

PRODUCT APPLICATION

PLANT BASED MEAT

PINEAPPLE FIBER POWDER
&
GREEN BANANA POWDER



PLANT BASED MEAT: BACKGROUND

Typical Product Construct

- ✓ Protein Source
- ✓ Fat
- ✓ Binders – Rice/Legume based Flours, Mod. Starch, Native Starches, Fibre and other Speciality ingredients with functional attributes
- ✓ Colors, Flavors & Seasoning

Key Players: Speciality Ingredients & Ecosystem

- Native starches – Tapioca, Potato, Corn based
- Fibres – Citrus, Soybean, Chicory root, Carrot, Oats, Wheat based
- Plant based flours – Rice, Soybean, Chickpea, Jackfruit, Potato, Tapioca, Cassava

**CP Kelco,
Dupont-Danisco,
Ingredion,
Tate&Lyle, Kerry,
Beneo**

Key Claims: Sustainable sourcing, natural/ clean label, Vegan, Non GMO

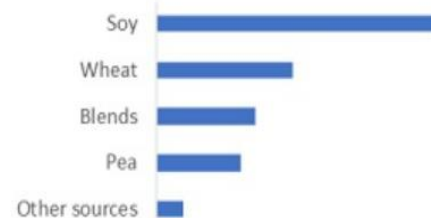
Opportunity:

- Sustainable sourcing
- Starch & Fibre based functional solution offering
- Clean label claims, source of Fibre, source of Resistant Starch, source of Vit & Minerals claims, Vegan/Plant based ingredient solutions

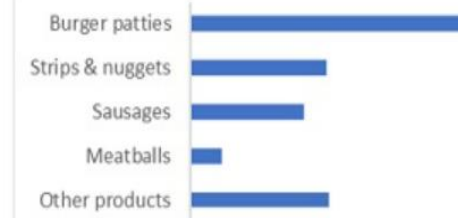
Overview of the Plant-Based Meat Market



BY SOURCE, 2022 (USD MILLION)



BY PRODUCT, 2022 (USD MILLION)



Key players in this market include Beyond Meat (US), Kellogg Company (US), Impossible Foods Inc. (US), Maple Leaf Foods (Canada), Unilever (UK), Conagra Foods (US), Tofurky (US), Gold&Green Foods Ltd (Finland), Sunfed (New Zealand), and Monde Nissin (Philippines)

PLANT BASED MEAT PROTOTYPE DEVELOPMENT - OVERVIEW

Patties



Nuggets



Meatballs



Sausage



Texturized Vegetable Protein (TVP) using GBP



Prototype Application Exercise- Dosage levels

Ingredient	Patties	Nuggets	Meat balls	Sausages	TVP*
GBP	Up to 15%	Up to 15%	Up to 15%	Up to 15%	Up to 20%
PFP	Up to 15%	Up to 15%	Up to 15%	NA	Up to 10%
Texturized GBP**	Up to 20%	Up to 20%	Up to 20%	Up to 30%	NA

Texturized form of GBP created using DSI Green Banana Powder in combination with Soy Protein Isolate

- Potential application in Meat balls, Patty, Sausage and Nuggets (up to 20-30%)
- Potential opportunity in Premix format application (one stop solution for plant-based meat formulations) targeting seasoning/flavor houses

➤ Product prototypes were developed at TF Lab and evaluated for basic physical characteristics, nutritional profile and sensorial parameters

➤ Different ratios/dosages were tested out to evaluate the ingredient performance in the selected food matrix

Organoleptic parameters:

- Texture comparable with standard/control sample
- No off-taste with the addition of GBP & PFP/Neutral in nature at the recommended dosage levels

Clean Label Ingredients:

- Alternate for CMC; sodium levels lower than CMC
- Alternate for potato starch: Better nutrition profile - GBP is a good source Resistant starch and minerals; PPP is a good source of fibre
- Potential alternate ingredient for Modified starch

**Needs recipe and process optimization*

*** Potential opportunity to try higher % of GBP for Dry TVP extrusions trials*

INGREDIENT FUNCTIONS CURRENT LANDSCAPE: PLANT BASED MEAT FORMULATIONS

Ingredient Categories	Key Functional Ingredients	Key Market Players	OHC	WHC	Gelling	Binding	Texture	Heat Stability
Proteins	Whey Protein Concentrate	Cargill, Roquette, Unibourne, Kerry, Synthite, Glanbia, Ankush life sciences	Medium	Medium	Low	High	High	High
	Whey Protein Isolate		Medium	Medium	Low	High	High	High
	Soy Protein Isolate		Medium	Medium	Low	High	High	High
	Algal Protein		Medium	Medium	Low	Medium	Medium	Medium
	Texturized Vegetable Proteins (Soy, Pea, Rice, Chickpea etc.)		Medium	High	High	High	High	High
Starches	Potato starch	Ingredion, DuPont, Beneo, DKSH, Roquette (IMCD), Tate & Lyle	Medium	High	Medium	High	Medium	High
	Corn Starch		Medium	High	Medium	High	Medium	High
	Modified Starches		Medium	High	High	High	Medium	High
Fibres	Citrus fibre	Anshul Life Sciences, Cargill, Barentz, Cosucra, JRS Fibers	Medium	High	Low	High	High	Medium
	Pea Fibre		Medium	High	Low	High	High	Medium
	Oat Fibre		Medium	High	Low	High	High	Medium
	Apple Fibre		Medium	High	Low	High	High	Medium
Stabilizers	CMC	DuPont, CPKelco, Ashland, Nouryon	High	High	High	High	High	High
Fats & Oils	Hydrogenated vegetable Fats	AAK kamani, Cargill	High	Nil	Low	High	Medium	Low
	Refined Oils		High	Nil	Low	High	Low	High
	Fat Flakes (Speciality Fats)		High	Nil	Low	High	High	Low
DSI Ingredients	Green Banana Powder	NA	Medium	High	High	High	Medium	High
	Pineapple Fibre Powder		Medium	High	Low	High	Medium	Low

DSI GBP & PFP : Key highlights

GREEN BANANA POWDER

- Good source of resistant starch and minerals
- Thickening properties at par / better than modified starch in optimised formulations
- Excellent clean label alternative to modified starch (specific to applications and needs validation)
- Extrusion friendly; good expansion and excellent ingredient in texturized protein formulations providing good expansion and texture in plant meat-based application
- Imparts a darker colour and appearance to the plant meat formulations most suited for red meat -based plant meat analogues (Beef, Pork etc)
- Can be used at high dosage levels (up to 15% tried) in plant-based meat applications such as Nuggets, Meat Balls, Patties, Sausages and a suitable bulking agent (subject to cost in use)
- Potential alternative to CMC- Because of its good WHC due to the higher starch content
- Potential alternative to CMC- Because of its good WHC due to the higher starch content

