PSIX-23

Physicochemical properties and starch gelatinization affected by corn grain processed using super-conditioned pelleting, extruding and puffing

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Introduction

- Corn grain is the predominant feed energy source in the ruminant livestock industry (Ferraretto et al, 2013). Approximately 75% of the corn grain energy value is derived from starch (calculated from NRC, 2001)
- Whole grain with an intact pericarp is largely or entirely resistant to digestion by ruminants because whole kernels are resistant to bacterial and host enzyme accessing to endosperm of grain kernel in the rumen and in the intestine, respectively (McAllister et al., 1994).
- Processing alter kernel structure, thereby enhancing the release of starch granules from the protein matrix and disrupting their order during gelatinization; this, in turn, increases the accessibility of starch to microbes in the rumen and increases the susceptibility to enzyme activity.
- Super-conditioning is a new conditioning technology in corn processing that can provide the benefits such as higher starch gelatinization and digestibility through the long-lasting treatment capacity, temperature controlling and perfect mixing of starch and gluten molecules in grain particles (Puntigam et al., 2016; Attar et al., 2017; Rahimi et al, 2020).
- Very recently researchers demonstrated that the starch gelatinization was boosted by super-conditioning than steam flaking (Rahimi et al, 2020). However, there is a gap of knowledge about how super-conditioning process affects the starch granule gelatinization in comparison with more intense processing methods.

Objectives

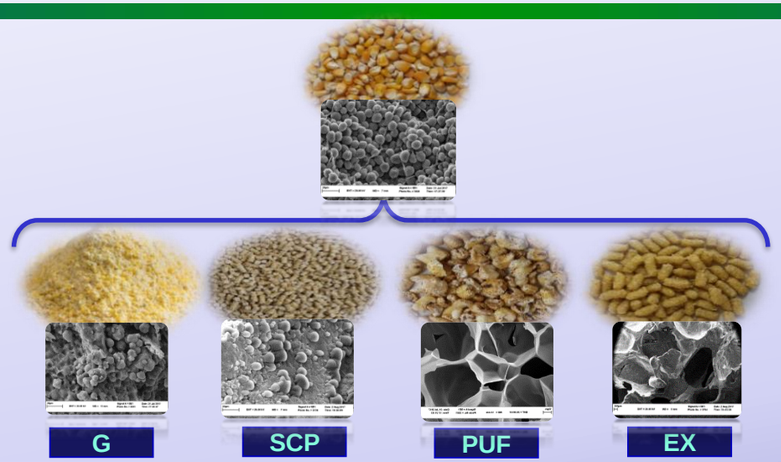
This study was conducted to determine the physical and chemical properties and starch gelatinization of corn grain processed using super-conditioned pelleting, extruding and puffing.

Materials and methods

- An Iranian corn variety (single crass 702) was processed by 4 processing methods.
- Applied processing methods were: 1) grinding (**G**, 2mm), 2) super-conditioned pelleting (**SCP**; moisture 20%, retention time 6 min and conditioning temperature 95ºC), 3) puffing (**PUF**; puffing temperature 200ºC, hot air velocity 25 m/s, feed rate 100 g/m) and 4) extruding (**EX**; moisture 20%, temperature of melting zone 75ºC and die zone 125ºC and time 150s).
- The particle size was measured by shaking through sieves of 9.51, 7.94, 6.35,4.75, 3.36, 2.36, 1.68, 1.18, 0.85, < 0.85 mm for 10 min. The apparent density and processing index (PI) were determined based on obtained volume weight. Chemical analyses were performed in accordance with the official methods of AOAC analysis (2012).
- Different parameters of damaged starch (absorption of iodine, Ai %; damaged starch content in UCD, Chopin units; UCDc, Chopin units on protein basis matter) were determined using the amperometric method (Chopin, ZI Val de Sein, 92390 VLG, France). Starch gelatinization was determined according to the enzymatic procedure (AACCMethod 76−31.01; K-SDAM, 09/2018).

Statistical analyses

Data analysis was done by GLM procedure of SAS (P<0.05) using a completely randomized design with 6 replications for every treatment by the model; Y = μ +Txi+εij, were Y is the variable, Txi is the effect due to the treatment, and εij is the experimental error.



Results

- Apparent density in G and SCP corn were similar but greater than EX and PUF corns (0.85 and 0.77 via 0.29 and 0.06 (kg/L), respectively). The PUF corn showed the most geometric mean particle size (10.55 mm) and followed by EX (8.68 mm), SCP (3.55 mm) and G (1.60 mm).
- The DM, OM, CP, EE, NDF and NFC % were not significantly (P>0.05) affected by different processing methods. Starch content in thermal processing methods of SCP, EX and PUF (73.27, 73.22 and 73.20 % of DM, respectively) was greater (P=0.04) than the G corn (72.23 % of DM).
- The highest (P<0.01) starch gelatinization was provided by the PUF (26.85 %), followed by the EX, SCP and G processes (22.95, 16.45 and 4.68 %, respectively). Also, higher starch damage parameters were observed by the PUF and Ex corns than SCP corn.

Table 1 Chemical compositions of the corn grain processed by different methods.

