THE VALUE OF BROKEN CORN AND FOREIGN MATERIAL IN IMPORTED U.S. CORN

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Purpose

U.S. corn shipments commonly contain broken corn and foreign material (BCFM), which is within standard contract specifications. Research shows that BCFM has nutrient and energy values comparable to whole kernels and can be beneficial in broiler diets at 6–10% (USGBC, 2025); however, some foreign buyers remain skeptical of its value. This factsheet summarizes nutrient and energy analyses of imported corn sampled at four commercial sites in southeast Mexico (Mérida and Veracruz) from reception through drawdown in feedlots and feed mills.

Research Overview – What was done

Four commercial grain storage facilities in southeast Mexico were used in a controlled one-year sampling program to determine the value of BCFM in the whole corn bulk. Corn samples were collected in two phases: (1) during bin filling, denoted as 100% fill, and (2) when the bin was equal to or less than 25% full. Samples were collected from June 2024 through April 2025 and shipped to Purdue University, West Lafayette, Indiana, for further analysis. Figure 1 is a schematic diagram of the sampling plan.

From the corn samples received, four different treatments were formulated to determine the nutrient and energy values of BCFM in comparison with whole kernels. Samples were homogenized using a Boerner Divider and then carefully split into the four experimental treatments: Batch As-Is (BAS), only Whole Kernels (WhK), only BCFM, and Whole Kernels + 3% BCFM, as shown in Figure 2.

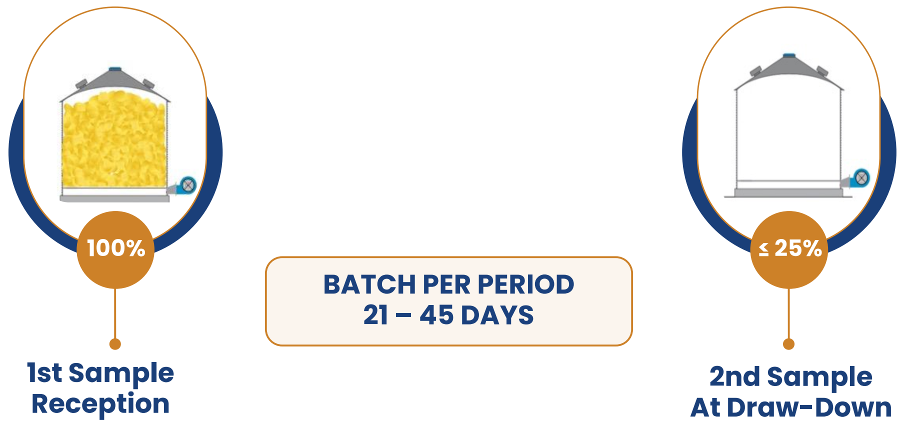

Figure 1. Drawdown sampling strategy across storage stages (June 2024–April 2025).

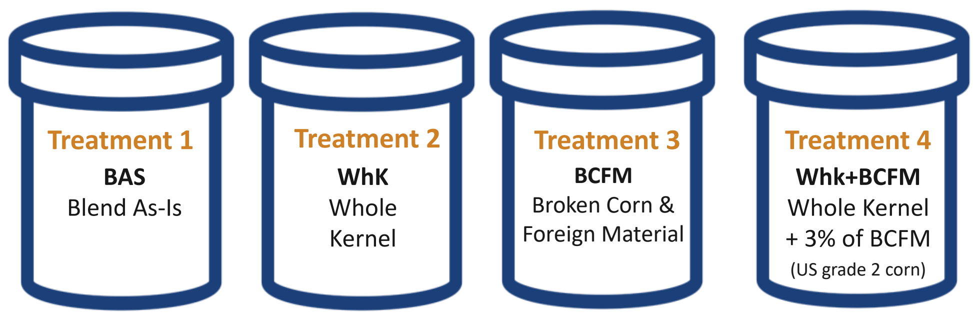

Figure 2. Treatments formulated to assess the nutrient and energy values of BCFM in comparison to whole kernels.