PINEAPPLE FIBRE POWDER

- Good source of dietary fibre and minerals
- Excellent ingredient for formulations that needs binding and texture
- Water absorption and binding characteristics comparable to apple fibre/citrus fibre etc; good alternative binder/thickener option for product formulations
- Natural and clean label source for minerals and fibre
- Cannot be used at very high dosage levels due to the powdery and crumbly texture and coarseness in mouthfeel (high dietary fibre source).
- Imparts a dark colour to the product which can be potential use in red meat-based plant meat analogue products
- Potential alternative to CMC- Because of its good WHC due to the higher starch content



KEY HIGHLIGHTS IN PROTOTYPE - MEAT BALLS

GBP @ 15% + Commercial TVP



Texturized GBP-TVP @ 20% + Green Banana Powder @15%



Formulation with Increase in GBP %

Ingredients	15% GBP+ Commercial TVP	Texturized GBP- TVP @20% + 15% GBP
Cold Water	12.45	12.45
Texturised Wheat Protein	11.07	0.00
Texturised Pea Protein	9.22	0.00
Extruded GBP-TVP	0.00	20.00
Refined Sunflower Oil	5.00	5.00
Hot water	32.00	32.00
Potato Starch	0.00	0.00
CMC	0.00	0.00
Salt	0.65	0.65
Fat Flakes	7.38	7.38
Aromild - Yeast extract	0.23	0.23
Springarom	0.38	0.38
Chicken Flavour	2.49	2.49
Garlic Powder	2.49	2.49
Onion Powder	2.49	2.49
Green Banana powder	15.00	15.00
TOTAL	100.00	100.00

- Overall, GBP in the powder form can be explored up to 10-15% and the texturized form of GBP can be looked up to 25%.
- Green Banana powder with good water holding properties is an excellent binder in plant meat- based formulations. It's a potential alternative regular starch-based ingredients used.
- Texturized GBP – imparts characteristic texture to plant meat-based formulations, comparable to the texture of commercially available Texturized protein.
- GBP and texturized GBP are both neutral in taste and imparts no after/off taste to the final product.
- GBP imparts darker colour appearance to the final product, good potential to look at Red Meat analogues
- Overall GBP and Texturized GBP has good potential in plant-based meatball application with the scope of increasing the GBP content beyond 20% in texturized format.

KEY HIGHLIGHTS IN PROTOTYPE - SAUSAGE

GBP @ 15% + Commercial TVP



Texturized GBP-TVP @ 30% + Green Banana Powder @5%



After casing- GBP @ 15% + Commercial TVP



After Casing- Texturized GBP-TVP @ 30% + Green Banana Powder @5%



Formulation with Increase in GBP %

Formulation	GBP @ 15% + Commercial TVP	Texturized GBP @ 30%
Texturized GBP-TVP		30
TVP Pea protein	18	
Aromild	0.80	0.80
Springarom	1.00	1.00
Salt	0.88	0.88
Garlic Powder	1.50	1.50
Onion Powder	1.50	1.50
Potato starch	0.00	0.00
Refined Sunflower oil	3.00	3.00
Fat Flakes	7.00	8.00
CMC	0.00	0.00
Hot water	30.00	30.00
Cold water	18.00	18.00
Pea fibre	3.00	0.00
Smoky BBQ oleoresin	0.05	0.05
GBP	15	5
Total	100	100



- Overall, GBP @ 15% in the powder form and texturized GBP up to 30% has good potential in the sausage application
- GBP with good water holding properties gives the sausage a good binding, however the overall texture needs to be optimised to have slightly better mouthfeel and reduced dryness
- GBP in powder and texturized is a good alternative for functional ingredients like CMC, Potato starch etc

KEY HIGHLIGHTS IN PROTOTYPE - NUGGETS

Pineapple Fibre Powder @ 15% + Commercial TVP



Texturized GBP-TVP @ 20% + Pineapple Fibre Powder @15%



Formulation with Increase in PFP %

Ingredients	PFP @15%	Extruded GBP-TVP
Cold water	22.00	22.00
Texturised wheat protein (DKSH)	12.67	0.00
Texturised GBP-TVP	0.00	20.00
Hot water	30.00	30.00
Fat flakes	11.00	8.00
Salt	0.83	0.83
Springarom	0.60	0.60
Ajirex - yeast extract	0.25	0.25
Wheat Gluten	3.33	3.33
Chicken flavour	5.00	0.00
Oleoresin		0.50
Pineapple fibre powder	15	15.00
Total	100.00	100.00

- Overall, PFP in the powder form can be explored up to 15% and the texturized GBP can be looked up to 20%.
- Texturized GBP in combination with PFP imparts good binding and texture to the formulation, however the recipe needs optimisation to deliver characteristic fibrous texture of nuggets
- PFP at higher % imparts characteristic fruity/tart note to the final formulation, hence optimisation of recipe with strong meat flavours to be explored
- Higher % of PFP has good water holding capacity thereby making the formulation slightly dry in nature; recipe optimisation in combination with humectants (sugar alcohols, glycerides etc) can address the overall dryness

KEY HIGHLIGHTS IN PROTOTYPE - PATTIES

**PFP @ 15%
+ Commercial TVP**



**Texturized GBP-TVP
@ 20% + Pineapple
Fibre Powder @15%**



Frozen Patties



Patties- Pan frying



Formulation with Increase in PFP %

Ingredients	Pineapple Fibre Powder @ 15%	Texturised GBP-TVP @ 20% + PFP @ 15%
Cold Water	20.00	20.00
Texturised Wheat Protein	6.47	0.00
Texturised Pea Protein	9.70	0.00
Texturized GBP-TVP	0.00	20.00
Hot water	31.50	31.50
Salt	1.00	1.00
Fat Flakes	13.00	13.00
Aromild - Yeast extract	0.24	0.24
Springarom	0.40	0.40
Beef flavour	2.43	2.43
Smoky BBQ oleoresin	0.20	0.20
Onion garlic oleoresin	0.40	0.40
PFP	15	15
TOTAL	100.34	100.00

- Overall, PFP in the powder form can be explored up to 15%
- Texturized GBP up to 20% in the patties still has good potential because of the nature of GBP- that helps in water retention thereby providing characteristic texture to patty formulation
- PFP at higher % imparts characteristic fruity/tart note to the final formulation, hence optimisation of recipe with strong meat flavours to be explored
- Higher % of PFP has good water holding capacity thereby making the formulation slightly dry in nature; recipe optimisation in combination with humectants (sugar alcohols, glycerides etc) can address the overall dryness

MEAT BALLS



PROTOTYPE APPLICATION : BENCHMARK INSPIRATIONS



Ingredients

Water, Soy Protein Concentrate, Sunflower Oil, Coconut Oil, 2% Or Less Of: Dried Garlic, Dried Onion, Methylcellulose, Soy Protein Isolate, Natural Flavours, Yeast Extract, Spices, Wheat Flour, Cultured Dextrose, Salt, Potato Protein, **Food Starch Modified**, Soy Leghemoglobin, Hydrolysed Soy Protein, Citric Acid, Mixed Tocopherols (Antioxidant)



Ingredients

Textured Soy Protein Concentrate, Canola Oil, Wheat Gluten, Soy protein isolate, Wheat flour, **Methyl cellulose, Seasonings & flavourings**



Ingredients

Jackfruit, Water, Soy flour, Coconut oil, Canola oil, White onion, Spices, Natural flavour, Breadcrumbs, Spices, Methyl cellulose, Salt

Methyl cellulose is one of the commonly used ingredients across all brands as a functional additive for binding. Other additives and functional ingredients for binding and texture in the current market sample landscape are majorly modified and native starches. Feed stock like Jackfruit, Green Banana etc also acts as a major functional ingredient as an alternate to texturized proteins.

