugar free	3	80
Rich in fibre	4	71
Is free range	5	69
Has 0% fat	6	66
Has no added salt	7	62
Ingredients are certified organic	8	60
Has reduced sugar	9	60
Has reduced fat	10	60
Added vitamins & minerals	11	56
Is GMO free	12	46
Is enriched with protein	13	46
Is grass fed	14	42

Category dynamics for sliced cooked meats

Functional Foods

- Nutritional / Health claim as per EFSA

- Refine health benefits platform and align with formulation by design

- https://www.bordbia.ie/globalassets/bordbia.ie/industry/marketing-reports/consumer-reports/functional-food-and-beverage-innovation-playbook-june-2019.pdf

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The market is dominated by three broad functional claims.

Global Value by Functional Claim (€million) 2018
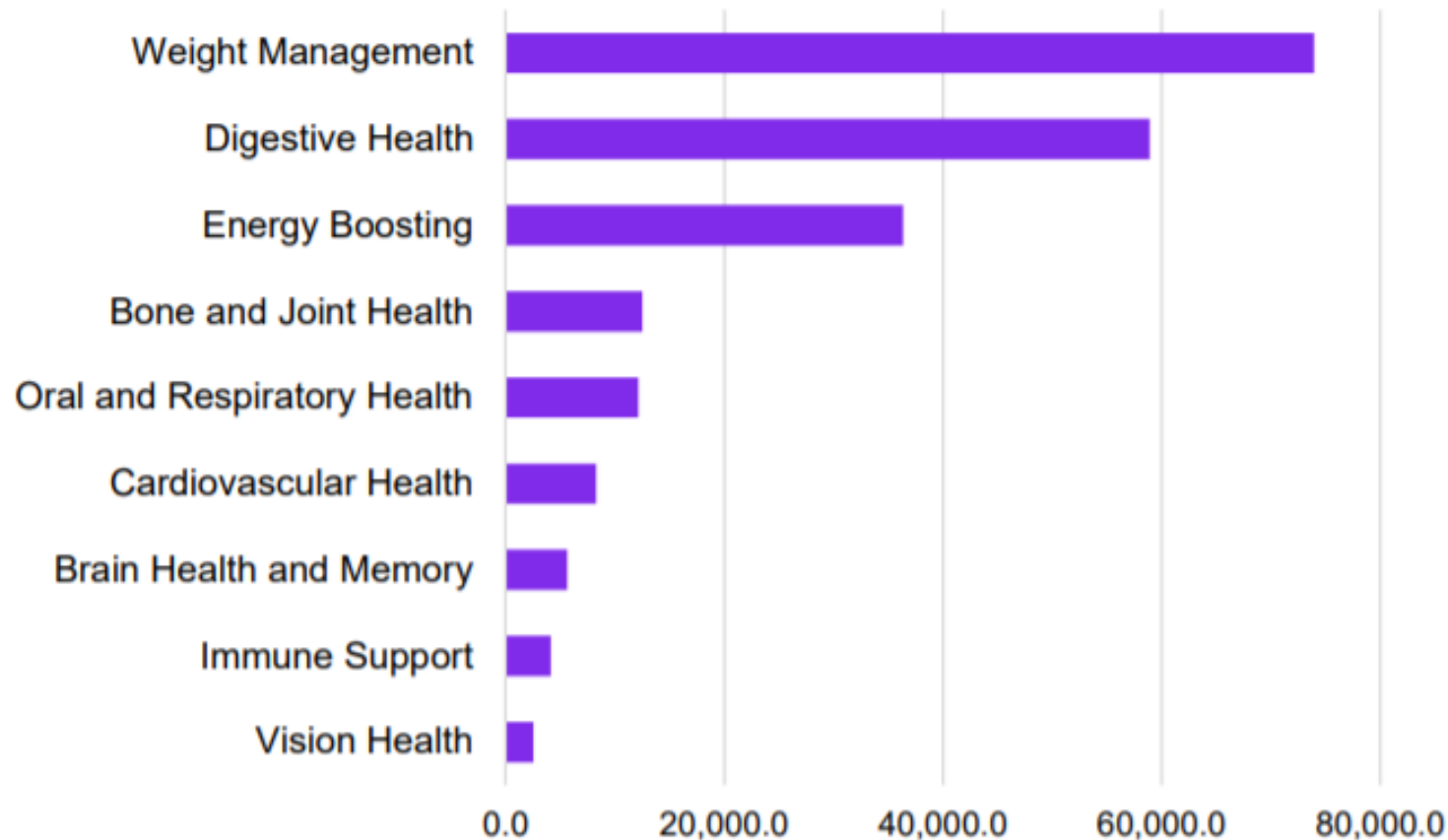
Weight management, digestive health and energy boosting claims make up the majority of the market.

