Optimization and computational evaluation of mechanical juice extraction from cassava leaves

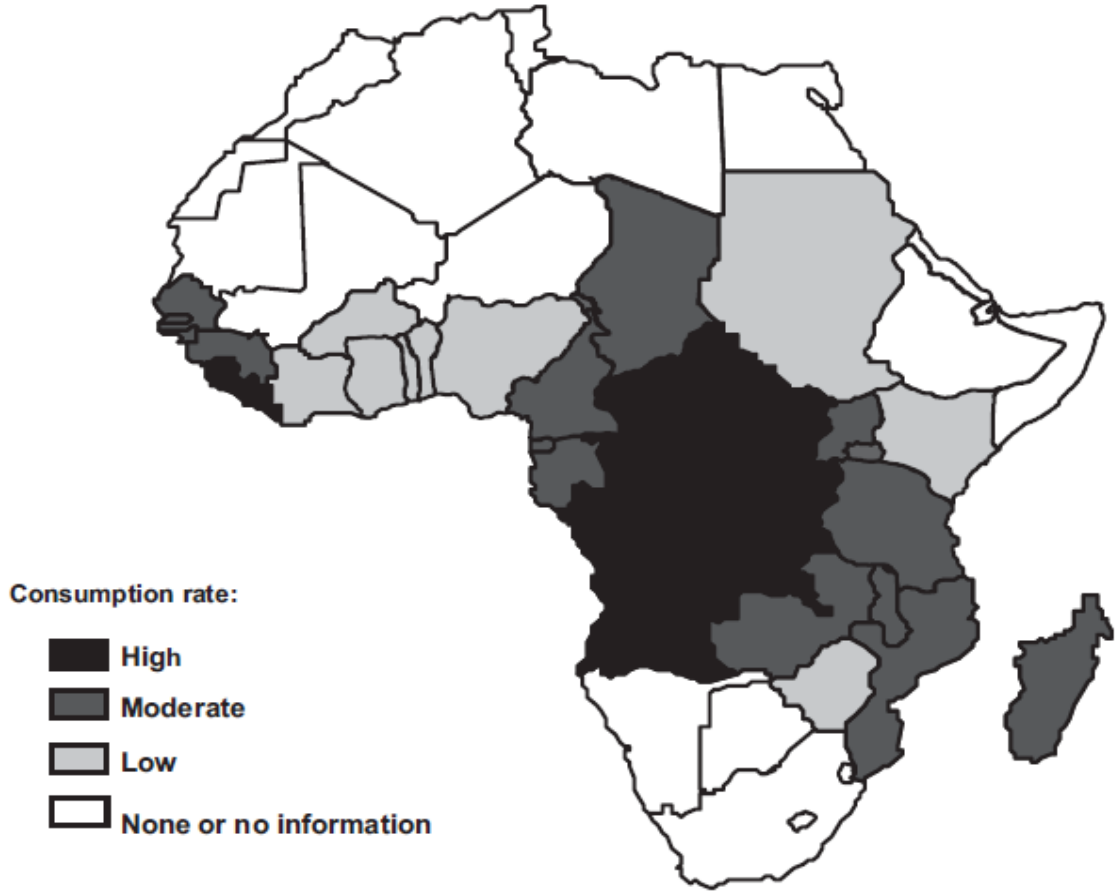


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Some facts about cassava

- Widely grown in tropical and subtropical countries
- 226 million tons estimated production in 2006 (FAO, 2008)
- Grown in 105 countries and ranks as world's fourth most important crop
- A staple food for nearly one billion people
- Mainly grown for starchy roots
- However, the stem, leaves and petioles of cassava are also edible and are widely used as food in Africa
- The Congolese call cassava leaves “old man’s meat”
- In some places, usually left in the field after cropping the roots

Consumption of cassava leaves in Africa



Ufuan Achidi, A., Ajayi, O. A., Bokanga, M., & Maziya-Dixon, B. (2005). The use of cassava leaves as food in Africa. *Ecology of Food and Nutrition, 44, 423-435.*

Consumption of cassava leaves

Country	Consumption level	Dish name
Angola	Frequently	Kizaka, Ngwada
Botswana	Eaten	
Brazil	As food supplement to combat malnutrition	Multimistura
Burundi	Eaten as spinach	
Cameroon	Highly appreciated by the people of Yaounde 30 to 100g/day	nkwen, Gweri
Central African Republic	Eaten as spinach	pondu, sakasaka
Congo	Preferred vegetables, 40 to 170g/day	pondu, sakasaka, matamba, and sombe
Democratic Republic of Congo (DRC)	500g/day	
Gabon	Eaten as spinach	
Indonesia	Eaten as vegetable	Daun Singkong, Daun ubi tumbuk
Liberia (Mano river counties of West Africa)	Eaten regularly accompaniment to rice	Pondo, sakasaka
Madagascar	Eaten throughout the country	ravitoto, ravinmahogo, and ambazaha
Malawi		chigwada
Malaysia	One of the traditional vegetable	Masak lemak pucuk ubi
Mali		Banankou boulou nan
Mozambique (Rural and north-east)	Eaten almost daily as side dish	Chigwada, mathapa
Nigeria	One of the twelve eaten as vegetable	
Philippines southern part of Mindanao	Widely used as vegetable	Ginataang cassava leaves
Rwanda	Eaten as spinach	Isombe
Sierra Leone and Guinea	Eaten regularly accompaniment to rice, eaten as vegetable	Cassada leaves, Mafe haako bantare
Sri Lanka (Monaragala)	35-100 g/day	Malluma
Tanzania	Eaten as vegetable	Kisanby, kisamvu
Zaire	Important part of the peasant meal, eaten as vegetable 500g per person	Mpondu, pondu, sakasaka
Zambia	Frequently	Kizaka, Ngwada
Zimbabwe	Eaten	