PROTOTYPE APPLICATION : MEAT BALLS

Product Construct

- Texturized Soy protein/ Dehydrated Jackfruit/ Wheat flour
- Protein concentrates/isolates (pea/soy)
- Fat : Sunflower Oil, Palm oil (fat flakes)
- Starch: GBP/GPP (as alternate to modified starch/other flours in benchmark product)
- Fibre: PPP
- Seasonings and Flavourings

** functional additives (methylcellulose/gums) shall be used wherever relevant to achieve desired texture and binding

Organoleptic attributes

- Juicy/Soft bite
- Salty
- Savoury
- Chicken/Meaty flavour



MEAT BALLS APPLICATION AND PROTOTYPE DEVELOPMENT EXERCISE

Ingredients	Control	9% PFP	6% GBP	3% PFP+6% GBP
Cold Water	12.04	12.27	12.45	12.13
Texturised Wheat Protein	11.11	10.91	11.07	10.74
Texturised Pea Protein	9.26	9.09	9.22	8.95
Refined Sunflower Oil	11.11	10.91	11.07	10.74
Hot water	34.26	33.64	34.12	33.10
Potato Starch	2.78	0.00	0.00	0.00
CMC	2.29	0.00	0.00	0.00
Salt	0.65	0.64	0.65	0.63
Pea Fibre	2.78	0.00	0.00	0.00
Fat Flakes	7.41	7.27	7.38	7.16
Aromild - Yeast extract	0.23	0.22	0.23	0.22
Springarom	0.38	0.37	0.38	0.37
Chicken Flavour	2.29	2.45	2.49	2.42
Garlic Powder	1.71	1.68	2.49	2.42
Onion Powder	1.71	1.68	2.49	2.42
Green Banana powder	0.00	0.00	5.98	5.82
Pineapple Fibre powder	0.00	8.84	0.00	2.91
TOTAL	100.00	100.00	100.00	100.00

Product	Sensorial Observations
Control	Good Colour, chunky Texture & flavour
PFP @ 9%	Slightly darker colour Complete replacement of Pea Fibre, Higher Fibre content.
GBP @ 6%	Darker in colour, comparable in terms of texture & taste of that of standard.
PFP @ 3% + GBP @6%	Darker in colour, Complete replacement of Pea Fibre & Potato starch. Good chunky texture & taste

NUTRITION FACT S/100g	STANDARD	PFP @ 9% + no CMC	GBP @ 6% + no CMC	PFP @ 3% + GBP @ 6% + no CMC
Energy (kcal)	329	340	326	329
Total Fat (g)	22	21	22	21
Sodium (mg)	622	378	401	382
Total Carbohydrate (g)	15	18	14	17
Dietary Fibre (g)	4	9	2	5
Total Sugars (g)	0.3	0.6	0.4	0.4
Added Sugars (g)	0	0	0	0
Protein (g)	16	15	16	16
Calcium (mg)	20	26	24	25
Iron (mg)	3	3	3	3
Potassium (mg)	176	181	269	276

- Key highlights- 100% replacement of potato starch, CMC and Pea fibre by addition of DSI GBP & PFP in the product
- Value addition is brought in terms of providing a nutritional product by bringing out rich in fibre, source of calcium and potassium claims
- GBP addition increases WHC of the product because of higher resistant starch content, whereas PFP also has good WAC by retaining the moisture inside by helping in retain the chunkiness and fibrous meat-like texture. However, increasing the dosages of the same altered the texture by causing pastiness in the product.
- Up to 9% PFP and 6% GBP was ideal for meat balls application
- Functionally, positioning it as a replacement of Native/Modified starches, Stabilizers, Fibres would be an ideal solution in meat balls application

MEATBALLS- PROCESS FLOW & IMAGE GALLERY

CONTROL



PFP @ 9% + no CMC



GBP @ 6% + no CMC



PFP @ 3% + GBP @ 6% + no CMC



- Control- Good meat-like firm and chunky texture
- Meat balls with 6% GBP+ 3% PFP- Darker appearance and a bit pasty inner texture
- GBP @ 6% + No CMC- Similar texture in par with control sample
- PFP-9%- Darker core appearance, however the flavour of pineapple fibre was a bit over-powering when compared to control sample

Hydration of TVP

- Empty the TVP in a bowl and add 69 ml of hot water to it.
- Cover the bowl with a cling wrap to ensure that it is not exposed to air to prevent drying of the TVP.
- Let it rest for at least 20 mins.

Hydration of Binding premix

- Empty the contents of the premix pack in a bowl
- Measure cold water* to the premix at small intervals while mixing it to ensure it is uniformly distributed and lump sizes are small.
- To the given fat flakes and 22g of Refined Sunflower Oil to the premix and blend uniformly until a moist, dough like consistency is achieved.

Preparation of meat balls dough

- Take the Rehydrated TVP and blitz it for 3-4 pulses in the blender to reduce the particle size of TVP.
- Add the hydrated dry mix to the TVP in the blender and blitz it for another 3-4 pulses.
- Knead the dough and split the dough such that you can make around 10 meat balls.
- Shape the meat balls into desirable size as per your preference.