Chemical composition (% DM)[2]	Applied methods[1]				SEM	P-value
	G	SCP	PUF	EX		
DM	90.6	90.3	90.2	90.3	1.31	0.060
OM	98.5	98.4	98.7	98.5	1.73	0.091
CP	7.3	7.6	7.5	7.4	1.34	0.104
aNDF	9.9 ^{a}	9.7 ^{ab}	9.3 ^{b}	9.3 ^{b}	0.26	0.055
ADF	3.6 ^{a}	2.3 ^{ab}	2.6 ^{ab}	2.5 ^{b}	1.08	0.008
EE	3.4	3.2	3.1	3.0	1.15	0.080
Starch	72.2^{b}	73.3 ^{a}	73.2^{a}	73.2^{a}	2.40	<0.001
NFC	77.7	77.7	78.7	78.7	1.62	0.095
NE_l (mJ/kg DM)	1.8 ^{b}	1.9 ^{a}	1.9 ^{a}	1.9 ^{a}	0.008	0.008
NE_g (mJ/kg DM)	1.3 ^{b}	1.4 ^{a}	1.4 ^{a}	1.4 ^{a}	0.012	0.006

$^{a-b}$ Means with different superscript letters in each row indicate a significant difference (P<0.01).
[1] G: Ground corn; SCP: Super-conditioning pelleted corn; PUF: Puffed corn; EX: Extruded corn.
[2] DM: Dry matter; OM: Organic matter; CP: Crude protein; aNDF: Neutral detergent fiber; ADF: Acid detergent fiber; EE: Eater extract; NFC: Non-fiber carbohydrate = 100 - (CP + aNDF + fat + ash); NE_l: Net energy of lactation = ((0.0245 × (81.38+ (CP × 0.36) – (ADF × 0.77)) – 0.12) × 4.184; NEg: Net energy of gain = ((0.029 × (81.38+ (CP × 0.36) – (ADF × 0.77)) – 1.01) × 4.184.

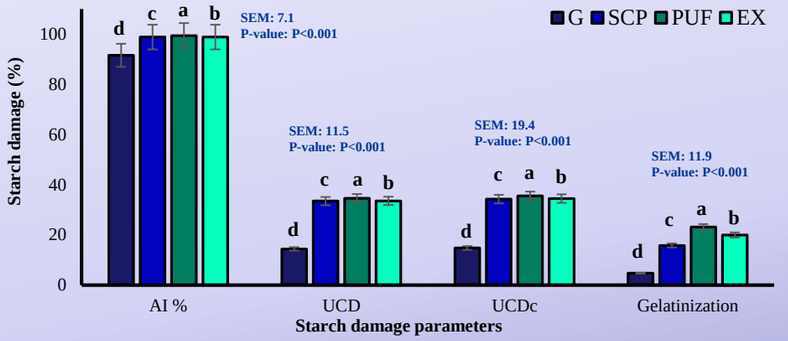


Figure 1: Starch damage and starch gelatinization of the corn grain processed by different methods.

Discussion

- This study revealed that super-conditioning of corn grain at a temperature of 95 °C for 6 min despite of greater apparent density, provided higher starch gelatinization than grounded corn, thus it can increase the efficacy of starch utilization in corn grain.
- In line with our study, Svihus et al. (2005) asserted that a higher temperature or prolonged heating can increase the extent of starch gelatinization and suggested that the intermolecular bonds of starch molecules can be broken down by water and heat, increasing the amount of water used in the hydrogen bonding sites, which in turn leads to the swelling and loss of crystallinity.
- Strong processing such as extrusion can lead to more complete gelatinization and disintegration of starch granules, which can be explained by the higher moisture content before extrusion (Kocik et al., 2013; Svihus et al., 2005). The narrow range of starch gelatinization in our study could be attributed to the different corn starch granule structures (floury or vitreous endosperm) and protein matrix in corn grains.
- Rahimi et al (2020) were observed higher starch gelatinization by super-conditioning than steam flaking method. However, in this study was observed that puffing and extruding processing with more intensity affect the starch granules structure and starch gelatinization.

Conclusion

Obtained results imply that super-conditioned pelleting process as a new processing method affects the starch granule gelatinization but lower than puffing and extruding processing methods.

References

1. Attar, A., Kermanshahi, H., Golian, A., 2017. Br. Poult. Sci. 59 (2), 190-197.
2. Ferraretto, L. F., Crump, P. M., Shaver, R. D. 2013. J. Dairy Sci. 96:533–55.
3. Kokić, B.M., Lević, J.D., Chrenková, M., Formelová, Z., Poláčiková, M., Rajský, M., Jovanović, R.D., 2013. Food Feed Res. 40, 93–99.
4. McAllister, T. A., H. D. Bae., G. A. Jones., K. J. Cheng. 1994. J. Anim. Sci.72:3004–3018.
5. Puntigam, R., Schedle, K., Schwarz, C., Wanzenböck, E., Eipper, J., Lechner, E.M., Gierus, M., 2016. Vet. Med. Zoot. 73 (95), 78-83.
6. Rahimi, A., Naserian, A. A., Valizadeh, R., Tahmasebi, A.M., Dehghani, H., Sung, K.I., Ghassemi Nejad, J. 2020. Anim. Feed Sci. Technol. 268: 114572.
7. Svihus, B., Uhlen, A.K., Harstad, O.M., 2005. Anim. Feed Sci. Technol. 122, 303–320.