Influence of Extruder Die Temperature on Physico-mechanical Characteristics of Cassava Flour Extrudates

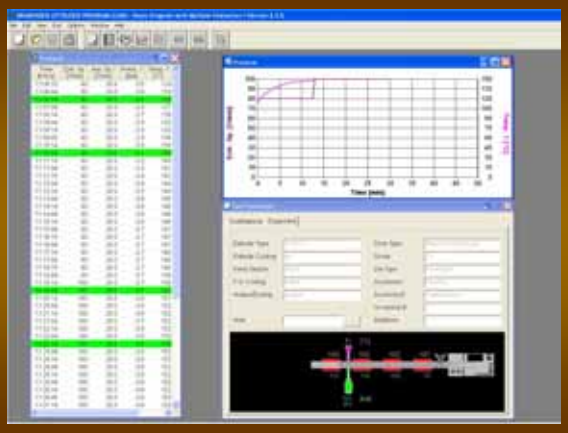
J. Thajudhin Sheriff
G. Padmaja
M.S. Sajeev
S.N. Moorthy

Central Tuber Crops Research Institute
Thiruvananthapuram, Kerala, INDIA

Introduction

- The demand for quick cooking or instant food products is expanding at a phenomenal rate and extrusion cooking is widely used in developing snack products.
- Cassava flour can be used as a satisfactory feed ingredient in snack food products.
- Considerable amount of work has been done to understand the effect of processing variables on physical characteristics of extrudates of cereal starches.
- Not much information is available about the effect of die temperature and other extrusion parameters on physico-mechanical characteristics of cassava flour extrudates.

Food Extruder



Experimental Conditions

Feed Zone Temperature	70ºC
Compression Zone Temperature	80ºC
Metering Zone Temperature	90ºC
Die Size	5mm
Compression Ratio	2:1
M.C of Cassava Flour	14%

Die Temperature	110, 120 & 130 ºC
Extruder Screw Speed	80, 100 & 120 rpm
Feeder Screw Speed	20, 25 & 30 rpm

Observations

- Volumetric output
- Expansion ratio :
- Bulk density
- Porosity
- Pressure
- Apparent Viscosity
- Hardness
- Toughness
- Snap force

Measured using texture analyzer

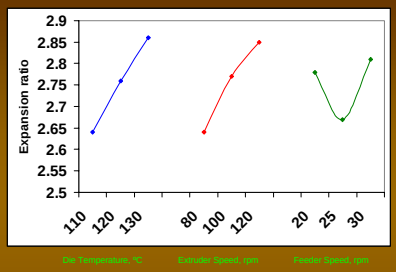
(Model: TAH Di M/s Stable Micro Systems, UK)

Effect of Die Temperature on Product Characteristics

Die Temp., °C	Expansion Ratio	Bulk Density, g/cm³	Porosity, %	Hardness, N	Toughness, Ng-S	Snap Force, N
110	2.64	1.96	19.59	100.99	95.12	50.47
120	2.76	1.63	24.66	106.61	95.53	48.51
130	2.86	1.11	26.39	75.41	99.78	48.03



Effect of Die Temperature on Flash of Extrudate



Effect of extrusion parameters on expansion ratio of cassava flour extrudate

Effect of Die Temperature on Machine Characteristics

Die Temp., °C	Output, Cm³/min	Pressure, Pa	Apparent Viscosity, Pa.S
110	0.0027	119.79	0.022
120	0.0030	102.904	0.016
130	0.0034	102.304	0.014

Cassava Flour
Moisture Content-14%
Starch Content-68.5%

Processing Conditions

- Extruder Screw Speed-80rpm
- Feeder Screw Speed-20rpm
- Die Diameter-5mm

- Temperature of Feed Zone-70°C
- Temperature of Compression Zone-80°C
- Temperature of Metering Zone-90°C


CF 80R 110C


CF 80R 120C


CF 80R 130C

Processing Conditions

- Temperature of Feed Zone-70°C
- Temperature of Compression Zone-80°C
- Temperature of Metering Zone-90°C
- Extruder Screw Speed-100rpm
- Feeder Screw Speed-25rpm
- Die Diameter-5mm

Cassava Flour
Moisture Content-14%
Starch Content-68.5%


CF 100R 110C


CF 100R 120C

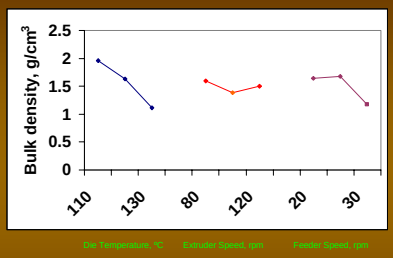

CF 100R 130C

Influence of Extrusion Parameters on Product Quality (F-Ratio)