Steaming of Meat balls

- Steam the meat balls in a steamer for about 10 mins.
- After steaming let the meat balls rest in the steamer for 2 min before taking it out.
- Let the meat balls cool down completely for 10-15 mins

Freezing Meat balls

- Once the meat balls cool down, transfer it to a plate and wrap it before placing them in the freezer
- Let it rest for 4 hours, preferably overnight at -18deg C

Frying Meatballs

- Once the meat balls are taken out from the freezer, let it thaw for 30 mins
- Deep fry it over a medium to high flame on a wok

Enjoy

- Serve it hot and enjoy the plant-based meat



PROTOTYPE APPLICATION : BENCHMARK INSPIRATIONS



Ingredients

Water, **Wheat Flour, Soy** Protein Concentrate, Soybean Oil, Sunflower Oil, 2% or less Of: **Potato Starch**, Methylcellulose, Natural Flavours, Salt, Cultured Dextrose, Wheat Gluten, Yeast Extract, **Yellow Corn Flour**, Dextrose, **Food Starch Modified**, Sugar, Garlic Powder, Onion Powder, Spices, Leavening (Cream of Tartar, Sodium Bicarbonate), Dried Yeast, Paprika Extract (for colour), Mixed Tocopherols (Antioxidant)



Ingredients

Vegetable protein preparation (70%) (water, **dehydrated textured wheat proteins (16%) (wheat proteins, wheat flour), rapeseed oil, wheat fibres (wheat fibres, psyllium fibres), egg white powder, modified starch, natural flavouring, thickener (E461)), coating (30%) (breadcrumb (wheat flour, yeast, salt), coating (water, wheat flour), vegetable oils (sunflower oil, rapeseed oil))**



Ingredients

Water, Breadcrumbs, **Refined Wheat Flour** (Maida), Dextrose, Iodized Salt, Yeast., Seasoning Mix [Vegetable fibre, Vegetable protein(soya), Spices and Condiments(Onion), Iodized salt, Stabiliser(INS 461)], Refined Sunflower Oil {Antioxidant (INS 319)}, Batter [Stabilizer (**INS 466**)], **Structured Vegetable protein(Soy wheat gluten, wheat starch), Pea fibre and starch, Seasonings, Flavour enhancer**

Methyl cellulose is one the key ingredient across all brands used as a functional additive for binding. Other additives and functional ingredients for binding and texture in the current market sample landscape are majorly modified and native starches like Potato, Tapioca etc. Fibres like wheat, psyllium etc are also used as binders and also provides desirable characteristic texture to the products

PROTOTYPE APPLICATION : nuggets

Product Construct

- Texturized Vegetable Protein: Soy / Pea / Wheat
- Fat : Sunflower Oil, Palm oil (fat flakes)
- Starch: GBP/GPP (as alternate to modified starch/other flours in benchmark product)
- Fibre: PPP
- Seasonings and Flavourings
- **For Batter:** Breadcrumbs/refined wheat flour/salt/seasoning mix (GBP can be tried as replacement to refined flour in batter to see effect on coating/crispiness)

** functional additives (methylcellulose/gums) may be used wherever relevant to achieve desired texture and binding

Organoleptic attributes

- Crispy/Crunchy texture outside
- Juicy/Soft texture inside
- Salty
- Savoury
- Chicken/Meaty flavour



NUGGETS- APPLICATION AND PROTOTYPE DEVELOPMENT EXERCISE

Ingredients	Control	PFP @ 8%	GBP @ 3.5%	PFP @ 9% + GBP @ 3.5%
Cold water	18.00	22.00	19.00	18.00
Texturised wheat protein	12.42	12.67	12.67	12.00
Hot water	30.00	30.00	30.00	30.00
Refined Sunflower Oil	7.50	7.50	7.50	7.50
Fat flakes	10.00	10.00	10.00	10.00
Salt	0.83	0.83	0.83	0.83
Aromild- yeast extract	0.42	0.42	0.42	0.42
Ajirex - yeast extract	0.25	0.25	0.25	0.25
Wheat Gluten	3.33	3.33	3.33	3.33
Chicken flavour	4.50	5.00	5.00	5.00
Potato Starch	3.00	0.00	0.00	0.00
Pea fibre	8.00	0.00	7.50	0.00
CMC	1.25	0.00	0.00	0.00
Green Banana powder	0.00	0.00	3.50	3.50
Pineapple fibre powder	0.00	8.00	0.00	9.00
Total	100	100	100	100

1. Key highlight- 100% replacement of potato starch, CMC and Pea fibre by addition of DSI GBP & PFP in the product
2. Value addition is brought in terms of providing a nutritional product by bringing out rich in fibre, source of potassium claims
3. GBP addition increases WHC of the product because of higher resistant starch content, whereas PFP also has good WAC by retaining the moisture inside by helping in retain the chunkiness and fibrous meat-like texture. However, increasing the dosages of the same altered the texture by causing pastiness in the product.
4. Up to 8% PFP and 3.5% GBP was ideal for nuggets application
5. Functionally, positioning it as a replacement of Native/Modified starches, Stabilizers, Fibres would be an ideal solution in nuggets application

Product	Sensorial Observations
Control	Good Colour, fibrous meat-like Texture & flavour
PFP @ 8%	A bit Pasty in texture, mouthfeel was a bit dry as well, texture was firm and not that fibrous
GBP @ 3.5%	Texture is comparable to control, yet pasty
PFP @ 9% + GBP @3.5%	Fibrous, yet pasty mouthfeel. Slight bitter after taste is perceived

NUTRITION FACT S/100g	STANDARD	PFP @ 8%	GBP @ 3.5%	PFP @ 9% + GBP @ 3.5%
Energy (kcal)	293	290	291	293
Total Fat (g)	19	20	19	19
Sodium (mg)	557	457	443	433
Total Carbohydrate (g)	15	12	14	15
Dietary Fibre (g)	7	7	7	8
Total Sugars (g)	0	0	0	0
Added Sugars (g)	0	0	0	0
Protein (g)	11	12	12	11
Calcium (mg)	7	14	7	14
Iron (mg)	0.4	1	0.4	1
Potassium (mg)	201	149	260	204

NUGGETS- PROCESS FLOW & IMAGE GALLERY

CONTROL



PFP @ 8%



GBP @ 3.5%



PFP @ 9% + GBP @3.5%



- Control- Good meat-like firm and fibrous texture with a good bite
- Nuggets with 3.5% GBP+ 9% PFP- Darker appearance and a bit pasty denser texture
- GBP @ 3.5% + No CMC- Similar texture in par with control sample, However, it had a pasty texture because of the higher starch content.
- PFP-8%- Little darker core appearance, however the flavour of pineapple fibre was a bit over-powering along with dense inner texture when compared to control sample

Hydration of TVP

- Empty the TVP in a bowl and add 60 ml of hot water to it.
- Cover the bowl with a cling wrap to ensure that it is not exposed to air to prevent drying of the TVP.
- Let it rest for at least 20 mins.

Hydration of Binding premix

- Empty the contents of the premix pack in a bowl
- Measure cold water* to the premix at small intervals while mixing it to ensure it is uniformly distributed and lump sizes are small.
- To the given fat flakes and 15g of Refined Sunflower Oil to the premix and blend uniformly until a moist, dough like consistency is achieved.

Preparation of Nuggets dough

- Take the Rehydrated TVP and blitz it for 3-4 pulses in the blender to reduce the particle size of TVP.
- Add the hydrated dry mix to the TVP in the blender and blitz it for another 3-4 pulses.
- Knead the dough and split the dough such that you can make around 10 nuggets.
- Shape the nuggets into desirable size as per your preference.

