Grinding Effect on Whole Sorghum Extrusion Performance and Products

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•Abstract

•Whole sorghum kernels, ground whole sorghum and ground whole sorghum with fines removed were tempered to 12, 14 or 16% moisture and extruded in a Maddox single screw friction-type extruder to analyze the effect of grinding on the extrusion performance and product characteristics. Commercial yellow cornmeal at 14% moisture was extruded as control. The optimum moisture content for sorghum extrusion was 14%. Extrusion of whole sorghum kernels consumed less energy and were processed faster than ground sorghum samples. The energy consumed by the extruder was lower for all sorghum samples compared to cornmeal at the same moisture content. The extruder was able to process more sorghum per time unit than cornmeal. Whole sorghum kernel extrusion produced extrudates with lower bulk density than when ground samples were used. Good quality sorghum snacks can be made from whole sorghum even without grinding. The texture of the extrudates was excellent.

Introduction

Expanded snacks are very popular because of their crunchy texture (Barrett and Peleg, 1992). *Corn, wheat, and rice are the most common cereals used in the extrusion of snacks and breakfast cereals are Sorghum is less expensive than other cereals but is not a major ingredient in extruded snacks.*

Previously, Acosta et al (2002) successfully extruded decorticated white sorghums to obtain snacks comparable in bulk density to those made from yellow cornmeal.

Acosta et al (2002) also concluded that whole sorghum kernels can be extruded into snacks using a friction extruder. This method produced whole grain products with excellent taste, texture and acceptability.

Objective

Extrude whole sorghum kernels and ground whole sorghum meals at different moisture levels to determine extrudate properties and extrusion performance.

Materials and Methods

Samples

ATx631xRTx436 white food sorghum grown in College Station, TX. in 2001 was utilized.

Whole sorghum kernels, ground whole sorghum, and ground whole sorghum with fines removed were extruded.

Yellow corn meal for snacks (ADM) was extruded for comparison.

Grinding *was with a Fitz Hammer-mill using a #10 US Sieve (2 mm). Fines were removed using a #50 US standard sieve (0.3 mm).*

Extrusion *was performed in a single screw, friction-type extruder* (model MX-300I, Maddox Inc, Dallas, TX) with L/D ratio of 4.

The sorghum treatments were tempered to 12, 14 or 16% moisture and extruded at 300 rpm screw speed using a die with 4 1/8 inch holes.

The current required to extrude the raw materials was monitored. The power was obtained by multiplying the current (Amps) by the the voltage (460 V).

The time required to extrude 10 kg of raw material was measured to calculate feed rate.

Baking and packaging

After extrusion, the samples were baked in a convection oven at 100°C for 30 min.

After baking, the samples were cooled and packaged in a metallic plastic-film.

Bulk density.

Weight of a 15 l container filled with extrudates.

Texture *of extrudates was evaluated using a TA-XT2i Texture Analyser (Texture Technologies Corp., Scarsdale, NY, Stable Micro Systems, Godalming, Surrey, UK) using a needle as a probe. The force to puncture 40 randomly selected extrudates per treatment were analyzed. Young's modulus was the slope of linear region of the Force vs. distance curve.*

ESEM

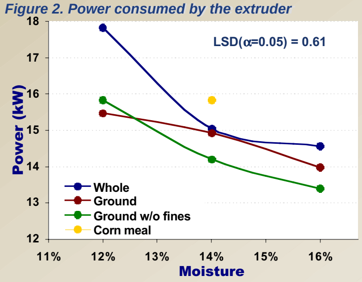
Extrudates were mounted on aluminum stubs with conductive adhesive and viewed in an Electroscan Model E-3 Environmental Scanning Electron Microscope (ESEM, Electroscan Corp., Wilmington, MA) with accelerating voltage of 20Kv.

Statistical Analysis *was performed with SAS V8 for Windows software, using α=0.05.*

Results and Discussion

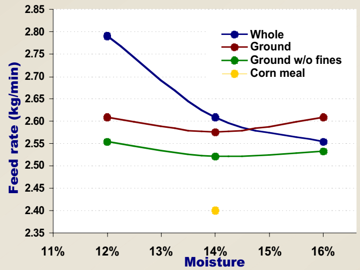
Figure 1. Sorghum and cornmeal extrudates.