However, as a greater number of health & wellness issues impact modern society, there are opportunities with other functional claims.

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Resilience – performance summary.

Think about a future where...

Promoting mental wellness is important to people.

In this future, modern lifestyles have greatly increased stress levels. As a result, mental health is now a health priority.

In this future, in order to address this, many people have dramatically reduced alcohol intake. They are also turning to food & drink products to relieve some of the stress that may keep them from living life to the full.

One chocolate product infuses CBD (the relaxing, non-psychoactive strain of cannabis) with Maca root (a herb which helps the body fight stress) and ginseng (which naturally boosts serotonin levels) to reduce stress.

LIKELIHOOD
88% v 83% average

STRENGTH
9.4 v 8.4 average

REGION
- IRE — 86%
- UK — 90%
- US — 87%
- AUS — 87%

GENDER
- ♀ 91%
- ♂ 83%

AGE
- 18-34 — 88%
- 35-49 — 89%
- 50-60 — 82%

TIMEFRAME
65% v 61% average — of people think this will become common within the **next 2 years**

POPULARITY
36% v 36% average — of people **think more than half of people** will purchase this product

TOP OCCASIONS
- **35%** Part of breakfast
- **29%** After working out/exercise
- **27%** Before working out/exercise

TOP CATEGORIES
- **38%** Sweet snacks
- **29%** Specialised sports nutrition products
- **27%** Savoury snacks

OVERALL PLATFORM RANKING
2nd

FUTURE LIKELIHOOD
Probable

n=260

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Fastrack product development & innovation

Preference Mapping

Consumer Clusters

Databases

Open Knowledge Platform

Drive...

Predictive modelling tools

DoE / Advanced Analytics – Cut-down the number of experiments with machine learning simulation

Cluster Mapping
• Preference Mapping
• Identify unmet needs

...Attributes

Technologies / Processes
• Nutritional profile
• Product Parameters (label)
• Sensory attributes / signature

Consumer Testing

Product Application

From DoE to Advanced Analytics and ML - Simulation followed by focused experimentation leads to rapid product development.

Business model & value proposition / IP

- B2B
- Software/data science platform for food innovation
- Ingredients prediction and (possibly) market insights
- Multi-dimensional database of functional & nutritional ingredients that are commercially viable