Nutritional aspects of cassava leaves

- High content of crude protein (17.7-38.1% dry weight) depending on the cultivar and climatic conditions
- High content of vitamins, B1, B2, C, carotenoids and minerals
- Total essential amino acid in cassava leaf protein is similar to
  - Hen's egg
  - Greater than spinach leaf, soybean, oat and rice grain
- High essential amino acids as compared with the FAO recommended pattern

Antinutritional aspects of cassava leaves

- Reduce nutrient bioavailability
  - Phytate
  - Trypsin inhibitor
  - Fiber
  - Nitrate
  - Oxalate
  - Polyphenols
  - Saponins
- Varies depending on the maturity status, climate condition and variety of cassava

Toxic aspects of cassava leaves

- Cyanogenic glycosides: the most toxic compound
- Three forms of cyanogens i.e.
  - Cyanogenic glucoside (95% linamarin and 5% lotaustralin)
  - Cyanohydrins
  - Free cyanide
- >100 ppm total cyanide (fresh weight basis): highly poisonous
- Must be detoxified to less than 10 ppm (proposed by WHO)
- Young leaves and newly germinated seedlings contain the highest concentration of cyanogens
- Leaves have 5 to 20 times more cyanogenic potential than roots
- However, leaves have 200 times more linamarase activity than roots

Sustainable future protein

- Insufficient good nutritional protein: the most serious problem
- Cassava leaves can be utilized to reduce this problem
- Leaves are abundant and the yield per hectare per year of leaf protein can be at least four times higher than that of seed protein
- However, direct consumption of leaves is strongly limited because of;

  High content of fiber

  Toxic substances

  Antinutritional factors

  Low digestibility and

  Bad taste
- It is possible to use this protein as human food if;

  Leaf material is processed to eliminate these limiting factors

Material and methods

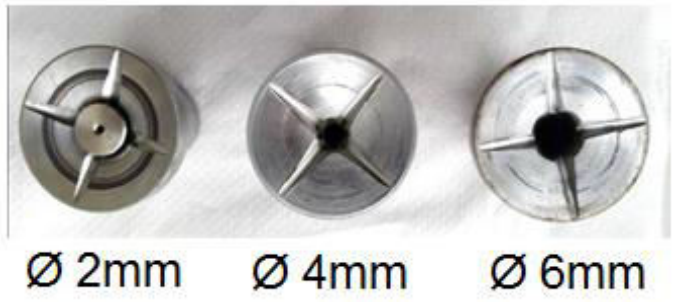


- **Oil press CA59G**
- Factory: IBG Monforts Oekotec GmbH & Co.KG
- Capacity: 3-5 kg/h
- El. power: 1,1 kW
- Weight: 80 kg
- Different diameter (2 – 6 mm)

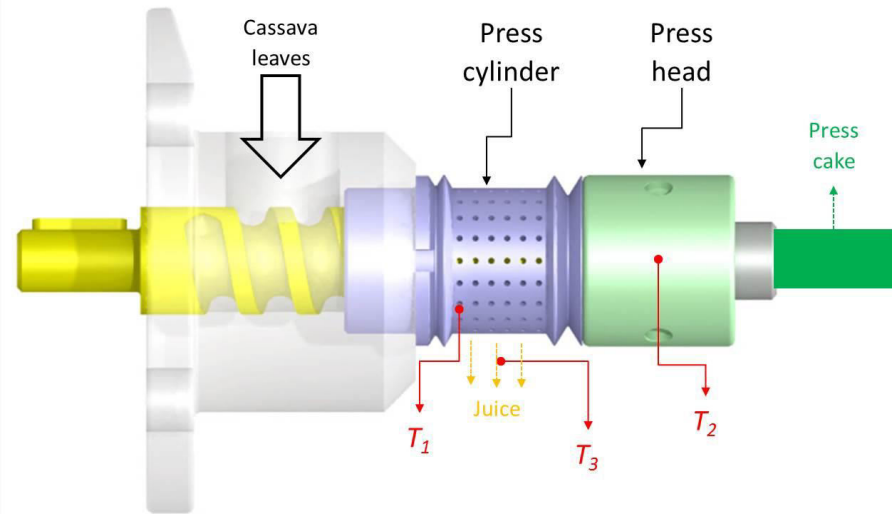
Influencing variables

Level	Screw speed, ω_s (rpm)	Nozzle diameter, $Ø_N$ (mm)
Low	18	4
Middle	28	5
High	40	6





Temperature measurement



Temperature measurement of press cylinder (T_1), press head (T_2), and juice (T_3)

