PET FOOD EXTRUSION PROCESS EFFECTS ON STARCH GELATINIZATION

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Executive Summary

This study was conducted in order to determine whether changes in extrusion processing parameters increased starch gelatinization in finished pet foods. Three diets were produced under three different extrusion-processing parameters. The highest percentage of starch gelatinization and % cook was observed for foods produced at a slow processing. Additionally, potato starch may be more readily gelatinized than rice or corn starches and could potentially amplify the effects of processing.

Introduction

Extrusion is a common pet food manufacturing method, which cooks starches and simultaneously shapes the raw material creating a finished convenient complete nutritional food. The starch cooking process is collectively known as "gelatinization" and represents a change in the conformational structure of the starch granule. This starch acts as the glue to bind the kibble together, add texture to the product, and if cooked effectively provides a ready source of energy for the dog. To properly cook the starch in the extruder the operator can modify inputs such as barrel temperature, die geometry, feed rate, feed moisture, feed particle size, screw configuration, and screw speed. These influence the level of energy applied to the food within the extruder barrel and ultimately the quality of the product for animal nourishment. With these factors in mind it was our objective to determine the effect of diet type and extruder inputs on starch gelatinization or as we commonly describe it "starch cook."

Materials and Methods

Experimental diets were a Chicken and Corn (CC), Chicken and Rice (CR), and Chicken and Potato (CP) based nutritionally complete dog food. The dry ingredients used to produce these diets were sourced, mixed and extruded at Ohio Pet Foods (Lisbon, Ohio). The dry ingredient mix was conveyed into a loss in weight preconditioning cylinder (Anderson, Stow, OH) where water and steam were added and the mash feed exited at a temperature of 95 °C. The heated and moistened mash was gravity fed from the pre-conditioner at a feed rate of 7,200 lb/hr into an Anderson Single Screw (Stow, OH) extruder with screw diameter of 20.3 cm (8 inches), a medium-sheer screw profile, and maximum motor load during full production of 100% of ampere rating. Barrel temperature recorded for all processing tests was 125°C with no additional steam added.

Treatment variables were water inclusion in the preconditioner and changing feed rate to affect the motor load. The three processing treatments were slow (S), moderate (M) and fast (F), as well as an unprocessed control (Cont) for each diet. The die shape and size differed for each diet and the open area of the die was computed based on these measures (0.67, 0.79, and 0.84 cm^2 for CC, CR, and CP, respectively). Upon exiting the extruder the moist (approximately 30% moisture) kibbles were conveyed by sanitary belt conveyor to a three phase dryer (Belt-O-Matic 330B3; Tippecanoe, IN) and then into a cooler (final temperature target 22 °C) before being packaged. Samples of finished product were collected and analyzed for proximate analysis, bulk density, and microbial contamination. Additionally, finished product was weighed (lbs) in a 1 cubic foot box for bulk density, and subsamples were analyzed for total starch and gelatinized starch by the glucoamylase procedure developed by Wenger Manufacturing (Sabetha, KS).

The experiment was organized as a completely randomized design, in a 3 x 3 factorial arrangements of treatments. Three diets and 3 levels of processing levels plus 1 control process. The data were analyzed by the General Linear Model procedure of SAS (Cary, NC), and main effect means were separated using a simple t-test with significance assigned with and α of 5%.

Results/Discussion

The main effect means for processing impact on bulk density, total and gelatinized starch, and % cook are reported in Table 1. Bulk density was numerically lowest for the slow treatment and heaviest for the moderate treatment. Differences in total starch due to process were not expected and may be a function of the process affecting the laboratory assay. The gelatinized starch and the % cook were increased ($P < 0.05$) for all processing levels over that of the control. While not analyzed per se, it appears that more processing may have had a linear effect on the cook%; wherein, it increases with each increment of the process to nearly 95% for the slow treatment. This would likely translate to improved digestibility for dogs consuming the diet. Finally, the main effect of diet on % cook was highest ($P < 0.05$) for the CP versus the CC and CR diets. This might suggest that it takes less energy to gelatinize the starch in potatoes than for corn and rice grains.

Conclusion

The goal of this experiment was to demonstrate the effect of extrusion processing parameters such as water and energy added (motor load) on the conversion of starch to a gelatinized and nutritionally available form. The results indicate that processing had an apparent effect on bulk density, starch gelatinization, and overall cook, and that dietary starch may also amplify this impact. Future studies will evaluate whether these effects translate to improvements in animal performance.

Table 1. Main effect means for processing conditions [control (Cont), slow (S), moderate (M), and fast (F)] on bulk density, total and gelatinized starch, and proportion of starch cooked "% Cook" in extruded dog food.

Item	Cont	S	M	F	SEM
Bulk Density, lb/cu ft	na	27.90	30.3	28.11	0.51
Starch, total %	41.91^{a}	40.11^{b}	40.84^{ab}	41.12^{ab}	0.3141
Starch, gelatinized, %	9.23^{a}	38.02^{b}	35.76^{b}	37.45^{b}	1.52
Cook, %	22.56^{a}	94.96^{b}	87.70^{b}	91.33^{b}	2.63

Means in a row with unlike superscripts differ $P<0.05$

Figure 1. Main effect means (SEM; 2.78) for diet type (Chicken and Corn (CC), Chicken and Potato (CP), and Chicken and Rice (CR)] on % cook