Steaming of Nuggets

- Steam the Nuggets in a steamer for about 10 mins.
- After steaming let the nuggets rest in the steamer for 2 min before taking it out.
- Let the nuggets cool down completely for 10-15 mins

Coating of Nuggets

- Once the nuggets have cooled down, Precoat it with Corn starch Slurry (1:1.5: Corn Starch: Water) and then immediately coat it with PanKo Bread Crumbs uniformly on both sides.

Freezing of Nuggets

- Once the nuggets are coated, transfer to a plate and wrap it before placing them into the freezer.
- Let it rest for at least 4 hours, preferably overnight at -18 deg C.

Frying of Nuggets

- Once the nuggets are taken out from the freezer, let it thaw for 30 mins.
- Deep fry it over a medium to high flame on a wok.



PROTOTYPE APPLICATION : BENCHMARK INSPIRATIONS



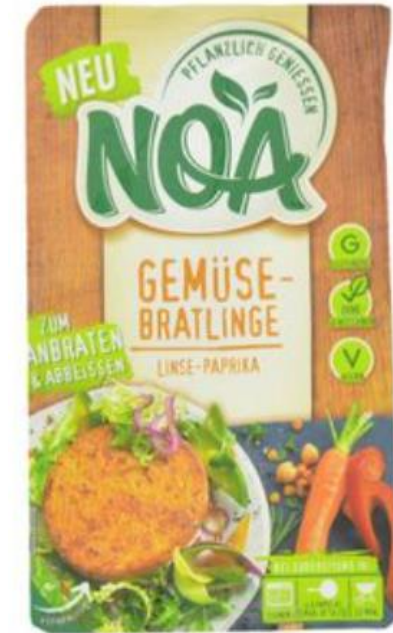
Ingredients

Water, Wheat Flour, Soy Protein Concentrate, Soybean Oil, Sunflower Oil, 2% Or Less Of **Potato Starch**, Methylcellulose, Salt, Natural flavours, Cultured Dextrose, Yeast Extract, Wheat Gluten, Dextrose, Yellow **Corn Flour, Food Starch Modified**, Sugar, Garlic Powder, Onion Powder, Spices, Leavening (Cream of Tartar, Sodium Bicarbonate), Dried Yeast, Paprika Extract (for colour), Mixed Tocopherols (Antioxidant), inc Gluconate, Niacin (Vitamin B3), Calcium Pantothenate (Vitamin B5), Thiamine Hydrochloride (Vitamin B1), Pyridoxine Hydrochloride (Vitamin B6), Riboflavin (Vitamin B2), Vitamin B12.



Ingredients

Water, pea protein, expeller-pressed canola oil, refined coconut oil, rice protein, natural flavours, dried yeast, ~~cocoa butter~~, methylcellulose, and less than 1% of **potato starch**, salt, potassium chloride, beet juice colour, apple extract, pomegranate concentrate, sunflower lecithin, vinegar, lemon juice concentrate, vitamins and minerals (zinc sulphate, niacinamide [vitamin B3], pyridoxine hydrochloride [vitamin B6], cyanocobalamin [vitamin B12], calcium pantothenate)



Ingredients

cooked legumes* (42%) (water, chickpeas, red lentils), vegetables (24%) (peppers puree (21%), carrots (3.5%)), **water, modified starch**, rapeseed oil, quinoa, roasted sunflower seeds, buckwheat, salt, brandy vinegar, spices, herbs, pea **protein, starch**, acidifier (citric acid), thickeners (xanthan, sodium alginate)

Methyl cellulose is one the commonly used ingredient across all brand as a functional additive for binding. Other additives and functional ingredients for binding and texture in the current market sample landscape are majorly modified and native starches like Potato, Tapioca etc.

PROTOTYPE APPLICATION : PATTIES

Product Construct

- Texturized Vegetable Protein: Soy / Pea / Wheat
- Protein concentrates and isolates (soy/pea)
- Fat : Sunflower Oil, Palm oil (fat flakes)
- Starch: GBP/GPP (as alternate to modified starch/other flours in benchmark)
- Fibre: PPP
- Seasonings and Flavourings

** functional additives (methylcellulose/gums) shall be used wherever relevant to achieve desired texture and binding

Organoleptic attributes

- Juicy/Soft bite
- Salty
- Savoury
- Meaty flavour (Beef/Chicken)



PATTIES- APPLICATION AND PROTOTYPE DEVELOPMENT EXERCISE

Ingredients	Control	GBP (5%)	PFP(10%)	GBP (4.5%+10% PFP)
Cold Water	12.34	12.28	12.13	11.84
Texturised Wheat Protein	6.58	6.55	6.47	6.32
Texturised Pea Protein	9.87	9.83	9.70	9.47
Refined Sunflower Oil	11.52	11.46	11.32	11.05
Hot water	32.91	32.75	32.33	31.58
Potato Starch	2.06	0.00	2.02	0.00
CMC	2.47	0.00	0.00	0.00
Salt	1.23	1.23	1.21	1.18
Pea Fibre	5.76	5.73	0.00	0.00
Fat Flakes	8.23	8.19	8.08	7.89
Aromild - Yeast extract	0.25	0.25	0.24	0.24
Springarom	0.41	0.41	0.40	0.39
Beef flavour	2.47	2.46	2.43	2.37
Smoky BBQ oleoresin	0.21	0.20	0.20	0.20
Garlic Powder	1.85	1.84	1.82	1.78
Onion Powder	1.85	1.84	1.82	1.78
GBP		5.00	0.00	4.50
PFP		0.00	10.00	10.00
TOTAL	100	100.00	100.00	100.00

Product	Sensorial Observations
Control	Good Colour, fibrous meat-like Texture & flavour
PFP @ 10%	Good texture, but slightly sour
GBP @ 5%	Texture is fibrous, yet pasty mouthfeel observed
PFP @ 10% + GBP @4.5%	Firm and slightly fibrous in texture observed, yet mouthfeel is pasty

NUTRITION FACT S/100g	STANDARD	PFP @ 10% + no CMC	GBP @ 5% + no CMC	PFP @ 10% + GBP @ 4.5% + no CMC
Energy (kcal)	324	330	311	325
Total Fat (g)	22	21	23	21
Sodium (mg)	742	592	643	563
Total Carbohydrate (g)	16	17	11	18
Dietary Fibre (g)	2	9	2	8
Total Sugars (g)	1	1	0	1
Added Sugars (g)	0.5	0	0	0
Protein (g)	14	13	14	12
Calcium (mg)	24	16	9	15
Iron (mg)	44.8	44	47	42
Potassium (mg)	92	126	171	197

1. Key Highlight- 100% replacement of potato starch, CMC and Pea fibre by addition of DSI GBP & PFP in the product
2. Value addition is brought in terms of providing a nutritional product by bringing out rich in fibre, source of calcium, iron and potassium claims
3. GBP addition increases WHC of the product because of higher resistant starch content, whereas PFP also has good WAC by retaining the moisture inside. The starch content in GBP was more ideal for a patty application because of its pasty texture, as patties are generally consisting of minced meat to finer texture. However, increasing the dosages of the same altered the texture by causing pastiness in the product.
4. Up to 10% PFP and 5% GBP was ideal for patties application
5. Functionally, positioning it as a replacement of Native/Modified starches, Stabilizers, Fibres would be an ideal solution in patties application

