Effect of extrusion cooking on the physicochemical properties, resistant starch, phenolic content and antioxidant capacities of green banana flour

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Background:

Banana is amongst the world's leading crops, after rice

interest banana flour's nutritional value (RS, DF, phenolic acid)

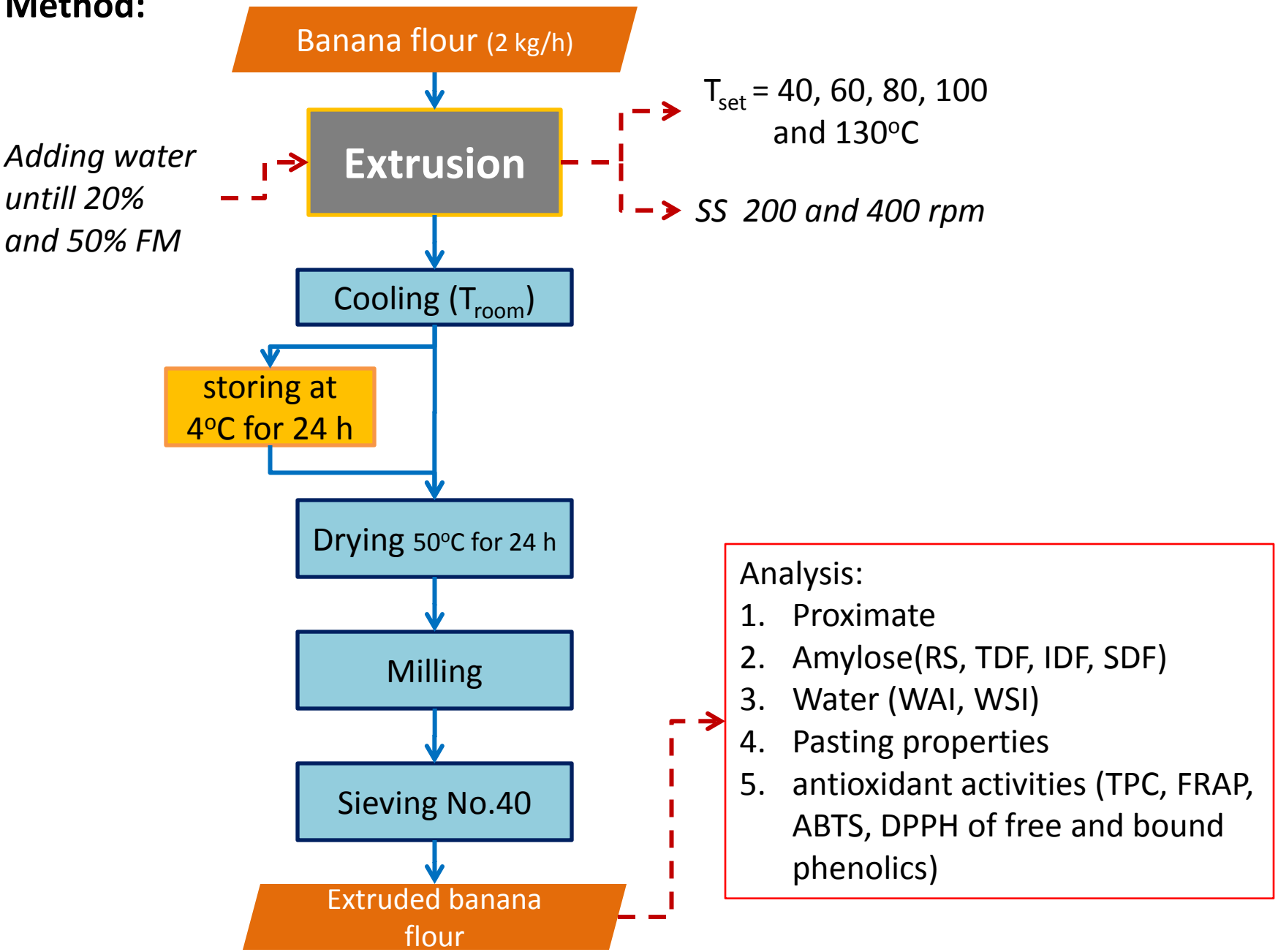
Extrusion changes physicochemical and functional properties

Study changes of extrude banana flour

Objective:

To study the **effects of (1) extrusion cooking process variables (FM and SS)** and **(2) storing of the extruded samples at 4°C for 24 h** on the physicochemical properties (WAI, WSI, pasting properties), the content of amylose, RS, dietary fibre (TDF, IDF and SDF), as well as total phenolic content and their antioxidant activities (TPC, FRAP, ABTS, DPPH of free and bound phenolics) of green banana flour, **in order to promote the utilisation of extruded green banana flour for further food use.**

Method:


Banana flour (2 kg/h)
Extrusion
Adding water untill 20% and 50% FM
T_{set} = 40, 60, 80, 100 and 130°C
SS 200 and 400 rpm
Cooling (T_{room})
storing at 4°C for 24 h
Drying 50°C for 24 h
Milling
Sieving No.40
Extruded banana flour
Analysis:
1. Proximate
2. Amylose(RS, TDF, IDF, SDF)
3. Water (WAI, WSI)
4. Pasting properties
5. antioxidant activities (TPC, FRAP, ABTS, DPPH of free and bound phenolics)

Result:

Amylose content:

✓No significant effect of FM, SS and storing on IDF, SDF
✓Extrusion cooking significantly increased IDF and TDF

Table 1
Amylose, RS contents, IDF, SDF, and TDF of extruded and native green banana flours stored at 4 °C for 0 and 24 h.