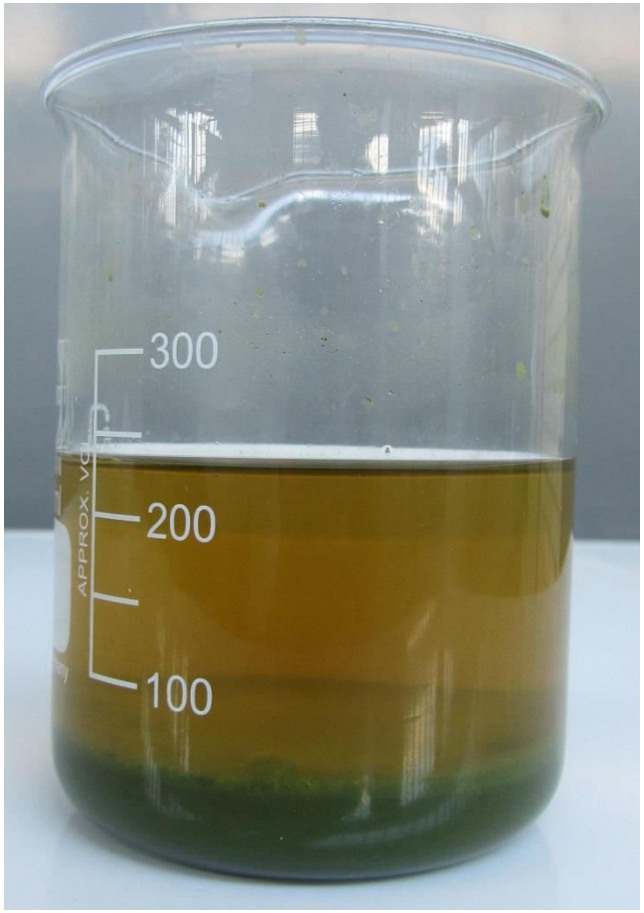
Cassava leaf pressing



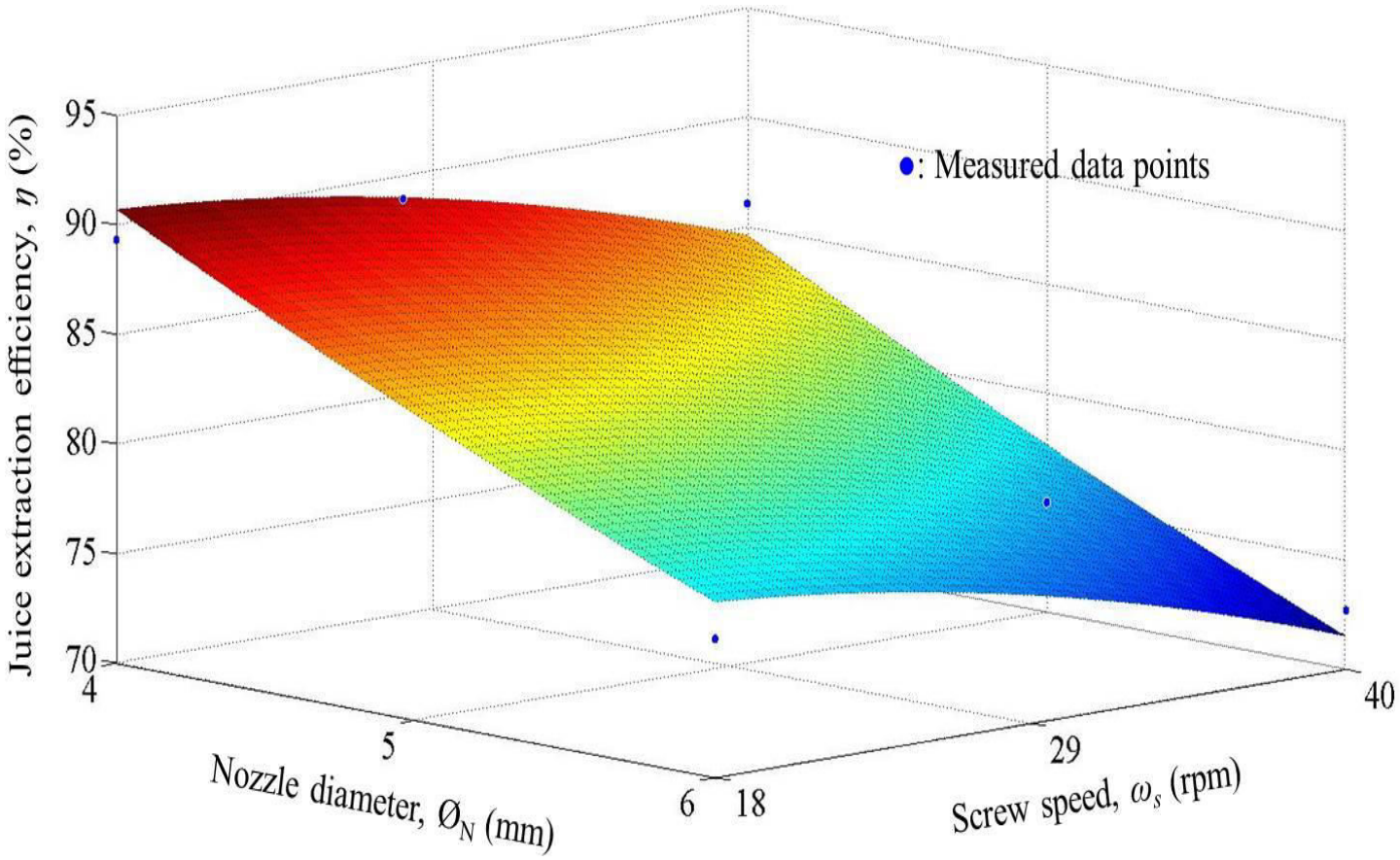


Cassava leaf juice sedimentation

