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Macauba (*Acrocomia aculeata*) pulp cell wall polysaccharides: Fractionation and evaluation of functional and rheological properties

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Macauba Palm

- Macauba palm is a tropical palm tree native to South America[1]
- Macauba palm is a promising energy crop:
  - High oil productivity: 2.5 – 5.0 tons of oil/hectare/year[1]
  - Integrated crop-livestock and forest-farming systems[2]
  - Does not compete with rainforest for land[1,2]
  - In Brazil, extensive native palm tree reservations can be found nationwide[2]
  - First commercial initiatives started in the past decade[1]

1 – Colombo et al., OCL. 2018; 25(1): D108
2 – Cardoso, A. et al. Ind. Crops Prod. 2017; 107: 573-580.

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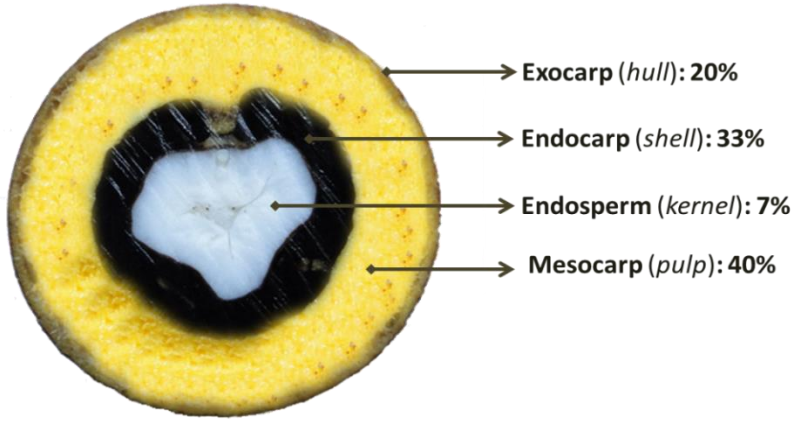
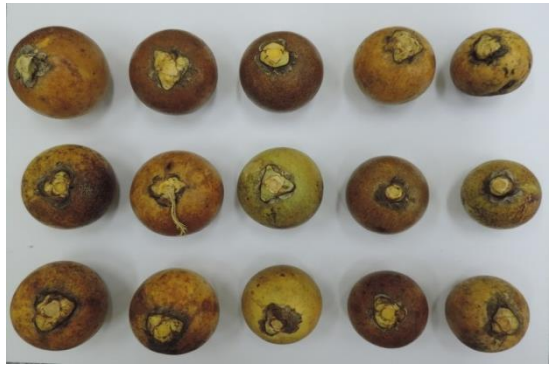
Macauba Fruits

The fruits are composed of five fractions

- Pulp and kernel are the main fractions of industrial interest due to a high oil content
- High potential as a multipurpose crop, with high potential for the simultaneous production of oil, proteins, and dietary fibers





Data from [3-5]

3 – Pires et al., Ind. Crops Prod. 2013; 44: 200.
4 – Sanjinez-Argandoña & Chuba, Rev. Bras. Fruct. 2011; 33: 1023.
5 – Lescano et al., African Journal of Food Science. 2015; 9: 113.

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Composition of Macauba De-oiled Pulp Meal

MESOCARP (PULP)

OIL

PULP MEAL

Component	Content (% DM)
Oil	0.9
Ash	6.2
Protein	5.9
Starch	15.1
Soluble dietary fibers	17.7
Insoluble dietary fibers	23.1
Carbohydrates	31.1

40.1% Total dietary fiber

Potential new source for sustainable and healthy food ingredients

Objectives

1. Fractionation and isolation of Macauba Cell Wall Polysaccharides (CWP)
2. Evaluate the rheological and functional properties of macauba CWP
3. Assess the potential of CWP fractions as food ingredients