Treatment	Amylose (%, w/w)	RS (%, DM)	Dietary fibre (%, DM)		
			IDF	SDF	TDF
Native flour	16.20 ± 0.86f	47.25 ± 2.15a	4.46 ± 0.16c	2.54 ± 0.18a	7.00 ± 0.01b
Extruded flour[a]					
(1) 20%, 200 rpm, 0 h	17.96 ± 0.04de	1.20 ± 0.14c	3.97 ± 0.18de	2.25 ± 0.03a	6.22 ± 0.10c
(2) 20%, 400 rpm, 0 h	17.25 ± 0.65ef	0.92 ± 0.12c	3.66 ± 0.10e	2.46 ± 0.05a	6.12 ± 0.04c
(3) 50%, 200 rpm, 0 h	30.16 ± 0.12b	3.82 ± 0.14b	5.37 ± 0.16ab	2.20 ± 0.07a	7.57 ± 0.06a
(4) 50%, 400 rpm, 0 h	24.89 ± 0.81c	3.62 ± 0.11b	5.06 ± 0.14b	2.46 ± 0.06a	7.53 ± 0.05a
(5) 20%, 200 rpm, 24 h	18.92 ± 0.90d	1.34 ± 0.12c	4.03 ± 0.07d	2.34 ± 0.14a	6.37 ± 0.05c
(6) 20%, 400 rpm, 24 h	17.60 ± 0.32ef	1.11 ± 0.06c	3.68 ± 0.17e	2.50 ± 0.24a	6.19 ± 0.05c
(7) 50%, 200 rpm, 24 h	33.49 ± 0.39a	4.00 ± 0.07b	5.49 ± 0.08a	2.21 ± 0.08a	7.71 ± 0.00a
(8) 50%, 400 rpm, 24 h	26.17 ± 0.62c	3.71 ± 0.09b	5.11 ± 0.12b	2.47 ± 0.07a	7.58 ± 0.03a
Analyses of variance	*p*-Value	*p*-Value	*p*-Value	*p*-Value	*p*-Value
Feed moisture (FM)	0.000	0.000	0.000	0.315	0.000
Screw speed (SS)	0.000	0.000	0.000	0.001	0.050
FM × SS	0.000	0.818	0.831	0.443	0.629
Block	0.004	0.000	0.318	0.443	0.088
R^2 (%)	98.70	99.40	98.30	67.20	98.40

Different letters (a–f) within the same column as compared to the native flour differ significantly ($p < 0.05$).
Values are means of triplicate ± standard deviation.
[a] Feed moisture (%), screw speed (rpm), stored at 4 °C for 0 or 24 h.

✓ Lower SS release of more starch and resulting in increased amylose content, RS
✓ Higher FM higher RS, not on amylose content
✓ **Storing increase amylose content by 2.0–9.9%**
✓ Extruded samples showed significantly higher content of amylose than native flour, but give lower RS (it was lost by themal process)

Water index and pasting properties

Higher FM → increase WAI, WSI
Higher SS → decrease WAI but increase WSI

Table 2
WAI (g/g), WSI (%) and pasting properties of extruded and native green banana flours stored at 4 °C for 0 and 24 h by the Brabender Viscograph E (unit: BU).