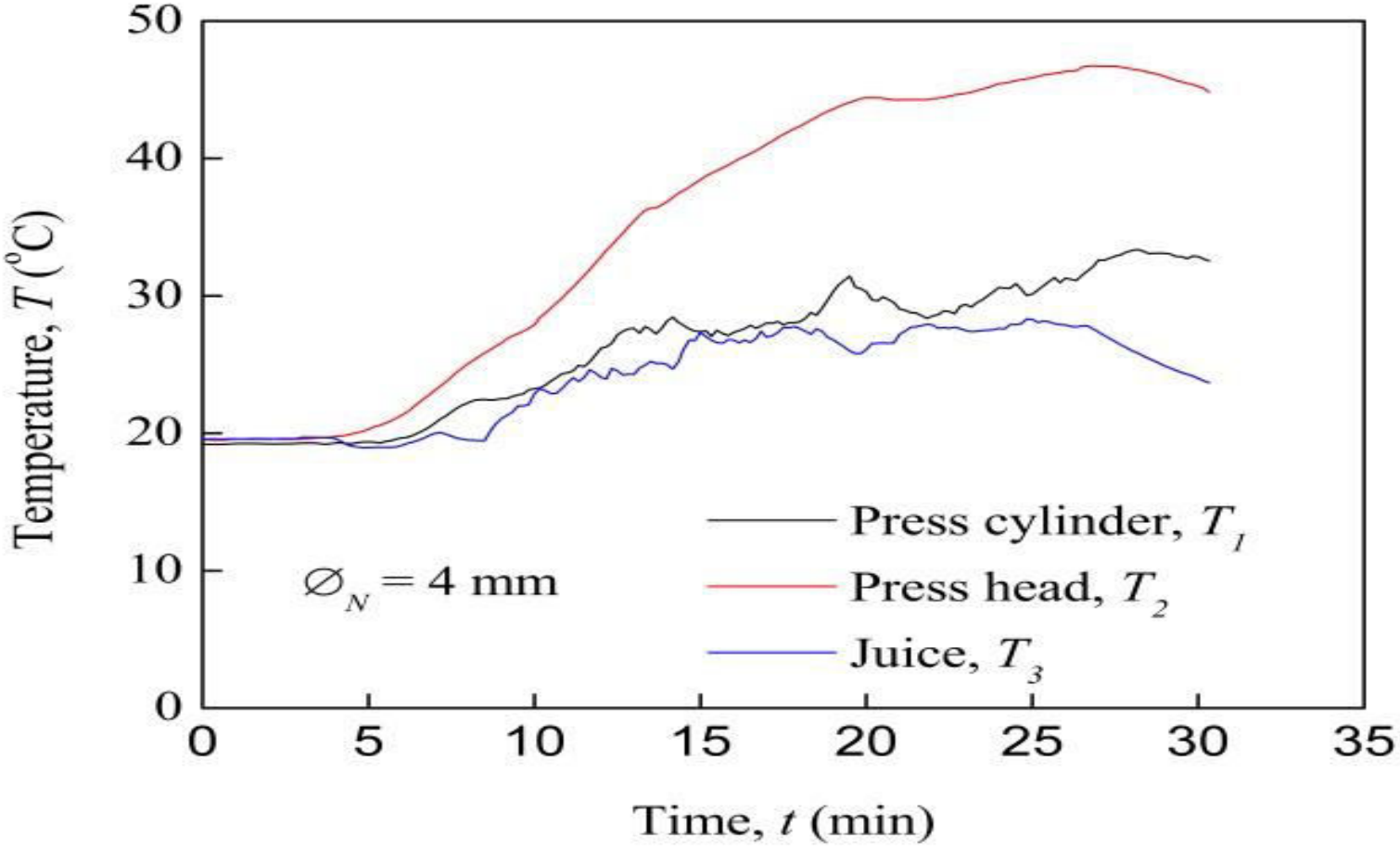




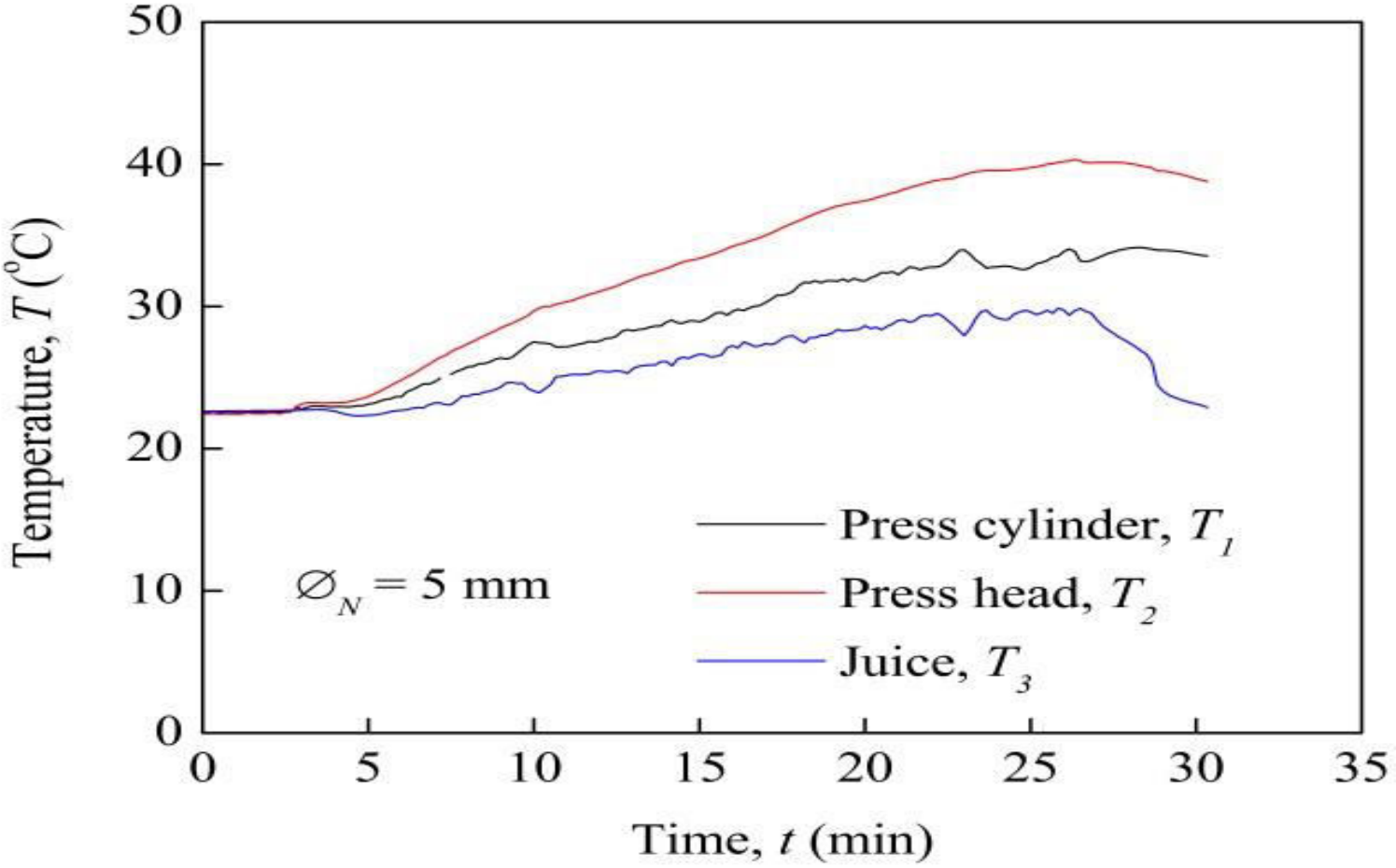
Extraction efficiency affected by nozzle