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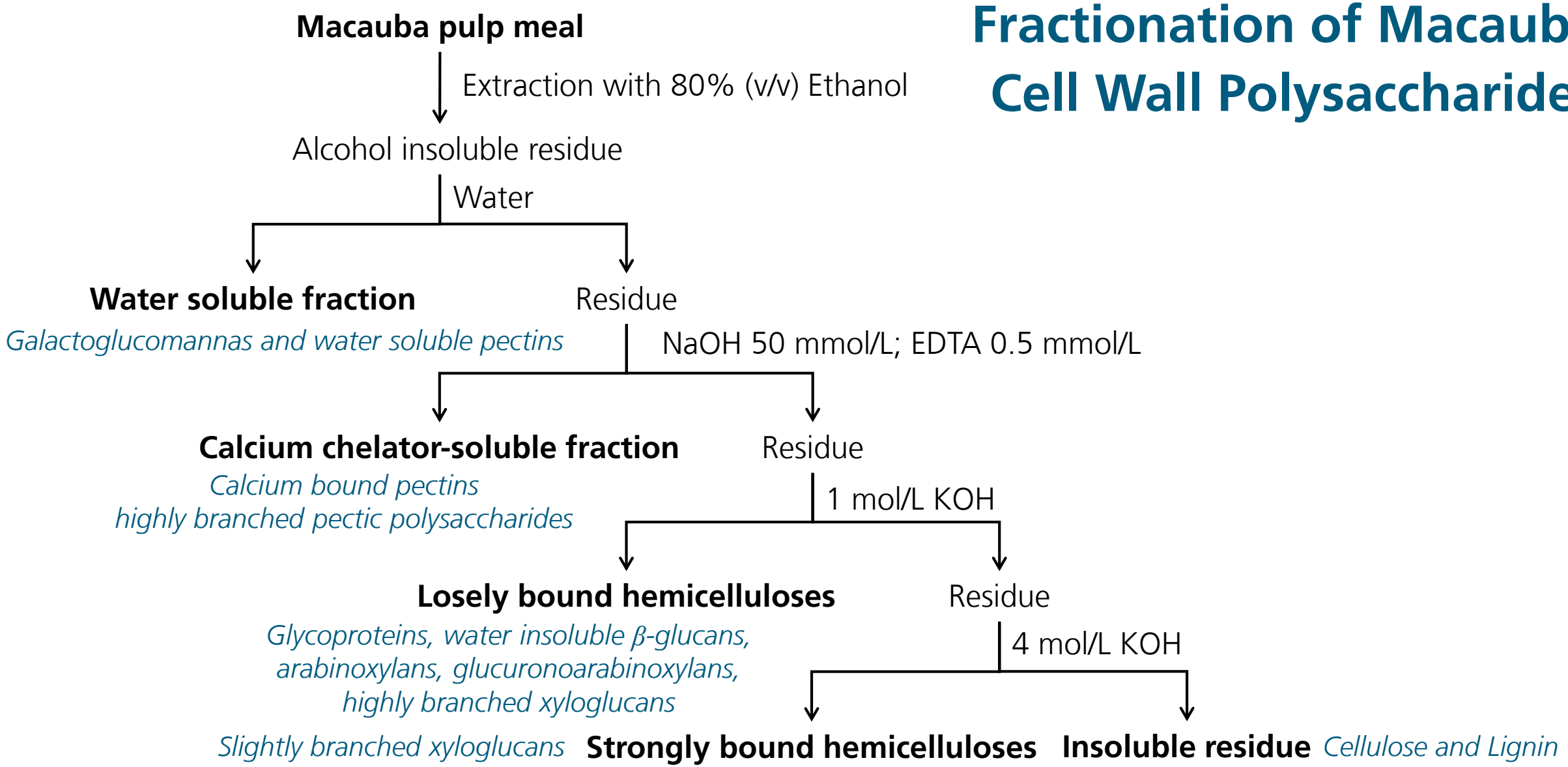
Fractionation of Macauba Cell Wall Polysaccharides