PATTIES- PROCESS FLOW & IMAGE GALLERY

CONTROL



GBP @ 5%



PFP @ 10%



GBP @ 4.5% + PFP @ 10%



- Control- Good meat-like firm and fibrous texture with a good bite
- Patties with 4.5% GBP+ 10% PFP -Darker appearance and a bit pasty denser texture. Higher fibre content caused it to be more fibrous which was not very ideal for a patty application
- GBP @ 5% + No CMC- Similar texture in par with control sample, However, it had a pasty texture because of the higher starch content which was like a patty application
- PFP-10%-Little darker core appearance, however the flavour of pineapple fibre was a bit over-powering along with dense inner texture when compared to control sample

Hydration of TVP

- Empty the TVP in a bowl and add 66 ml of hot water to it.
- Cover the bowl with a cling wrap to ensure that it is not exposed to air to prevent drying of the TVP.
- Let it rest for atleast 20 mins.

Hydration of dry mix

- Empty the contents of the premix pack in a bowl
- Measure cold water* to the premix at small intervals while mixing it to ensure it is uniformly distributed and lump sizes are small.
- To the given fat flakes and 24% of Refined Sunflower Oil to the premix and blend uniformly until a moist, dough like consistency is achieved.

Preparation of Patty dough

- Take the Rehydrated TVP and blitz it for 3-4 pulses in the blender to reduce the particle size of TVP.
- Add the hydrated dry mix to the TVP in the blender and blitz it for another 3-4 pulses.
- Knead the dough and split the dough into 4 halves.
- Shape the split dough into patties.

Steaming of patties

- Steam the patties in a steamer for about 10 mins.
- After steaming let the patties rest in the steamer for 2 min before taking it out.
- Let the patties cool down completely for 10-15 mins

Freezing of patties

- Once the patties have cooled down, transfer to a plate and cling wrap it before placing them into the freezer.
- Let it rest for atleast 4 hours.

Cooking of patties

- Once the patties are taken out from the freezer, let it thaw for 30 mins.
- Shallow fry it over a medium flame on a pan.



PROTOTYPE APPLICATION : BENCHMARK INSPIRATIONS



Ingredients

Water, Soy Protein Concentrate, Sunflower Oil, Coconut Oil, 2% Or Less Of: Methylcellulose, Salt, Yeast Extract, Natural flavours, Cultured Dextrose, Food Starch **Modified**, Onion Powder, Garlic Powder, Citric Acid, Spices, Chili Flakes, Cayenne, Soy Leghemoglobin, Mixed Tocopherols (antioxidant), Soy Protein Isolate Vitamins & Minerals: Zinc Gluconate, Niacin, Pyridoxine Hydrochloride (vitamin B6), Riboflavin (vitamin B2), Vitamin B12



Ingredients

Water, pea protein, edible vegetable oil (refined coconut & sunflower oil), rice protein, **faba bean protein, potato starch**, salt, fruit & vegetable concentrate (beetroot, carrot, pepper), **apple fibre**, citrus extract, stabilizer (INS 461 & INS 404)



Ingredients

Water, Soy Protein Concentrate, Natural flavours (Includes Onion and Garlic), High Oleic Sunflower Oil, Soy Protein Isolate, **Modified Vegetable Gum**, Beet Powder (colour), Caramel colour

Methyl cellulose is one the key ingredient across all brands used as a functional additive for binding. Other additives and functional ingredients for binding and texture in the current market sample landscape are majorly modified and native starches like Potato, Tapioca etc. Fibres like wheat, psyllium etc are also used as binders and also provides desirable characteristic texture to the products

PROTOTYPE APPLICATION : SAUSAGE

Product Construct

- Texturized Vegetable Protein: Soy / Pea
- Protein concentrates/isolates (pea/mycelial protein)
- Fat : Sunflower Oil, Palm oil (fat flakes)
- Starch: GBP/GPP (as an alternate to modified starch/other flours in benchmark product)
- Fibre: PPP
- Seasonings and Flavourings

** functional additives (methylcellulose/gums) shall be used wherever relevant to achieve desired texture and binding

Organoleptic attributes

- Juicy/Soft texture
- Salty/Savoury
- Chicken/Meaty flavour



SAUSAGE- APPLICATION AND PROTOTYPE DEVELOPMENT EXERCISE

Formulation	DOE 1	DOE 2	DOE 3	DOE 4	DOE 5
TDU TVP		20			
TVP Pea protein	20.00		18	20	18
Aromild	0.80	0.80	0.80	0.80	0.80
Springarom	1.00	1.00	1.00	1.00	1.00
Salt	0.88	0.88	0.88	0.88	0.88
Garlic Powder	1.50	1.50	1.50	1.50	1.50
Onion Powder	1.50	1.50	1.50	1.50	1.50
Potato starch	1.00	1.00	0.00	1.00	0.00
Refined Sunflower oil	3.00	3.00	3.00	3.00	3.00
Fat Flakes	11.00	11.00	11.00	11.00	11.00
CMC	2.50	2.50	0.00	0.00	0.00
Hot water	33.00	33.00	33.00	32.50	32.00
Cold water	21.00	21.00	21.00	21.00	21.00
Pea fibre	3.00	3.00	3.00	0.00	0.00
Smoky BBQ oleoresin	0.05	0.05	0.05	0.05	0.05
GBP			5		3.5
PFP				6	6
Total	100	100	100	100	100

Product	Sensorial Observations
Control (DOE-1)	The sausages were holding the shape, firm with good outer casing. The inner was a bit pasty though.
Extruded TVP-GBP (DOE-2)	The texture was firmer than the control sample, the colour was more ideal for a sausage. The inner texture was chunky and a bit pasty too.
GBP @ 5%- (DOE 3)	The texture of the sausage was pasty when compared to the control and extruded TVP sausages. The inner portion was completely pasty
PFP @ 6%- (DOE 4)	The sausages didn't hold the shape at all.
PFP @ 6% + GBP @ 3.5%- (DOE 5)	The sausages completely disintegrated

1. Key highlight- 100% replacement of potato starch, CMC and Pea fibre was evaluated. However, 100% replacement of texturized protein was the key highlight by addition of DSI Extruded GBP in the product
2. Value addition is brought in terms of providing a nutritional product by bringing out rich in fibre, source of potassium claims.
3. Up to 6% PFP and 5% GBP was evaluated for sausages application
4. Functionally, positioning it as a replacement of existing texturized soy/pea/wheat protein would be ideal. Also, extruded version of GBP worked well for sausage application