diameter and screw press speed



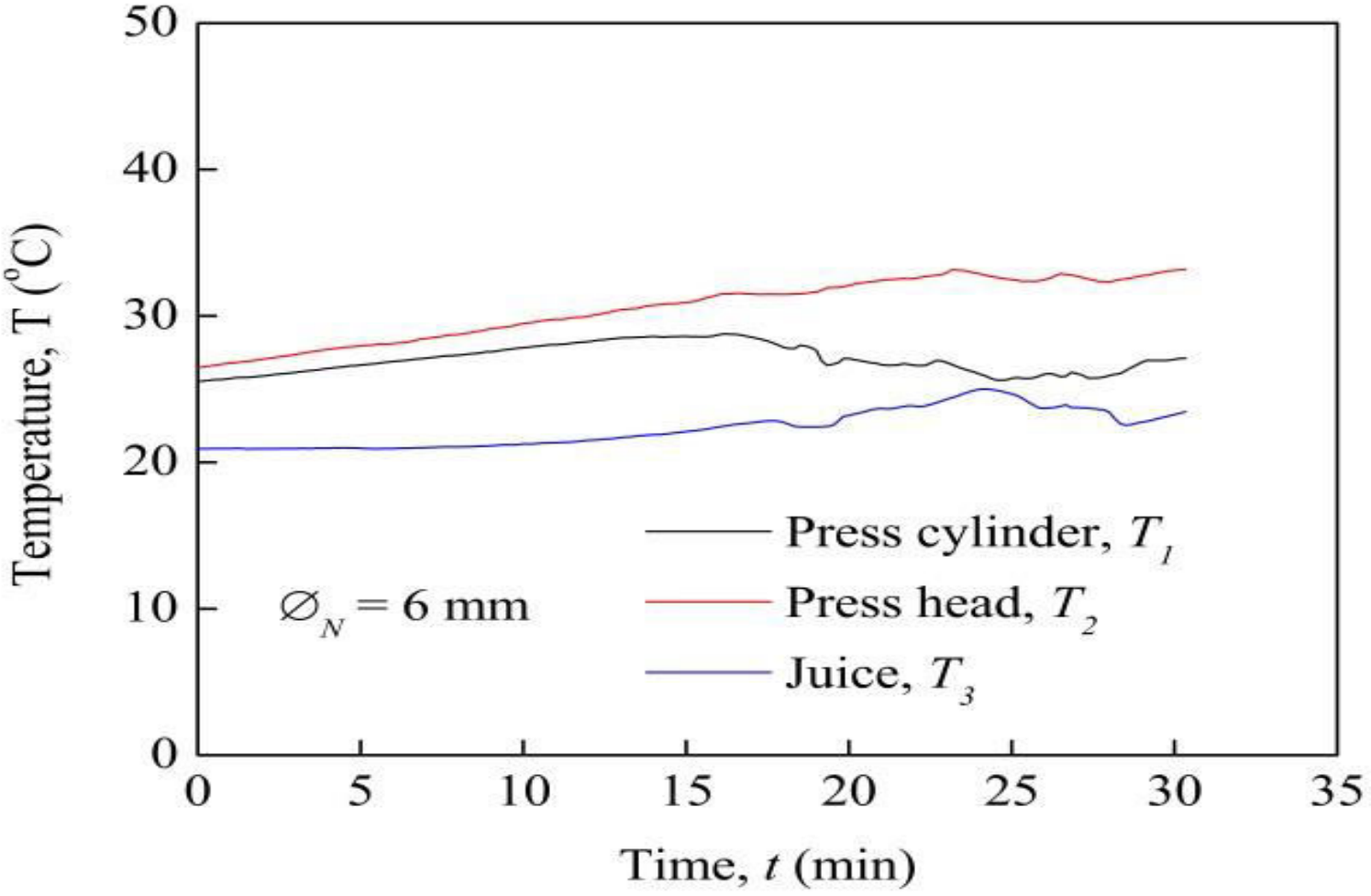
Temperature measurement at 18 rpm for 4mm nozzle diameter