Yield of Macauba Polysaccharide Fractions

Polysaccharide fraction	Relative content (%)			
	Macauba	Apple[6]	Olive[7]	Tomato[8]
Water soluble fraction	**21.8 ± 0.8^{c}**	5.6	Not reported	5.1
Calcium chelator-soluble fraction	4.1 ± 0.3^{e}	4.4	17.4	38.6
Loosely bound hemicelluloses	**27.6 ± 0.3^{b}**	Not reported	10.5	24.1
Strongly bound hemicelluloses	7.3 ± 0.2^{d}	16.8	4.9	29.1
Cellulose and lignin (insoluble residue)	**39.2 ± 0.4^{a}**	35.6	Not reported	Not reported

- High content of water soluble polysaccharides
- Main fractions: water-soluble, loosely bound hemicelluloses and cellulose and lignin

6 – Fügel et al. Food Chemistry. 2004; 87(1), 141-150.
7 – Coimbra et al. Carbohydrate Research. 1994; 252, 245-262.
8 – Li et al. Carbohydrate polymers. 2019; 219, 181-190.

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Functionality of Macauba Polysaccharide Fractions

Polysaccharide fraction	Water binding capacity (mL/g DM)	Oil binding capacity (mL/g DM)
Water soluble fraction	ND	1.2 ± 0.1[b]
Calcium chelator-soluble fraction	1.4 ± 0.3[c]	1.4 ± 0.1[b]
Loosely bound hemicelluloses	4.6 ± 0.2[b]	1.1 ± 0.3[b]
Strongly bound hemicelluloses	8.8 ± 0.3[a]	1.1 ± 0.2[b]
Cellulose and lignin (insoluble residue)	8.8± 0.1[a]	8.2 ± 0.3[a]

Rice bran dietary fiber[9]:
WBC: 4.9 mL/g
OBC: 4.5 mL/g

Orange alcohol insoluble residue[10]
WBC: 15.5 mL/g
OBC: 5.1 mL/g

Tomato peel fiber[11]
WBC: 6.8 mL/g
OBC: 1.5 mL/g

- Variability in functionality of polysaccharide fractions:
  - Difference in chemical composition and molecular structure
  - Wide range of possible applications

- Functionality within the range of other sources of dietary fiber

9 – Abdul-Hamid et al. Food chemistry. 2000; 68(1), 15-19.
10 – Chau et al. J. Agric. Food Chem. 2003; 51(9), 2615-2618.
11 – Navarro-González et al. Food Res. Int. 2011; 44, 1528–1535.