Figure 2. Power consumed by the extruder



•Extrusion of whole sorghum (all treatments) required less energy than cornmeal extrusion at the same moisture content.
•*Grinding sorghum did not decrease power consumption compared to whole sorghum, except at 12% moisture.*
•Removal of fines in ground sorghum samples decreased energy consumption.
•The energy consumed decreased as moisture increased.

Figure 3. Processing capacity of the extruder



•Grinding sorghum actually reduced the feed rate at 12% moisture.
•Solids feed rate for all sorghum samples was higher than corn meal.
•Feed rate decreased with increasing moisture content.
•Feed rate was lower for ground sorghum without fines compared to ground sorghum.

Figure 4. Elastic (Young 's) modulus of extrudates as measured with a Texture Analyzer.

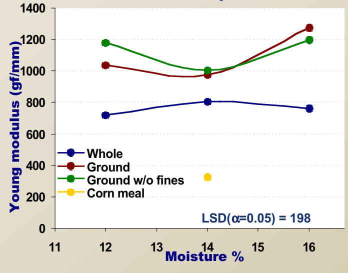
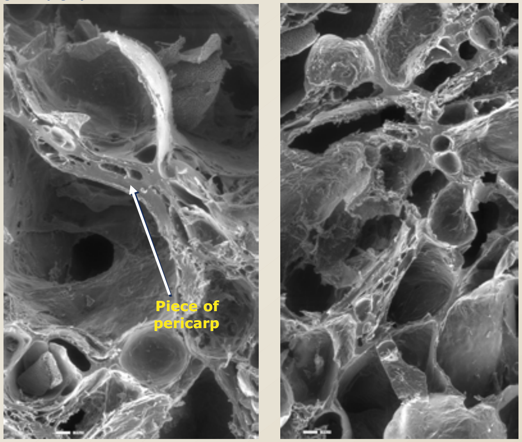
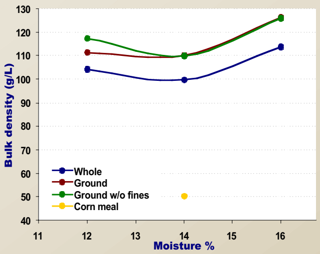


Figure 5. ESEM of extrudates made from whole (un-ground, left) and ground sorghum (right) extruded at 14% moisture.



•Extrudates of whole sorghum had larger pieces of pericarp compared to those made from ground sorghum.
•Large pieces of pericarp in whole sorghum extrudates made small air cells collapse to form large air cells with thicker cell walls.
•*Ground sorghum samples produced extrudates with smaller air cell more equally distributed.*

Figure 6. Bulk density of extrudates.



•Extrudates from whole sorghum had lower density than those from ground sorghum.
•Bulk density of cornmeal extrudates was lower than those from sorghum.
•Bulk density was lower for extrudates produced at 14% moisture.
•Removal of fines did not significantly affect extrudate bulk density.

•Elastic modulus was lower for corn.
•Whole sorghum extrudates had the lowest modulus of the sorghum extrudates.
•Although the cell walls in extrudates made from whole sorghum were thicker, they were less stiff than those from ground sorghum.
•The large pieces of pericarp probably caused the cell walls to be deformed with less force.
•Extrudates made from cornmeal retained more bubbles with thinner cell walls, giving the lower modulus value.

Conclusions

•Extrusion of whole sorghum kernel consumed less power and was processed faster than cornmeal.
•*Whole sorghum extrudates were more expanded, less stiff, had larger air cells and pericarp pieces, and thicker walls than ground sorghum extrudates.*
•*Removal of fines from ground sorghum did not improve expansion but decreased power consumption.*
•*All sorghum samples expanded more when extruded at 14% moisture.*
•*Whole sorghum can be directly processed into healthy snacks with excellent texture.*
•*Significant savings in processing may be achieved (no decortication, no milling, lower energy consumption by extruder and no dry matter losses).*

Acknowledgements

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References

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Barrett, A.H. and Peleg, M. 1992. Extrudate cell structure-texture relationships. J. Food Sci 57(5): 1253-1257.