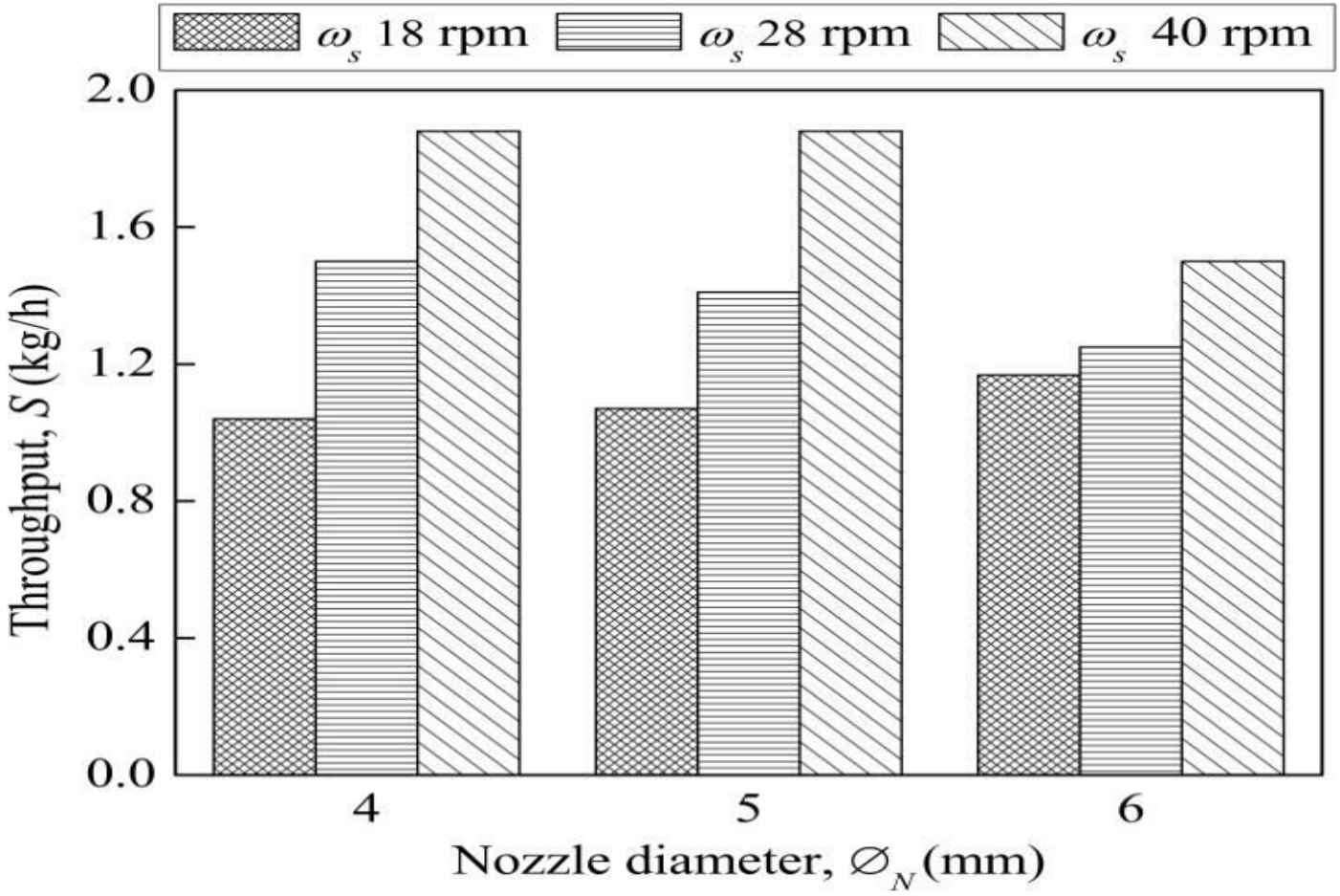
Temperature measurement at 18 rpm for 5mm nozzle diameter



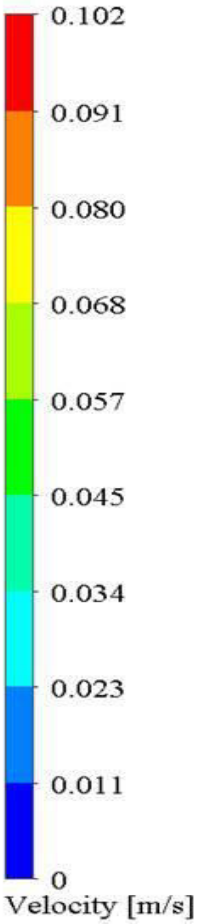
Temperature measurement at 18 rpm for 6mm nozzle diameter