NUTRITION FACT S/100g	Control (DOE 1)	Extruded TVP- GBP (DOE-2)	GBP @ 5%- (DOE 3)
Energy (kcal)	305	325	307
Total Fat (g)	19	20	19
Sodium (mg)	909	653	634
Total Carbohydrate (g)	12	8	14
Dietary Fibre (g)	4	2	4
Total Sugars (g)	0.5	0.5	0.5
Added Sugars (g)	0	2	0
Protein (g)	19	19	18
Calcium (mg)	20	20	19
Iron (mg)	5	5	5
Potassium (mg)	119	77	218

**EXTRUSION OF TVP's
USING GREEN
BANANA POWDER
AND PINEAPPLE
FIBRE POWDER**



PROTOTYPE APPLICATION : BENCHMARK INSPIRATIONS



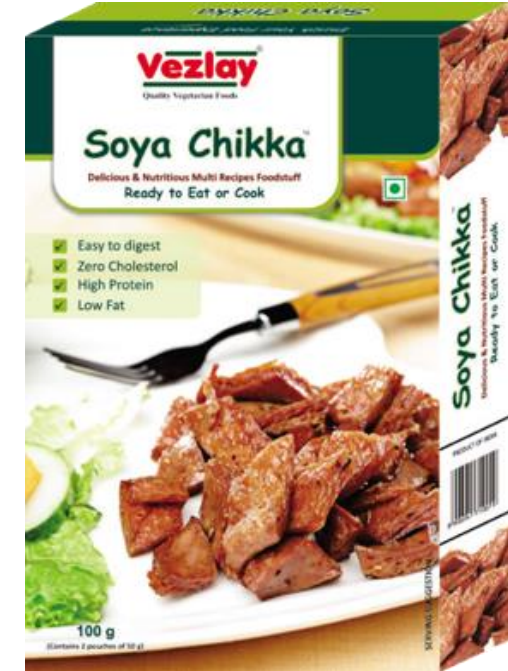
Ingredients

Water, Soy Protein Concentrate, Sunflower Oil, Coconut Oil, Natural Flavours, 2% Or Less Of: Methylcellulose, Cultured Dextrose, **Food Starch Modified**, Yeast Extract, Soy Leghemoglobin, Salt, Mixed Tocopherols (Antioxidant), L-tryptophan, Soy Protein Isolate



Ingredients

Isolated Soy Protein, Mushroom Chunk, Textured Soy Protein, **Starch**, Water, Vegetable Oil, Vegetarian Seasoning



Ingredients

Vegetable Protein(Soy), Wheat Flour, Wheat Proteins, Rice, **Starch**, Vegetable Oil, Spices & Condiments.

Modified starch, Native starches (potato,tapioca) are most commonly used as binders across texturised vegetable protein products

PROTOTYPE APPLICATION : MEAT ANALOGUES

Product Construct

- Protein Isolates/Concentrates: Soy / Pea / Mycelial protein/ Algal protein
- Fat : Sunflower Oil
- Starch: GBP/GPP (as alternate to modified starch/other flours in Control)
- Fibre: PFP
- Seasonings and Flavourings

Organoleptic attributes

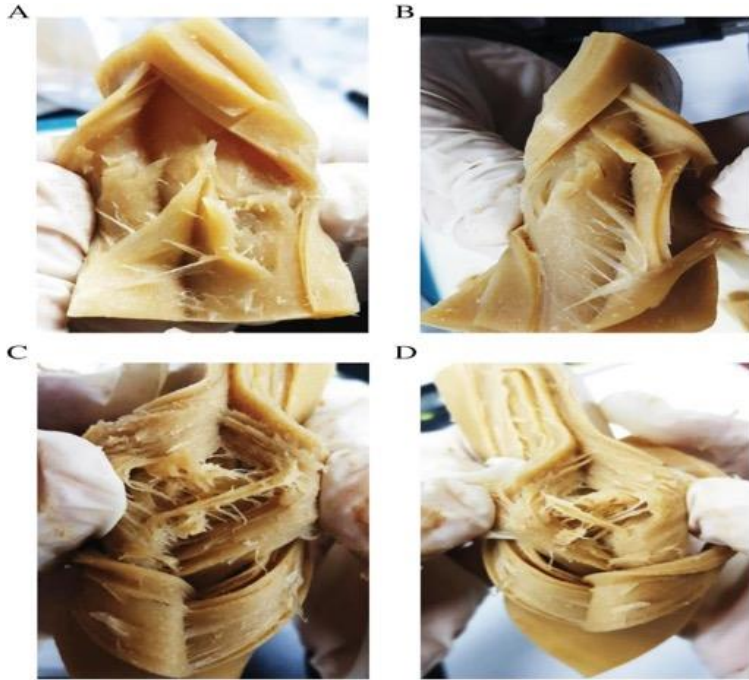
- Fibrous meaty texture
- Chunky and juicy
- Salty
- Savoury
- Meaty flavour (Beef/Pork/seafood/chicken)

Process Technology:

Extrusion (High Moisture and Low Moisture)



HIGH MOISTURE MEAT ANALOGUES



- This type of textured product is remarkably like meat in appearance, texture and mouthfeel when properly cooked.
- A special extruder configuration and die design is used to produce this type of product.
- Structured meat analog has a striated, layered structure like muscle meat.
- Typically, it contains at least 60–70% moisture, 2–5% oil, and 10–15% protein. Once it is made, it must be frozen for storage because of high moisture content or retorted in cans for longer shelf life

LOW MOISTURE MEAT ANALOGUES



Products prepared by the low-moisture extrusion technique have a porous structure and must be rehydrated with water; absorption volume 3 times the weight of dried product and rehydration time of min 15 minutes in boiling water



This is generally processed using low-moisture twin-screw extrusion technology. Dry TVP is composed of pre-combined dry ingredients and water and does not generally include fats during extrusion. Post-extrusion, it is passed through a dryer, packaged, and sold as a finished ingredient or further used in formulations to create alternate meat products like nugget, patty, sausage etc

KEY OBJECTIVES & DESIGN OF EXPERIMENTS

- To develop dry TVP using Isolated Soy Protein as control.
- To incorporate Green Banana powder, Pineapple Fibre powder to understand their role as starches/fibres in enhancing the texture of TVP.
- To evaluate the Dry TVP in end use application- i.e., Patties, Nuggets, Meat balls, Sausages etc.

