Wheat co-products: Nutritional properties for swine diets

Wheat co-products are produced from the flour milling industry and can include: wheat bran, wheat middlings (often referred to as midds), wheat millrun, wheat shorts, and wheat red dog. Each co-product is classified based on the combination and concentration of wheat bran, germ, and residual endosperm to comprise each co-product (Huang et al., 2012).

Wheat co-product classification

The Association of American Feed Control Officials (2023) classifies wheat bran as the coarse outer covering of the wheat kernel as separated from cleaned and scoured wheat in the usual process of milling. Wheat middlings, wheat millrun, wheat shorts, and wheat red dog are produced when wheat bran is combined with wheat germ, flour, and some offal from the "tail of the mill" and are classified based on crude fiber (CF) content. Wheat middlings, millrun, shorts, and red dog must contain no more than 11, 9.5, 7, and 4% CF, respectively (AAFCO, 2023).

Although wheat co-product classification is outlined by AAFCO (2023), there are discrepancies in terminology based on geographical location among the co-products. This fact sheet discusses and summarizes important nutrient differences between each of the co-products for clear characterization.

Nutrient concentrations

Fiber content progressively decreases, and starch increases from wheat bran to middlings, millrun, shorts, and red dog (Table 1).

Wheat bran, middlings, and millrun have a high phosphorus (P) content. Therefore, incorporation of these co-products would result in less supplemental P in the diet which can help reduce diet costs. Wheat shorts and red dog are lower in P than other wheat co-products and are more similar to conventional wheat.

Table 1. Wheat co-product fiber, starch, and P content[1]

	Wheat co-product				
Item, %	Bran	Midds	Millrun	Shorts	Red dog
CF	10.2	8.4	8.9	5.3	2.6
ADF	11.3	10.5	13.6	6.3	2.5
NDF	39.4	34.7	34.4	25.0	11.6
TDF	42.9	37.8	38.0	19.3	13.9
IDF	39.6	34.7	35.5	15.2	12.8
SDF	3.2	2.9	2.4	4.1	1.1
Starch	14.5	20.3	20.3	33.3	54.9
P	0.99	1.05	0.97	0.40	0.30

[1] Stas et al., 2024

Wheat middlings and millrun have very similar mean nutrient concentrations. The similarities may be a result of terminology differences from geographical locations and the co-products may be nutritionally equivalent.

Energy considerations

The energy content of wheat co-products is dependent on the level of starch and overall fiber with each (Huang et al., 2014; Lyu et al., 2023). Therefore, wheat bran has the lowest digestible energy (DE) and metabolizable energy (ME), whereas wheat red dog has the greatest DE and ME (Table 2). Mean energy values were not developed for wheat millrun because only a single publication was obtained (Woyengo and Ziljstra, 2021).

Table 2. Wheat co-product energy concentration[1]

	Wheat co-product			
Item	Bran	Midds	Shorts	Red dog
GE	4,551	4,468	4,426	4,343
DE	2,796	2,982	3,344	3,665
ME	2,636	2,872	3,152	3,473
NE[2]	1,950	2,085	2,343	2,578

[1] Stas et al., 2024

[2] Calculated using Eq. 1-8 from NRC (2012).

Cite as: Stas, Ethan B., Joel M. DeRouchey, Mike D. Tokach, Jason C. Woodworth, Robert D. Goodband, and Jordan T. Gebhardt. 2024. Kansas State University Swine Nutrition Guide: *Wheat co-products: Nutritional properties for swine diets.*
"This project is supported in part by funding from the Kansas Wheat Commission"

Wheat co-product inclusion in swine diets will reduce the energy density due to their fiber concentration. Therefore, growth of nursery and finishing pigs will decrease unless other energy sources such as fat are added to the diet to maintain the energy concentration. Wheat bran, middlings, and millrun have been shown to decrease growth when energy is not held constant (Stewart et al., 2013; De Jong et al., 2016; Kpogo et al., 2021). Wheat shorts and red dog have lower fiber and higher energy due to increased starch levels; therefore, they can be incorporated into diets without impacting pig growth as much.

In sows, wheat co-product application may be most beneficial in gestation. Including high fiber wheat co-products to target an NDF level of 30% of the diet can help increase satiety of sows to reduce aggressive behavior (Guillemet et al., 2007).