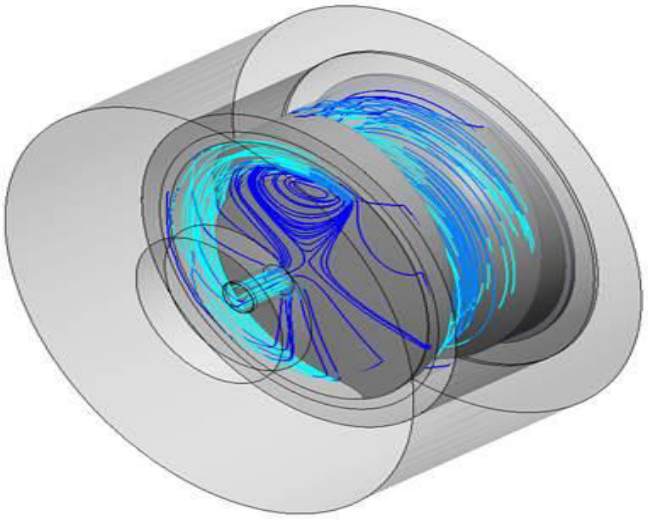


Throughput at different nozzle diameters and screw speed



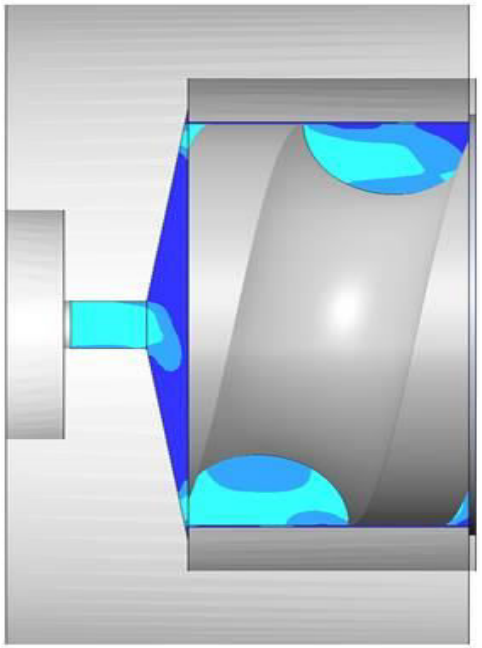
Simulation of velocity (side view) and flow trajectories (isometric view) in press head under optimized condition



