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Initial exploration of the techno-functional properties of Bynda

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1. Background

UPP have developed a process to utilise remaining parts of broccoli after harvest to create value added food ingredients. They have a protein, starch and fibre stream. It is the fibre stream, Bynda, which has been discussed with SPG Innovation and will be the focus of this work. UPP would like to understand the functional properties of their Bynda ingredient to support applications work and sales activities.

The following work has been planned to deliver a body of evidence which demonstrates the technical functionality of the broccoli fibre and how this can best be used in food applications.

2. Materials

Bynda was supplied by UPP, the remainder of the materials were sourced by SPG Innovation. A list of these materials can be found in Table 2.1.

Table 2.1 Ingredient list including the suppliers

Ingredient	Supplier
Reverse osmosis water	Waternation
Sodium hydroxide (0.1M)	Scientific Laboratory Supplies
Hydrochloric acid (1M)	Scientific Laboratory Supplies
Vegetable oil	COOP

Specific batch information is available upon request

3. Methods

3.1. Water Holding Capacity

Water Holding Capacity (WHC) is the ability of a material to retain water within its structure. It measures how much water a substance can absorb and hold without releasing it, even under centrifugation.

Samples of 0.45g were dispersed in 15 mL of reverse osmosis (RO) water and mixed using vortex (Stuart, UK) at 2,500 rpm for 30 seconds. Then, the dispersions were adjusted to different pHs (pH 4.0, pH 7.0) ±0.05 by drop wise addition of 0.1 M NaOH or 1 M HCl. RO water was added to the dispersion to adjust the final volume to 22.05 ml. The dispersion was mixed on vortex at 2,500 rpm for 30 seconds. The samples were stored for 24 hours at room temperature.

The dispersion was mixed on vortex at 2,500 rpm for 30 seconds. The samples were centrifuged at 1,800g for 10 minutes (IEC, USA). The supernatant was pipetted off, and the dry material weight was recorded (Ohaus, USA). Tests were performed in triplicate.

Adapted from AACC Method 88-04 (1983), which was developed by Quinn and Paton (1979).

The WHC was calculated using the following equation:

$$WHC\ (\%) = \frac{Weight\ of\ water\ retained\ (g)}{Weight\ of\ dry\ material}$$

3.2. Oil Holding Capacity

Oil Holding Capacity (OHC) is the ability of a material to retain oil within its structure. It measures how much oil a substance can absorb and hold without releasing it, even under centrifugation.

Samples of 0.45g were dispersed in 22.05 mL of vegetable oil and mixed using vortex (Stuart, UK) at 2,500 rpm for 30 seconds. The samples were stored for 24 hours at room temperature.

The dispersion was mixed on vortex at 2,500 for 30 seconds. The samples were centrifuged at 1,800g for 10 minutes (IEC, USA). The supernatant was pipetted off, and the dry material weight was recorded (Ohaus, USA). Tests were performed in triplicate.

Adapted from AACC Method 88-04 (1983), which was developed by Quinn and Paton (1979).

The OHC was calculated using the following equation:

$$OHC\ (\%) = \frac{Weight\ of\ oil\ retained\ (g)}{Weight\ of\ dry\ material}$$

3.3. Gelation

Least gelation concentration (LGC) is the minimum concentration of a substance (usually a protein or hydrocolloid) in a solution or dispersion required to form a gel under specified conditions, such as pH.

Aliquots of 0.1 M NaOH, 1 M HCl, or RO water were dispensed into centrifuge tubes and mixed using a vortex mixer (Stuart, UK) at 2,500 rpm for 5 seconds. Samples were prepared at concentrations of 4%, 6%, 8%, 10%, 12%, 14%, 16%, 18%, and 20% (w/v) and dispersed in the respective solutions. The dispersions, pH 4.0, pH 7.0, or left unadjusted, were brought to a final volume of 5 mL, and mixed using a vortex mixer (Stuart, UK) at 2,500 rpm for 30 seconds.

Next, the test tubes were heated at 90°C for 1 hour in a water bath (SLS, UK). After heating, the centrifuge tubes were promptly cooled under running tap water for 10 min and then kept in a refrigerator at 4°C for 2 hours.

The strength of the coagulum formed was assessed by turning the tube upside down. The lowest concentration, which formed a stable gel, was considered the LGC.

Method obtained from Brishti et al. (2017) which was adapted from Circle et al. (1964).

4. Results

4.1. Water Holding Capacity

During the pH adjustment step, it was noted that the un-adjusted pH of the Bynda in a 2% suspension was pH 4.3. For a control, WHC values were taken from Bynda with no pH adjustment. It was noted that the supernatant of samples with no adjustment and pH 4.0 was a golden yellow colour. However, at pH 7.0 the supernatant colour changed a peachy orange colour.

The highest WHC value was recorded when the pH was adjusted to pH 7.0 at 15.28ml/g. The lowest WHC value was recorded on the Bynda with no pH adjustment at 14.46ml/g. The samples were not statistically significant from each other.