DESIGN OF EXPERIMENTS

S. No	Blends	Ratio
1.	ISP	100%
2.	ISP:GBP	80:20
3.	ISP:GBP:PFP	70:20:10

ISP – Isolated Soy Protein
GBP – Green Banana Powder
PFP – Pineapple Fibre Powder

DRY BLEND BEFORE EXTRUSION



EXTRUDER



Brabender- twin screw extruder (4-zone)

Machine Specifications

- Temperature control: partially or fully tempered liner
- Screw length (D : L): diameter 20, length 40
- Drive power: 3 x 400 V; 9,5 kW / 3 x 230 V; 16 kW
- Speed: 600 min⁻¹ – 1.200 min⁻¹
- Max. torque: 2 x 40 Nm
- Max. working temperature: 250 °C – 400 °C
- Max. throughput: 1 - 20 kg/h*
- Segmented screw: yes
- Screw rotation: co-rotating
- Special features: horizontally split barrel
- Dimensions (L x W x H): 2013 x 606.5 x 1566 mm
- Weight: approx. 480 kg

*depending on raw material and application



Low / High Moisture Extrusion / Protein Texturization

- Low-moisture extrusion: After being denatured in the screw section of the TwinLab-F 20/40, the proteins are flash-expanded in the die section. Dry extruded proteins are hydrated after extrusion and often optionally coated with flavors.
- High-moisture extrusion: The cooling section allows cooling of the denatured protein in order to build a laminar structure.
- Examples: texturized protein chunks, vegan patties, pasta sauce or nuggets

EXTRUDED TVP- MOISTURE AND NUTRITIONAL ANALYSIS

S. No	Blends	Ratio	Initial moisture of the blend before extrusion	Moisture during extrusion	Final moisture of the dry TVP's
1.	ISP	100%	7.4%	23%	4.2%
2.	ISP : GBP	80:20	8.0%	23%	2.7%
3.	ISP : GBP : PFP	70:20 :10	7.6%	26%	1.08%

Nutrition Facts # Approx values per 100g	CONTROL 100% ISP	ISP (80%): GBP (20%)	ISP (70%): GBP (20%): PFP (10%)
Energy (kcal)	368	377	400
Protein (g)	91	75	67
Total Fat (g)	0.5	1	1
Total Carbs (g)	0	18	27
Total Sugars (g)	0	0	0.3
Dietary Fibre (g)	0	1.5	9
Sodium (mg)	0	0	0
Calcium (mg)	0	0	8
Magnesium (mg)	0	17	21
Phosphorous (mg)	0	0	5
Potassium (mg)	0	340	400
Iron (mg)	0	0.3	1

EXTRUDED TVP- BULK DENSITY

CONTROL – 100%
Isolated Soy
Protein



B.D – 0.12 g/ml

80:20 – 80% Isolated
Soy Protein, 20% GBP



B.D – 0.12 g/ml

Density was comparable
with control

70:20:10 – 70%
Isolated Soy Protein,
20% GBP, 10% PFP



B.D – 0.21 g/ml

Density was found to be higher
with the addition of fiber

REHYDRATION OF EXTRUDED TVP IN HOT WATER

Control -
Rehydration at 0
minutes



Control -
Rehydration after
20 minutes



80:20 -
Rehydration at 0
minutes



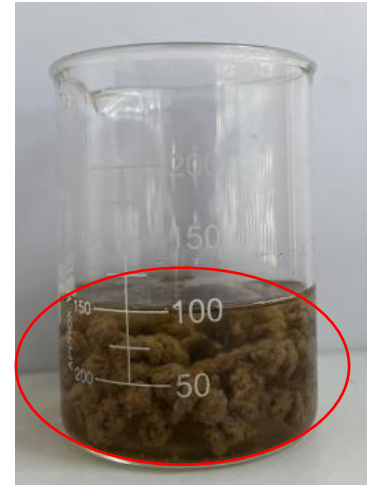
80:20 -
Rehydration after
20 minutes



70:20:10 -
Rehydration
at 0 minutes



70:20:10 -
Rehydration after
20 minutes



Colour and fibrous texture was appealing, rate of rehydration and expansion was good

Fibrous and comparable with control; rate of rehydration and expansion was good

It was denser and sticky in nature, completely submerged after 20 minutes of rehydration

OBSERVATIONS AND FINDINGS- POST REHYDRATION

CONTROL – 100% Isolated Soy Protein



Fibrous texture

80:20 – 80% Isolated Soy Protein, 20% GBP



Fibrous and comparable with control

70:20:10 – 70% Isolated Soy Protein, 20% GBP, 10% PFP



Pasty in texture

OTHER EXTRUSION TRIALS



**80 % : ISP
20% : Fermented Chickpea
flour**



**60 %: ISP,
14 % : Fermented Chickpea
flour,
26 % : GBP**

Observations:

- 1. 80 % : ISP 20% : Fermented Chickpea flour** – Product did not get puffed up because of the nature of the chickpea flour.
- 2. 60 %: ISP, 14% : Fermented Chickpea flour, 26% : GBP**
Addition of GBP aided in a better puffed product when compared with 1st formulation.
Highlighting the extrusion friendly nature of GBP.
But this hindered the rehydration of the product resulting in a dense texture.

EXTRUDED TVP APPLICATION- IMAGE GALLERY



CONTROL – 100%
Isolated Soy
Protein



80:20 – 80% Isolated
Soy Protein, 20% GBP



70:20:10 – 70%
Isolated Soy Protein,
20% GBP, 10% PFP

PATTIES-COMPARISON OF CONTROL & EXTRUDED TVP (80 ISP : 20 GBP)

Ingredients	DOE 1 CONTROL TVP	DOE 2 EXTRUDED TVP (80:20)	DOE 3 CONTROL TVP + GBP	DOE 4 EXTRUDED TVP (80:20) + GBP
Cold Water	12	12	12	12
Texturised Pea Protein	20		20	
Texturised Soy protein with GBP (80:20)	0	21.5	0	20
Refined Sunflower Oil	8	8	8	8
Hot water	38.05	38.05	39.43	39.43
Potato Starch	2.56	1.06	0	0
CMC	1.28	1.28	0	0
Salt	1	1	1	1
Pea Fibre	5	5	5	5
Fat Flakes	6	6	5.46	5.46
Aromild - Yeast extract	0.3	0.3	0.3	0.3
Green Banana powder	0	0	3	3
Beef flavour	0.8	0.8	0.8	0.8
Smoky BBQ oleoresin	0.01	0.01	0.01	0.01
Garlic Powder	0.5	0.5	0.5	0.5
Onion Powder	0.5	0.5	0.5	0.5
BreadCrumbs	4	4	4	4
TOTAL	100.00	100.00	100.00	100.00

SENSORIAL OBSERVATIONS WITH IMAGES



**CONTROL TVP
(Pea Protein)**

Characteristic texture, good crispy outer structure, lightly pasty inside. Had a good bite.



**CONTROL TVP
with GBP
(Powder form)**

Texture was not pasty. Structure and bite was slightly firm, comparable to a beef patty. Fatty mouthfeel noted.



**Extruded TVP
Soy (80:20)**

Better texture when compared with control but slightly soft in the centre. Besides that, there was a chewiness and umami note.



**Extruded TVP (80:20) with
GBP (Texturized form)**

Texture was chunky and chewy, structure was firmer.



1·2 **taste**

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