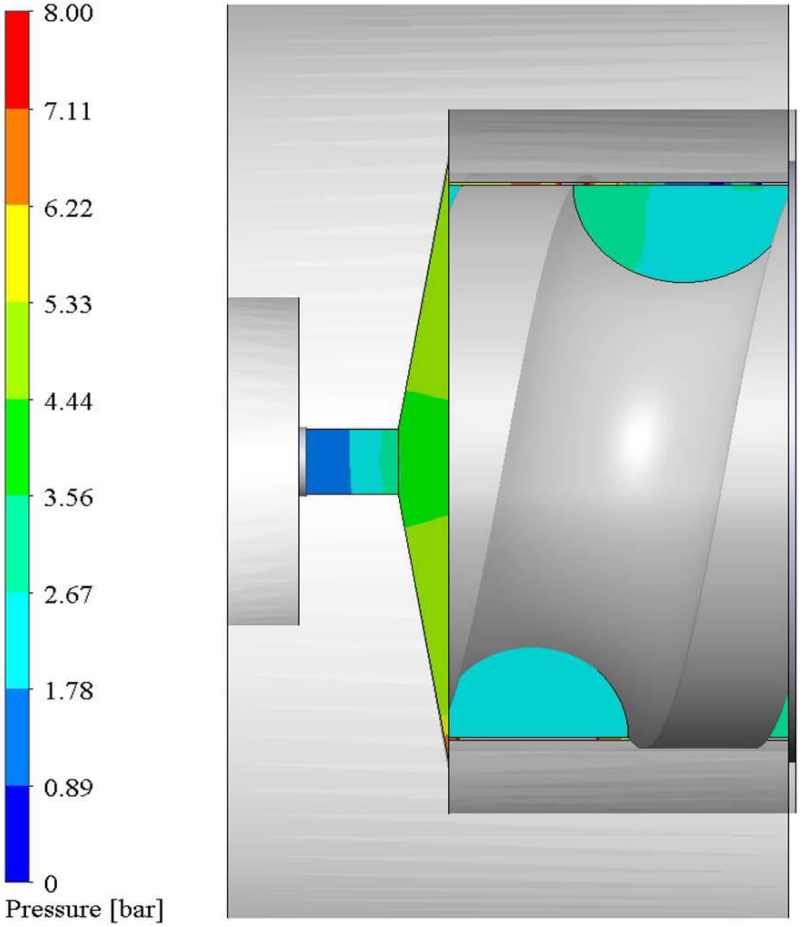


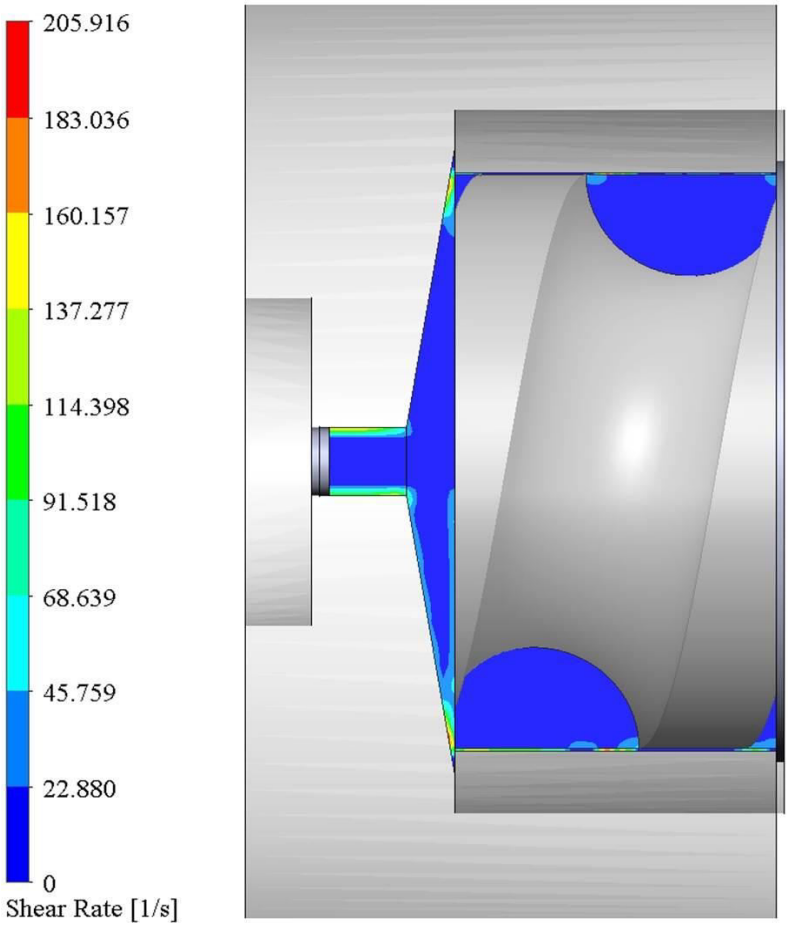
Isometric view

Side view



Computational pressure (left) and shear rate (right) in press head at 18 rpm screw press, and 4 mm nozzle size





Conclusions

- Cassava leaves pressing was optimized using the screw press speed and the nozzle diameter
- Lower motor speed and the lower nozzle diameter leads to a higher extraction efficiency
- A low temperature of the press head under optimum conditions may suggest not to have a negative effect on the protein present in the juice as well as in the press cake
- Flow simulation of cassava leaf considered as non-Newtonian fluid seems capable of simulating the leafy material during pressing
- High rotational speed leads to high velocity of material, but not throughput
- Improvement in geometry parameters such as pitch diameter, and bore holes of press cylinder can be made, in order to increase cassava juice extraction

Acknowledgements

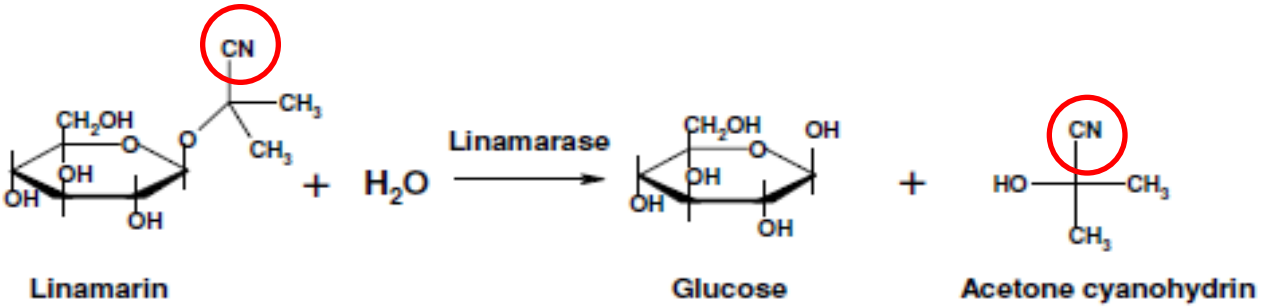
- This work was financially supported by the German Federal Ministry of Education and Research (BMBF) with funds from the German Federal Ministry for Economic Cooperation and Development (BMZ) as part of the GlobE program through project BiomassWeb – Improving food security in Africa through increased system productivity of biomass-based value webs.

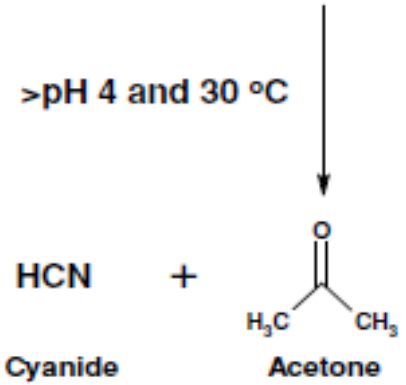




Thanks for your attention!

Breakdown linamarin





- Linamarin: major cyanogenic glucoside
- Linamarase catalyzes linamarin hydrolysis to glucose and acetone cyanohydrin
- While hydroxynitrile lyase catalyses cyanohydrins hydrolysis to hydrogen cyanide (HCN) and a ketone
- Hence cause serious illness or death of the consumers