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Next Steps

- State-of-the-Art / Freedom-to-Operate (IP)
- Define / refine model system (emulsified gel) and profile for finished product / benchmark (texture & nutrition)
- Characterisation raw material and target finished product
- Understand innate/inherent profile of the medium and what scope we have for modification
- Agree and align on fortification (i.e. aligned with health benefits / DRA / customers requirements & expectations)
- Agree on project timelines
- Carry out mass balance and projections for all nutrients
- Apply compliance and formulation by design principles
- Develop early innovation portfolio (i.e. USP / differentiation / health benefit platform) to finalise a robust formulation by design.
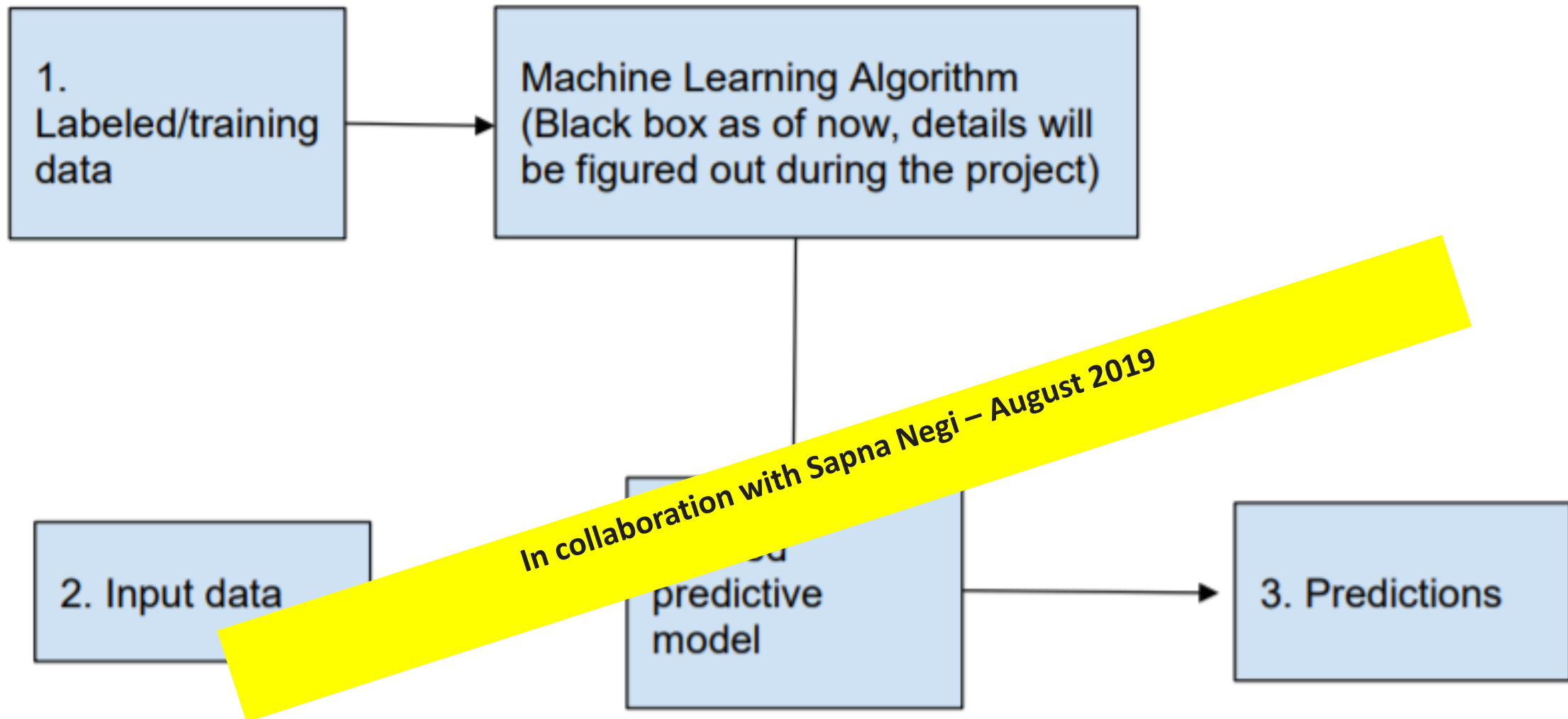
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Thank You

👤 **Raphaëlle O'Connor**

📱 +353876765112

✉️ raphaelle.oconnor@hotmail.com

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Back-Up slides

RD&I + Data Science => Advanced analytics / ML / AI

1. Labeled/training data

Machine Learning Algorithm (Black box as of now, details will be figured out during the project)

2. Input data

predictive model

3. Predictions

In collaboration with Sapna Negi – August 2019

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1. Training/Labeled data for a predictive model (manually collect a few hundreds)

1A - Alternative sustainable Ingredients

Ingredient Name	Characteristics (from technical data sheet)	Functionality in food (upon heating)
Flours	Moisture / Dry matter Particle size distribution (<50, 100, 150, 200, 300, 500μm) Water holding capacity / Syneresis Ash content Degree of polymerization (DP) pH Conductivity Solubility at 25C Wettability Dispersibility Reducing power Sweetness Viscosity at different temperatures Freezing point depression Sorption isotherm Process stability (acid and thermal) Stability during storage Nutritional profile (energy,	Viscosity Hardness Springiness Cohesiveness Elasticity

	soluble/insoluble/dietary fiber, protein, carbohydrate, sugar, fat, sodium, vitamins & minerals)	
Concentrates	Same as above	Same as above
Isolates	Same as above	Same as above
Starches	Same as above	Same as above
Hydrocolloids	Same as above	Same as above
Fibers	Same as above	Same as above

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Vegetarian Burger	Hardness	Water	25 to 40
	Springiness	Flour	10 to 25
	Cohesiveness	Concentrate	5 to 10
	Elasticity	Starch	3 to 8
		Hydrocolloids	0 to 1
		Fiber	5 to 15

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Differentiation

- Commercial available ingredients vs. isolation of functional or bioactive compounds
- Data Science capability platform for other companies in the same space

The first-ever patent covering machine learning methods and systems for food ingredient discovery.

Discovery System

Data Collection

Communication Network

Functional & Molecular Assays

U.S. Patent No. 9760834