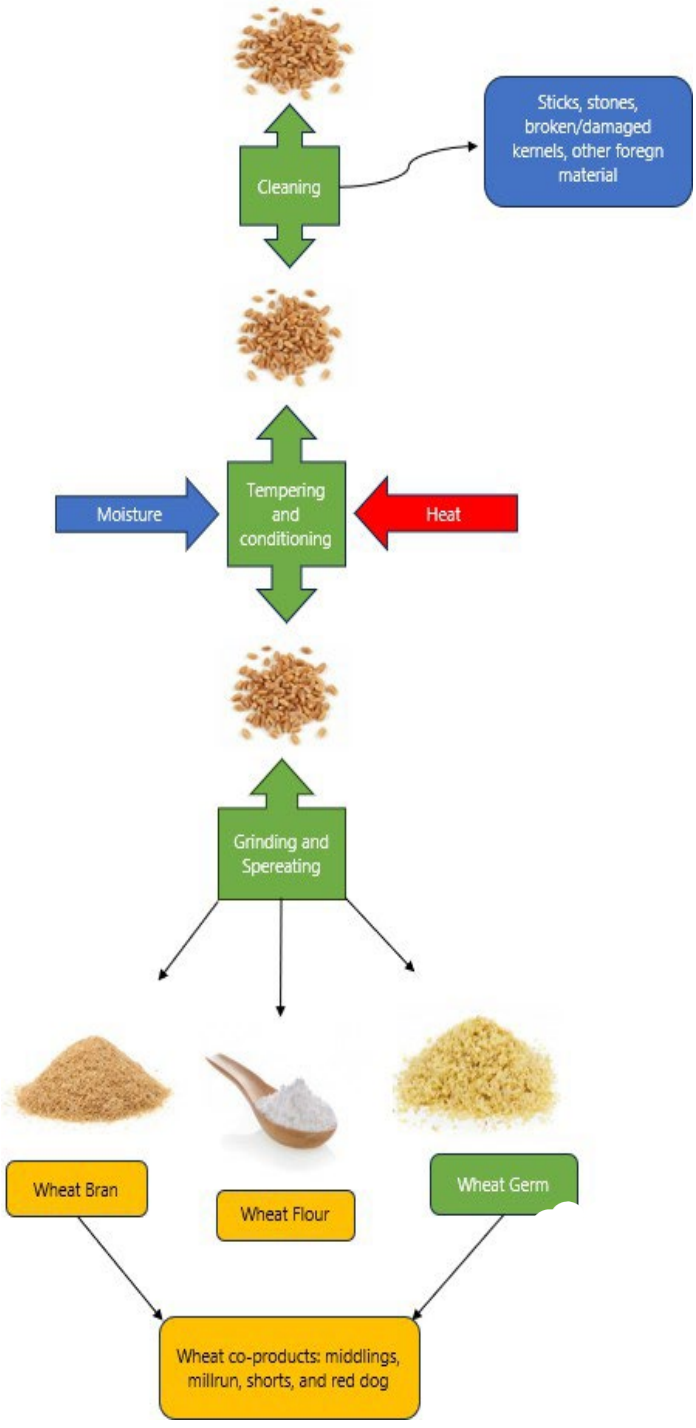
Crude protein and amino acid content and standardized ileal digestibility

Overall, wheat co-products have a higher content of crude protein (CP) and amino acid (AA) compared to conventional wheat (Table 3). Wheat shorts and red dog have higher standardized ileal digestibility (SID) of CP and AA than wheat bran and middlings. Although wheat bran and middlings have lower SID of CP and AA because of their fiber content, they still contain a high concentration of CP and AA. Therefore, they can be utilized to partially replace intact protein sources and feed grade AA can be utilized to complement their AA profile.

Gastrointestinal health

High fiber ingredients are gaining attention because of their ability to potentially provide gastrointestinal benefits. Inclusion of wheat co-products in nursery diets has been observed to improve fecal consistency, antioxidant capacity, gut morphology, and reduce pathogenic bacterial populations (Molist et al., 2010; Berrocoso et al., 2015). Wheat co- products have also been found to increase the abundance of bacteria involved in short chain fatty acid production, antioxidant function, immune response, and lactic acid production of growing pigs and sows (Li et al., 2023; Wang et al., 2023).

Figure 1. Wheat milling flow diagram.



More information about nutritional characteristics associated with wheat co-products is described by Stas et al. (2024).

Table 3. Wheat co-product protein and amino acid content and standardized ileal digestibility (SID)[1]

	Wheat co-product CP and AA concentration						Wheat co-product SID of CP and AA[2]				
Item	Wheat	Bran	Midds	Millrun	Shorts	Red dog	Wheat	Bran	Midds	Shorts	Red dog
CP, %	12.6	16.0	16.5	16.6	16.3	13.8	87.2	67.5	70.6	85.9	88.1
AA%											
Lys	0.38	0.62	0.70	0.74	0.59	0.45	76.8	69.3	70.2	87.9	83.1
Met	0.19	0.23	0.24	0.23	0.25	0.24	88.3	76.9	79.8	91.3	93.0
Thr	0.35	0.49	0.52	0.52	0.51	0.41	80.9	68.1	70.6	86.7	86.5
Trp	0.15	0.18	0.17	0.19	0.20	0.16	86.5	66.1	77.6	89.0	89.2
Val	0.56	0.72	0.76	0.75	0.73	0.60	85.0	73.7	75.2	90.1	86.8
Ile	0.43	0.49	0.52	0.52	0.49	0.44	87.1	73.9	74.9	86.1	89.7

[1] Stas et al., 2024

[2] No publications were obtained for the SID values of wheat millrun.