Table 4.1 WHC of Bynda with no adjustment and with the pH adjusted to pH 4.0 and pH 7.0.

Sample	WHC (ml/g)
No adjustment	14.46 ± 0.28
pH 4.0	15.18 ± 1.48
pH 7.0	15.28 ± 0.87

Mean values ± standard deviation.

4.2. Oil Holding Capacity

OHC tests concluded that Bynda can hold 2.47g of oil per 1g which can be converted to 2.69ml of oil per 1g. The density of vegetable oil is 0.917g/ml (Andrade et al., 2013).

Table 4.2 OHC of Bynda

Sample	OHC (g/g)	OHC (ml/g)
Bynda	2.47 ± 0.17	2.69 ± 0.18

Mean value ± standard deviation.

4.3. Gelation

Gelation tests concluded that Bynda has an LGC of 8% across all tested conditions.

Table 4.3 LGC of Bynda with no adjustment and with the pH adjusted to pH 4.0 and pH 7.0.

Sample	LGC (%)
No adjustment	8 ± 0
pH 4	8 ± 0
pH 7	8 ± 0

Mean value ± standard deviation.

5. Discussion

5.1. Water Holding Capacity

Bynda has a WHC of 14.46ml/g, as shown in table 5.1. From our experience, we know of fibre suppliers who market their materials solely for their water holding/ water absorption abilities, their products' WHC sit in the range from 4.2 to 15g/g. Other suppliers have modified fibre material, such as Carboxymethyl cellulose (CMC), which have high WHCs, we have seen up to 25g/g.

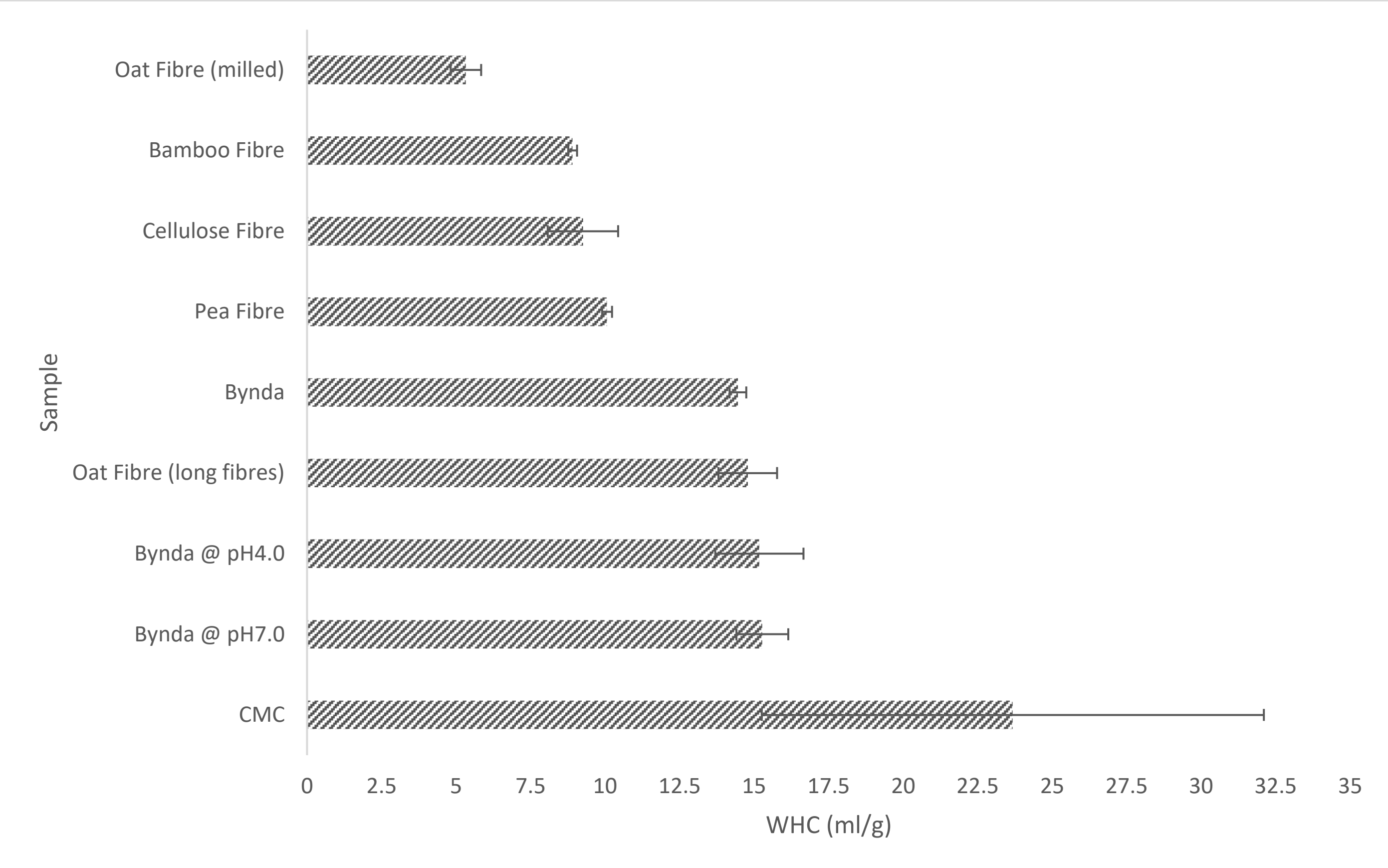

Figure 5.1 Comparison of mean WHC values of Bynda against competitor fibres. Error bars represent the standard deviation. SPG Innovation data.