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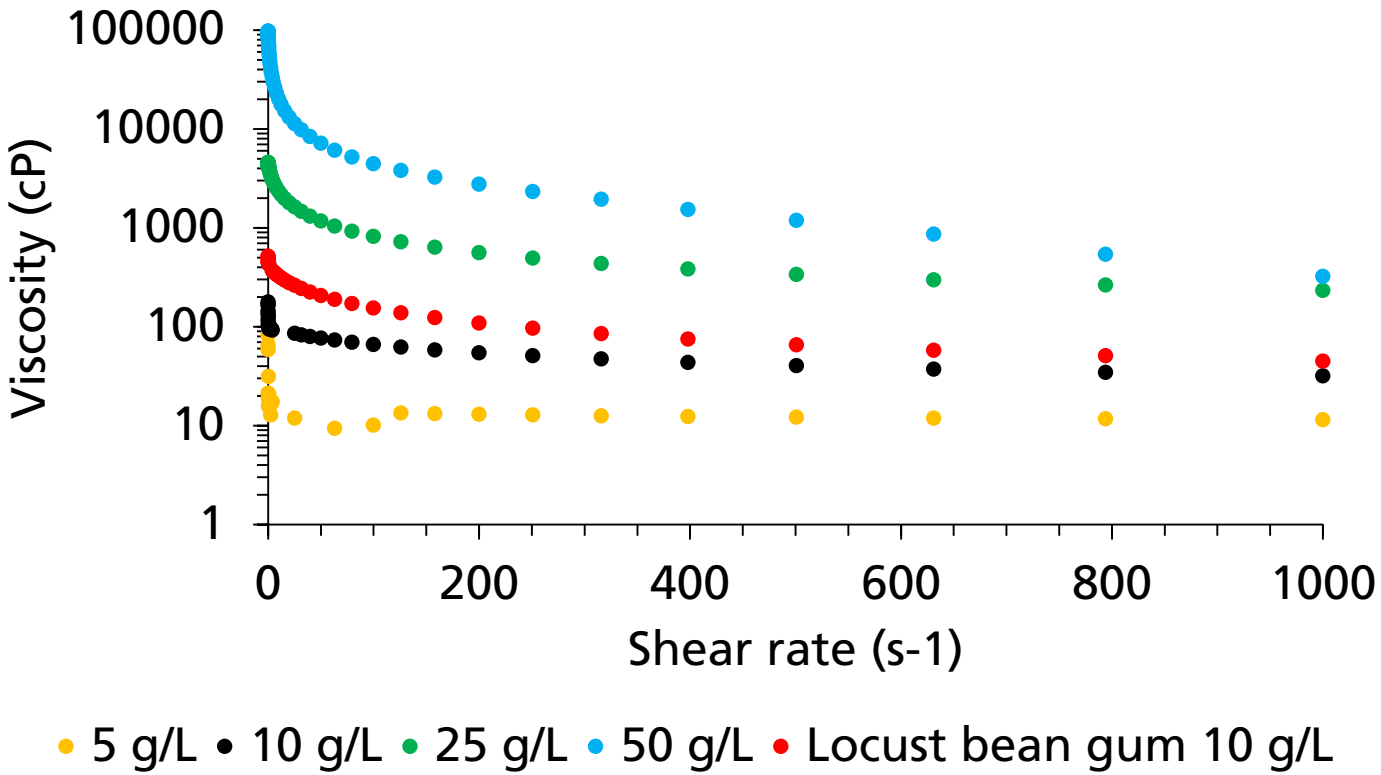
Rheological Properties of Macauba Polysaccharide Fractions