References

Association of American Feed Control Officials. 2023. Official names and definitions of feed ingredients: wheat products. Ch. 6. pp. 512 – 513.

Berrocoso, J. D., D. Menoyo, P. Guzmán, B. Saldana, L. Cámara, and G. G. Mateos. 2015. Effects of fiber inclusion on growth performance and nutrient digestibility of piglets reared under optimal or poor hygienic conditions. J. Anim. Sci. 93:3919-3931. doi:10.2527/jas2015-9137.

De Jong, J. A., J. M. DeRouchey, M. D. Tokach, S. S. Dritz, and R. D. Goodband. 2014. Effects of dietary wheat middlings, corn dried distillers grains with solubles, and net energy formulation on nursery pig performance. J. Anim. Sci. 92:3471-3481. doi:10.2527/jas2013-7350.

Guillemet, R., A. Hamard, H. Quesnel, M. C. Pére, M. Etienne, J. Y. Dourmad, and M. C. Meunier-Salaün. 2007. Dietary fibre for gestating sows: effects on parturition progress, behaviour, litter and sow performance. Animal. 1:872-880. doi:10.1017/s1751731107000110.

Huang, Q., C. X. Shi, Y. B. Su, Z. Y. Liu, D. F. Li, L. Liu, C. F. Huang, X. S. Piao, and C. H. Lai. 2014. Prediction of the digestible and metabolizable energy content of wheat milling by-products for growing pigs from chemical composition. Anim. Feed Sci. and Tech. 196:107-116. doi:10.1016/j.anifeedsci.2014.06.009.

Huang, Q., X. S. Piao, P. Ren, D. F. Li. 2012. Prediction of digestible and metabolizable energy content and standardized ileal amino acid digestibility in wheat shorts and red dog for growing pigs. Asian-Aust. J. Anim. Sci. 25:1748-1758. doi:10.5713/ajas.2012.12298.

Kpogo, A. L., J. Jose, J. C. Panisson, A. K. Agyekum, B. Z. Predicala, A. C. Alvarado, J. M. Agnew, C. J. Sprenger, and A. D. Beaulieu. 2021. Greenhouse gases and performance of growing pigs fed wheat-based diets containing wheat millrun and a multi-carbohydrase enzyme. J. Anim. Sci. 99:1-9. doi:10.1093/jas/skab213.

Li, Z., Y. Zhao, H. Wang, W. Zhang, C. Zhang, J. Xie, and X. Ma. 2023. High-fibre diets regulate antioxidant capacity and promote intestinal health by regulating bacterial microbiota in growing pigs. J. Anim. Phys. Anim. Nutr. 2013:1-9. doi:10.1111/jpn.13897.

Lyu, Z., Y. Chen, F. Wang, L. Liu, S. Zhang, and C. Lai. 2023. Net energy and its establishment of prediction equations for wheat bran in growing pigs. Anim. Biosci. 36:108-118. doi:10.5713/ab.220001.

Molist, F., A. Gómez de Segura, J. F. Pérez, S. K. Bhandari, D. O. Krause, and C. M. Nyachoti. 2010. Effect of wheat bran on the health and performance of weaned pigs challenged with Escherichia coli K88+. Liv. Sci. 189:1-10. doi:10.1016/j.livsci.2010.06.067.

Stas, E. B., J. M. DeRouchey, R. D. Goodband, M. D. Tokach, J. C. Woodworth, and J. T. Gebhardt. 2024. Nutritional guide to feeding wheat and wheat co-products intended for swine: a review. *Submitted to* Transl. Anim. Sci.

Stewart, L. L., D. Y. Kil, F. Ji, R. B. Hinson, A. D. Beaulieu, G. L. Allee, J. F. Patience, J. E. Pettigrew, and H. H. Stein. 2013. Effects of dietary soybean hulls and wheat middlings on body composition, nutrient and energy retention, and the net energy of diets and ingredients fed to growing and finishing pigs. J. Anim. Sci. 91:2756-2765. doi:10.2527/jas2012-5147.

Wang, Z., W. Wang, S. Xu, J. Ding, X. Zeng, H. Liu, and F. Wang. 2023. Diets enriched with finely ground wheat bran alter digesta passage rate and composition of the gut microbiome in sows. Anim. Nutr. 276:105315. doi:10.1016/j.aninu.2022.08.012.

Woyengo, T. A., and R. T. Zijlstra. 2021. Net energy of canola meal, field pea, and wheat millrun fed to growing-finishing pigs. 99:1-8. J. Anim. Sci. doi:10.1093/jas/skab229.