Figure 5.1 demonstrates Bynda's strong WHC capabilities compared to commercial fibres. Bynda's WHC outperforms many fibres. CMC, a modified cellulose derivative, was the only tested sample to outperform Bynda. Bynda has a significant advantage as, to SPG Innovation's knowledge, there is no 'modification' label needed for Bynda. Which would sit as a 'natural' alternative whilst delivering a strong WHC functionality.

A high WHC provides many functional properties to a variety of food matrices. Binding and retaining water within a food matrix improves yield, binds ingredients together, reduces cook loss and reduces syneresis during both thermal processing and storage. Increased water retention contributes to an improved texture, juiciness and succulent mouthfeel. In addition, a high WHC can control the formation of ice crystals, as to increase the stability during the freezing and thawing process (Gelroth & Ranhotra, 2001).

The following product categories benefit from high WHC ingredients:

- Meat & plant-based meat
- Bakery
- Dairy & ice cream
- Sauces and dressings
- Beverages

5.2. Oil Holding Capacity

Table 4.2 shows the OHC of Bynda is 2.47g/g which when compared to literature is relatively high for a vegetable fibre. For reference, a paper records the OHCs of several commercial to be 1.34-1.76 g/g for citrus fibre, 1.85-3.13 g/g for pea fibre and 1.48-4.41 g/g for oat fibre (Wagner, Richter and Ganjyal, 2024). Dry Fiba's OHC abilities place it within the range of fibres on the market which are sold for their OHC capabilities.

Oil holding can reduce fat migration, enhance texture and mouthfeel and improve flavour retention. A high OHC helps to create rich creamy and smooth textures in food products such as sauces and spreads. This techno-functional property can be exploited in the form of fat reduction as foods with high OHC can mimic the mouthfeel of fat. As high OHC ingredients support uniform fat distribution and reduce phase separation, they are valuable in emulsified food matrices and those which contain lipids.

The following product categories benefit from high OHC ingredients:

- Sauces, dressings and spreads
- Bakery
- Dairy
- Fried and coated products

5.3. Gelation

Table 4.3 shows the LGC of Bynda in all conditions tested was 8%. Altering the pH does not affect the gelation properties of Bynda which allows this functionality to be used in a variety of food matrices.

Comparing Bynda's LGC to those recorded in literature, Bynda has a low LGC which highlights its ability to gel. Typical LGC values vary depending on the type of material. Protein isolates such as soy, pea, fava bean and lentil have a range of LGC from 12% to 15% as reported by Ma *et al.* (2022). Whole cereal flours often have a lower LCG. Wheat, rice and potato flours have a range of LGC from 6% to 8% as reported by Chandra and Samsher (2013).

A low LGC shows that Bynda can form a stable gel network at a relatively low usage level. Meaning Bynda can bind or set food matrices. This property is particularly beneficial in foods where phase separation would negatively affect the quality of the product. Such as, emulsified and high moisture food products.

The following product categories benefit from low LGC ingredients:

- Plant based meat analogues
- Emulsified meat products e.g. sausages and pates
- Plant based dairy products
- Bakery fillings and fruit preparations
- Desserts e.g. puddings

6. Conclusion

Overall, Bynda demonstrates strong techno-functional properties. The WHC positions Bynda at the upper end of unmodified commercial fibres and is comparable to chemically modified fibres. Bynda has a significant benefit of being a clean label ingredient. The OHC of Bynda sits within the range of fibres marketed for their oil binding abilities. The low LGC % of Bynda indicates efficient gel network formation at low usage levels.

When considered holistically, these techno-functional properties position Bynda as a functional ingredient with a wide range of potential applications. Including meat and plant-based meat, bakery, dairy and plant-based dairy, dressings, sauces, ice cream and beverages.

7. Next Steps

The initial exploration of the techno-functional properties of Bynda has shown it's potential as a functional ingredient. There are other tests which SPG Innovation can perform to test other functionalities including but not limited to:

- Emulsion activity
- Foaming capacity and foaming stability
- Water absorption and water solubility

In addition to techno-functional testing, SPG Innovation would recommend trialling Bynda within product applications. SPG Innovation can trial Bynda within plant-based meat analogues, sauces and beverage amongst many other applications. We have a flexible and agile approach to working with our trusted clients and would be happy to work up some next steps concepts together.

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