Flow Behavior of the Water Soluble Fraction

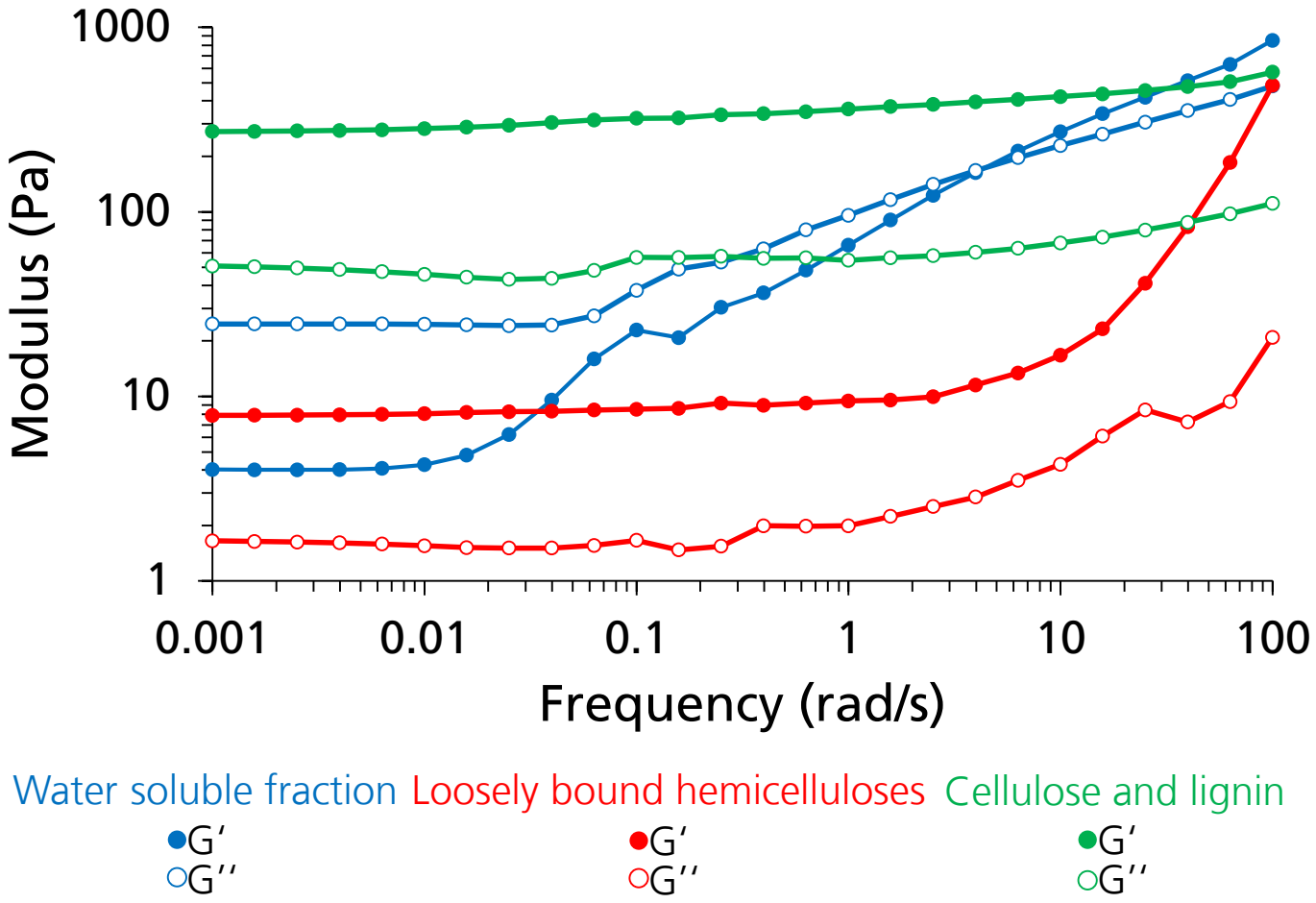


Water soluble fraction

- Shear thinning behavior
- 1000-fold increase in viscosity with concentration from 5 to 50 g/L
- Similar profile as Locust bean gum
- High potential as food hydrocolloid

Rheological Properties of Macauba Polysaccharide Fractions

Viscoelastic properties: Water-soluble, loosely bound hemicellulose, cellulose and lignin at 50 g/L



- Water soluble fraction: dilute viscous solution
- Loosely bound hemicellulose: Weak gel
- Cellulose and lignin fraction: gel behavior

Rheological Properties of Macauba Polysaccharide Fractions

- Isolated fractions presented distinct functional and rheological behavior:
  - Influenced by composition and molecular properties of the polysaccharides

Potential applications

- Water soluble fraction: thickening agent
- Loosely bound hemicellulose: stabilizer, products requiring moderate water binding capacity
- Cellulose and lignin fraction: stabilizer, products requiring high water and oil binding capacities
- Prevention phase separation and improve freeze-thaw behavior: ice creams, dairy desserts, ready-to-eat meals

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Conclusions and Outlook

- Macauba is a novel source for innovative, sustainable and functional dietary fibers.
- Characterization of cell wall polysaccharides provided insightful information about the chemical composition and economic potential of side streams from agro-industries.
- Our results provide a framework for the downstream fractionation of Macauba pulp dietary fibers and future exploitation as a food ingredient.
- The compositional and molecular characterization of the isolated polysaccharide fractions can elucidate the difference in functionality and rheological properties (currently under investigation).

Acknowledgment

This research was financially supported by the German Federal Ministry of Education and Research (BMBF) under the program Bioeconomy International [Grant No. 031B0282].

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Thank you for your attention

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5. Lescano et al. Nutrients content, characterization and oil extraction from *Acrocomia aculeata* (Jacq.) Lodd. fruits. African Journal of Food Science. 2015; 9: 113-119.

6. Fügel, R., Carle, R., & Schieber, A. A novel approach to quality and authenticity control of fruit products using fractionation and characterisation of cell wall polysaccharides. Food Chemistry. 2004; 87(1), 141-150.

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