Nutritional and gross energy analysis were conducted on ground samples of the four treatments using traditional wet chemistry and near-infrared spectroscopy (NIR) methods at two certified feed laboratories in the United States. Eight nutritional parameters were measured (gross energy (GE), crude protein, nitrogen, crude fat, crude fiber, starch, calcium, and phosphorus) for every treatment during both fill levels. Each treatment had one replicate sample per batch, with a total of seven batches sampled over the course of the study, making up seven replications per treatment.

A value retention index (VRI) was computed for a direct comparison of nutrient levels between BCFM and whole kernels (WhK) and between BCFM and No.2 U.S. corn (whole kernels + 3% BCFM). The percentage of each nutrient retained in BCFM compared to the corresponding nutrient in WhK and whole kernels + 3% BCFM was calculated as shown below, equation 1:

$$\mathrm{VRI_{nutrient}} = \left(\frac{\mathrm{Mean_{BCFM}}}{\mathrm{Mean_{WhK}}}\right) \times 100 \quad \text{or} \quad \mathrm{VRI_{nutrient}} = \left(\frac{\mathrm{Mean_{BCFM}}}{\mathrm{Mean_{WhK+3\%BCFM}}}\right) \times 100 \quad \text{(Eq.1)}$$

In feed component evaluation, the VRI is often used to project the relative contribution of a material to nutritional composition in relation to a standard or ideal reference. A value of 100% indicates a one-to-one similarity between both treatments compared. The lower the percentage, the lower is the value of interest in the treatment (e.g., BCFM) compared to the standards, WhK, and whole kernels + 3% BCFM.

One-way ANOVA was used to detect differences among treatments for each nutrient, and Tukey's Honest Significant Difference (HSD) test was applied to identify statistically significant pairwise differences at the 95% confidence level ($p < 0.05$).

Feed quality predictions were generated for BCFM inclusion levels of 3%, 7%, 10%, and 12% using a simple weighted-average model, allowing the nutritional impacts of BCFM to be extrapolated across this range.

Table 1. Statistical comparison of the nutrient composition of whole kernels, whole kernels with 3% BCFM and only BCFM for U.S. imported corn at reception.

Nutrient	WhK Mean (SD)	WhK + 3% BCFM Mean (SD)	BCFM Mean (SD)	VRI (%) [WhK vs BCFM]	VRI (%) [WhK+3%BCFM vs BCFM]
Gross Energy (kcal/g)	3.86 (0.12) N	3.90 (0.05) N	3.86 (0.05) N	100%	99%
Crude Protein (%)	7.25 (0.31) N	7.16 (0.32) N	7.51 (0.65) N	104%	105%
Crude Fat (%)	3.33 (0.21) Y	3.03 (0.31) N	2.79 (0.32) N	84%	92%
Crude Fiber (%)	1.36 (0.19) N	1.35 (0.15) N	1.56 (0.38) N	115%	116%
Starch (%)	65.69 (0.78) N	65.64 (1.08) N	65.04 (1.10) N	99%	99%
Calcium (%)	0.01 (0.00)	0.01 (0.00)	0.02 (0.01)	NEGL	200%
Phosphorus (%)	0.22 (0.02) N	0.22 (0.02) N	0.22 (0.01) N	98%	99%

Table 2. Statistical comparison of the nutrient composition of whole kernels, whole kernels with 3% BCFM and only BCFM for U.S. imported corn after drawdown to ≤25%.

Nutrient	WhK Mean (SD)	WhK + 3% BCFM Mean (SD)	BCFM Mean (SD)	VRI (%) [WhK vs BCFM]	VRI (%) [WhK+3%BCFM vs BCFM]
Gross Energy (kcal/g)	3.74 (0.05) N	3.76 (0.08) N	3.69 (0.09) N	98%	98%
Crude Protein (%)	7.00 (0.32) N	6.97 (0.30) N	7.36 (0.83) N	105%	106%
Crude Fat (%)	3.14 (0.31) Y	3.19 (0.28) Y	1.93 (0.83) N	61%	61%
Crude Fiber (%)	1.84 (0.13) N	2.10 (0.28) Y	2.41 (0.59) N	131%	115%
Starch (%)	64.86 (1.20) N	65.43 (0.95) N	64.05 (2.41) N	99%	98%
Calcium (%)	0.01 (0.00)	0.01 (0.00)	0.02 (0.01)	NEGL	200%
Phosphorus (%)	0.21 (0.01) N	0.21 (0.01) N	0.22 (0.01) N	104%	102%