Treatment	WAI	WSI	Peak viscosity	Hot paste viscosity	Cold paste viscosity	Breakdown	Setback
Native flour	2.44 ± 0.01b	7.60 ± 0.06e	1292.5 ± 6.4a	749.5 ± 7.8a	1064.0 ± 0.0a	543.0 ± 1.4d	314.5 ± 7.8d
Extruded flour[a]							
(1) 20%, 200 rpm, 0 h	1.93 ± 0.24c	73.04 ± 0.68c	120.0 ± 12.7e	15.5 ± 2.1e	53.0 ± 8.5e	104.5 ± 10.6e	37.5 ± 6.4e
(2) 20%, 400 rpm, 0 h	1.47 ± 0.04d	77.45 ± 0.76a	114.0 ± 11.3e	13.0 ± 1.4e	39.0 ± 7.1e	101.0 ± 9.9e	26.0 ± 5.7e
(3) 50%, 200 rpm, 0 h	3.35 ± 0.08a	8.45 ± 0.15de	1162.0 ± 21.2b	371.0 ± 2.6b	751.0 ± 15.6b	791.0 ± 3.8a	380.0 ± 7.1a
(4) 50%, 400 rpm, 0 h	3.13 ± 0.05a	9.25 ± 0.20d	867.0 ± 7.1d	276.0 ± 2.7d	607.0 ± 14.1d	591.0 ± 5.7c	331.0 ± 1.4c
(5) 20%, 200 rpm, 24 h	1.95 ± 0.38c	74.77 ± 0.90b	132.5 ± 12.0e	17.0 ± 2.8e	55.5 ± 7.8e	115.5 ± 9.2e	38.5 ± 4.9e
(6) 20%, 400 rpm, 24 h	1.50 ± 0.04d	78.41 ± 1.59a	116.0 ± 8.5e	16.0 ± 2.8e	41.5 ± 2.1e	100.0 ± 5.7e	25.5 ± 4.9e
(7) 50%, 200 rpm, 24 h	3.41 ± 0.12a	8.84 ± 0.21d	1179.5 ± 20.5b	383.5 ± 10.6b	765.5 ± 21.9b	796.0 ± 1.1a	382.0 ± 1.3a
(8) 50%, 400 rpm, 24 h	3.20 ± 0.19a	9.48 ± 0.68d	953.5 ± 16.3c	305.0 ± 2.8c	653.5 ± 13.4c	648.5 ± 13.4b	348.5 ± 10.6b
Analyses of variance	*p*-Value	*p*-Value	*p*-Value	*p*-Value	*p*-Value	*p*-Value	*p*-Value
Feed moisture (FM)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Screw speed (SS)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FM × SS	0.060	0.000	0.000	0.000	0.000	0.000	0.003
Block	0.456	0.008	0.029	0.058	0.054	0.135	0.212
R^2 (%)	96.20	99.90	99.80	99.70	99.80	99.60	99.90

Different letters (a–d) within the same column as compared to the native flour differ significantly ($p < 0.05$).
Values are means of triplicate ± standard deviation.
[a] Feed moisture (%), screw speed (rpm), stored at 4 °C for 0 or 24 h.

✓ The pasting properties of the extruded flours were all lower compared to native flour, except for breakdown and setback values in the extruded flours at higher FM
✓ Higher FM and lower SS caused less starch degradation and thus corresponded with the
✓ highest amylose content, exhibited the highest setback values, indicating an increase in retrogradation tendency, and leading to higher RS formation.

Adsorption kinetics

Table 4
Free, bound, and total phenolics of extruded and native samples from green banana flour stored at 4 °C for 0 and 24 h.

Treatment	Phenolic contents (mg GAE/ 100 g db)		
	Free	Bound	Total
Native flour	158.83 ± 1.88a	61.47 ± 2.48f	220.30 ± 0.59a
Extruded flour[a]			
(1) 20%, 200 rpm, 0 h	53.22 ± 2.73d	73.72 ± 0.93cd	126.95 ± 3.66d
(2) 20%, rpm, 0 h	57.91 ± 2.84c	82.11 ± 3.60ab	140.02 ± 0.76c
(3) 50%, 200 rpm, 0 h	39.27 ± 1.68f	67.89 ± 4.69de	107.16 ± 3.01f
(4) 50%, 400 rpm, 0 h	33.15 ± 0.31g	65.93 ± 1.99ef	99.09 ± 2.30g
(5) 20%, 200 rpm, 24 h	54.53 ± 0.66cd	76.80 ± 0.61bc	131.33 ± 0.06d
(6) 20%, 400 rpm, 24 h	63.48 ± 1.84b	85.67 ± 3.22a	149.15 ± 1.38b
(7) 50%, 200 rpm, 24 h	44.98 ± 1.19e	70.08 ± 0.09de	115.06 ± 1.10e
(8) 50%, 400 rpm, 24 h	38.93 ± 0.61f	69.43 ± 1.22de	108.36 ± 1.82f
Analyses of variance	*p*-Value	*p*-Value	*p*-Value
Feed moisture (FM)	0.000	0.000	0.000
Screw speed (SS)	0.702	0.007	0.003
FM × SS	0.000	0.001	0.000
Block	0.000	0.017	0.000
R^2 (%)	97.60	92.90	98.80

Different letters (a–g) within the same column as compared to the native flour differ significantly ($p < 0.05$).
Values are means of triplicate ± standard deviation.
[a] Feed moisture (%), screw speed (rpm), stored at 4 °C for 0 or 24 h.

✓ extrusion cooking caused a significant decrease in total phenolic content (32.3–55.0%), mostly due to a reduction in their free phenolics (60.0–79.1%), while bound phenolics significantly increased (6.8–28.2%).

✓ Storing significantly increased the content of free, bound and total phenolics

Conclusion:

1. The interaction between FM and SS significantly affected the amylose content, WSI, pasting properties, TPC and their antioxidant activities (FRAP, ABTS, DPPH) in free and bound phenolics in the extruded banana flours.
2. Storage condition was also an important factor to improve the final extruded flours properties, amylose content was significantly increased, as well as RS, and content of free, bound and total phenolics.
3. Regarding the samples extruded at low FM, although they were low in RS, WAI, pasting properties, the high TDF, WSI, TPC and their antioxidant activities in free and bound phenolics make them of interest in utilising as functional ingredients in a variety of cereal foods in the future.