Sources of Variation	Ex. Ratio	Density, g/cm³	Porosity, %	Hardness, N	Toughness, N-S	Snap Force, N
Die Temperature	25.55	213.45	336.799	1.31	0.23	0.31
Extruder Screw Speed	23.34	53.48	415.949	2.24	5.04	2.24
Feeder Screw Speed	10.39	140.00	67.3340	2.96	0.32	4.14
Die Temperature*Extruder Screw Speed	4.22	12.88	166.310	1.12	2.20	0.99
Die Temperature* Feeder Screw Speed	3.95	14.31	54.2357	1.00	2.40	2.71
Extruder Screw Speed* Feeder Screw Speed	11.88	29.03	482.170	1.25	0.32	0.40
Die Temperature*Extruder Screw Speed* Feeder Screw Speed	5.55	20.07	146.083	0.69	1.06	0.72

Effect of Extruder Screw Speed on Product Characteristics

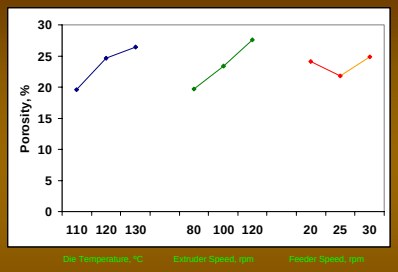
Extruder Screw Speed, rpm	Expansion Ratio	Bulk Density, g/cm³	Porosity, %	Hardness, N	Toughness, Ng-S	Snap Force, N
80	2.64	1.81	19.71	119.07	110.13	52.47
100	2.77	1.39	23.38	85.72	86.98	49.05
120	2.85	1.50	27.55	78.23	93.32	45.49



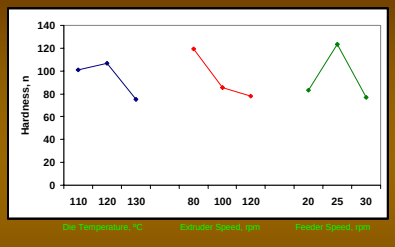
Effect of extrusion parameters on bulk density of cassava flour extrudate

Effect of Feeder Screw Speed on Product Characteristics

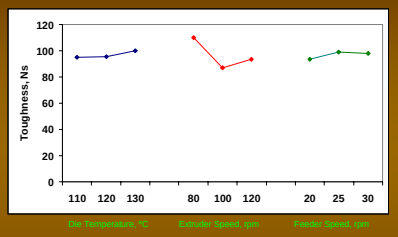
Feeder Screw Speed, rpm	Expansion Ratio	Bulk Density, g/cm^3	Porosity, %	Hardness, N	Toughness, Ng-S	Snap Force, N
20	2.78	1.84	24.06	82.97	93.38	46.94
25	2.47	1.68	21.77	123.11	99.07	54.43
30	2.81	1.17	24.81	76.94	97.98	45.63



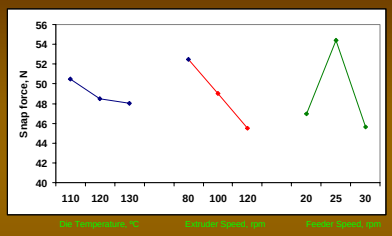
Effect of extrusion parameters on porosity of cassava flour extrudate



Effect of extrusion parameters on hardness of cassava flour extrudate



Effect of extrusion parameters on toughness of cassava flour extrudate



Effect of extrusion parameters on snap force of cassava flour extrudate

Influence of Extrusion Parameters on Output and Pressure (F-Ratio)

Sources of Variation	Output ($Cm^3 Min^{-1}$)	Pressure (Pa)
Die Temperature	54.45	84.78
Extruder Screw Speed	44.00	82.17
Feeder Screw Speed	46.36	27.14
Die Temperature*Extruder Screw Speed	4.94	11.28
Die Temperature* Feeder Screw Speed	4.96	19.95
Extruder Screw Speed* Feeder Screw Speed	24.09	0.33
Die Temperature*Extruder Screw Speed*Feeder Screw Speed	6.45	3.18

Effect of Extruder and Feeder Screw Speed on Machine Characteristics

Ex. Screw Speed, rpm	Output, Cm^3/min	Pressure, Pa	Apparent Viscosity, Pa.S
80	0.0027	116.14	0.021
100	0.0033	111.526	0.017
120	0.0031	97.363	0.014

Feeder Screw Speed, rpm	Output, Cm^3/min	Pressure, Pa	Apparent Viscosity, Pa.S
20	0.0028	102.937	0.018
25	0.0029	114.144	0.020
30	0.0034	107.911	0.015

Conclusions

- Die temperature exerted maximum influence on expansion ratio and bulk density
- Expansion ratio, bulk density, hardness, snap force and pressure were lowest at 130°C
- Porosity and out put were highest at 130°C
- Interaction of extruder speed and feeder speed had maximum influence on porosity

- Expansion ratio, bulk density, hardness, snap force, pressure and apparent viscosity were lowest at 120 rpm of extruder screw speed.
- Porosity was highest at 120 rpm of extruder screw speed.

- Expansion ratio, bulk density, hardness, snap force, and apparent viscosity were lowest at 30 rpm of feeder screw speed.