- *Mean values and standard deviations (SD) are shown in parentheses.*
- *Statistical significance was determined using two-tailed t-tests assuming unequal variances.*
- *All nutrients were statistically evaluated assuming $n = 7$ per treatment, with the exception of calcium, which was excluded from statistical comparison due to values at or below the analytical detection threshold ("<0.01").*

- *N in superscript indicate nutrient of whole kernels or kernels with 3% BCFM has no significant difference compared with BCFM, and Y indicates a significant difference compared with BCFM.*

Key Findings

Table 1 and 2 shows a comparison of the energy and nutrient values of whole kernels, whole kernels + 3% BCFM, and only BCFM based on VRI, one-way ANOVA, and Tukey's (HSD) tests.

The nutrient and energy analysis of samples of whole kernels, whole kernels + 3% BCFM, and only BCFM supports the following:

- BCFM contained 98–100% of the nutrient value of whole corn for most parameters (energy, protein, starch, fiber, phosphorus), except crude fat, which showed a modest decline in samples at reception and drawdown below 25% (after up to 45 days in storage).
- Value Retention Index (VRI) for BCFM remained high, confirming its strong similarity with whole kernels and whole kernels + 3% BCFM (that is, U.S. No. 2 corn grade).
- Modeling using weighted blends of nutrition composition (Table 3) indicated that including 3–12% BCFM in feed formulations caused minimal nutritional loss and thus strong feed potential.

Table 3. Weighted average of nutritional values by BCFM inclusion level at reception.

Nutrient	3% BCFM	7% BCFM	10% BCFM	12% BCFM
Gross Energy (kcal/g)	3.862	3.862	3.862	3.862
Crude Protein (%)	7.258	7.268	7.276	7.281
Nitrogen (%)	1.176	1.177	1.177	1.177
Crude Fat (%)	3.309	3.287	3.271	3.261
Crude Fiber (%)	1.368	1.376	1.382	1.386
Starch (%)	65.662	65.601	65.556	65.529
Calcium (%)	0.01	0.011	0.011	0.012
Phosphorus (%)	0.221	0.22	0.219	0.219

Economic Implications

- In a 40,000 MT shipment of U.S. No. 2 corn (3% BCFM) at a spot price of $4.55 per bushel, the BCFM portion recovered, which is 98% of the feed value of whole kernels, representing a nutritional and financial value of ~$210,650 USD.
- Screening out and discarding this fraction would result in direct financial losses without improving feed performance.

BCFM should not be treated as waste but rather as a valuable component in feed manufacturing. However, facilities must adopt appropriate handling and storage strategies to prevent fungal growth and aflatoxin accumulation in BCFM over time.

Conclusions

The findings from this study, conducted in commercial feedlots and a feed mill in Mérida and Veracruz, provide a practical framework for stored grain management in tropical environments and for integrating BCFM utilization into feed production systems. Rather than viewing BCFM as a defect, stakeholders should develop management strategies to maximize its use as a feed resource whose value can be retained through improved handling protocols, stored grain management, and training. This paradigm shift benefits both U.S. exporters—by enhancing customer satisfaction—by reducing feed costs and nutrient losses.

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Authorship, declaration of competing interest, and funding

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The author(s) declares that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this factsheet. Also, we hereby state that the mention of equipment and agricultural technological companies is strictly for academic research related to the work conducted, and not to advertise, promote, or defame any company identified or not identified in this paper.

Funding for this research was provided to Purdue University by the U.S. Grains and Bioproducts Council Mexico Storage Program under Award No. 19067994 (2023), and we appreciate the USGBC for the grant provided to support this research.