Feedstuffs, July 11, 2005 **Feedstuffs Reprint**

SWGP has potential use in milk replacers

Research has shown soluble wheat gluten protein to be a high-quality and highly digestible source of soluble protein, yielding equal or better performance in calves and nursery pigs versus all-milk protein or soy protein supplements in milk replacers.

By **DREW A. VERMEIRE**

SOLUBLE wheat gluten protein (SWGP) is gaining popularity in the U.S. as a supplemental source of high-quality, economical protein for milk replacers.

Due to advances in wheat cultivation and protein separation technologies by European manufacturers, the resulting SWGP yields calf performance either better than or no different from all-milk formulas, is an excellent source of digestible amino acids that complement whey composition, has no observed negative nutrient interactions and is high in solubility.

Research with veal calves, herd replacement calves and nursery pigs has shown equal or superior performance effects of SWGP versus skim milk powder, whey protein concentrate, soy protein isolate and/or soybean meal.

Contributing to U.S. farmers' willingness to try SWGP is a decade of documented field experience in Europe, with millions of veal calves yielding equal or better growth rates and lower cost of gain versus all-milk proteins. Under current U.S. economic conditions, milk replacers made with SWGP for replacement calves could save U.S. calf producers $4-6 per bag of milk replacer without sacrificing calf performance.

Background information about SWGP and key research studies comparing SWGP as a protein supplement versus other milk replacer compositions are summarized below.

*Dr. Drew Vermeire is president of Nouriche Nutrition Ltd.

1. Performance of veal calves fed skim milk or soluble wheat protein with or without branched-chain amino acids

Live weight, lb.	Skim milk	Soluble wheat gluten	Soluble wheat gluten + BCAA
Day 29	132.7	135.8	136.5
Day 86	285.5	290.8	291.7
Day 146	486.1	487.0	492.9
Live weight gain, lb.			
Days 29-86	152.8	154.0	155.2
Days 86-146	200.6	196.2	201.2
Days 29-146	353.4	350.2	356.4
Feed:gain			
Days 29-86	1.38	1.40	1.40
Days 86-146	1.88	1.96	1.91
Days 29-146	1.66	1.71	1.69
Overall ADG, lb.	3.02	2.99	3.05

Overall performance: no significant differences.
Source: ***Ortigues-Marty et al., 2003***.

2. Performance and economics of soluble wheat protein in milk replacer for replacement calves

CP content in milk replacer, %	Proportion of CP from SWGP, % of CP	Weight gain, weeks 0-4, lb.	Total gain, weeks 0-4, lb.	Starter feed consumption, weeks 4-6, lb.	Estimated retail price of milk replacer, $ per bag	Cost of gain, $/lb.
20	0	16.1	23.8ab	10.4a	43.99	1.94
20	30	16.5	22.3ab	9.5ab	40.00	1.88
20	50	15.2	24.7a	9.7ab	37.35	1.59
18	0	16.6	17.2b	7.5b	41.30	2.49
18	33	17.0	23.4ab	9.9ab	37.30	1.68

Adapted from Terui et al., 1996.

Background

SWGP is manufactured from wheat flour by separating the gluten protein from wheat starch. The protein is then enzymatically hydrolyzed and transformed to small proteins and peptides before drying.

The resulting product is highly digestible and has many beneficial characteristics for milk replacers, including: high protein content (greater than 80%), amino acid composition that is very complementary to whey powder (De Laporte and Demeersman, 1991), high solubility, being a fine powder, creamy white color, neutral taste and odor, high emulsifying capacity and emulsion stability.

Veal calves

Recent research showed that SWGP yielded similar results versus skim milk powder in milk replacers for veal calves. Ortigues-Marty et al. (2003) compared performance of veal calves fed SWGP in replacement for skim milk powder in grower and finisher feeds after a 28-day adaptation period.

Calves were fed one of two diets starting at 29 days of age. The control diet was comprised of skim milk powder, whey protein concentrate and whey, whereas the

treatment diets were comprised of SWGP, whey protein concentrate and whey with or without supplemental branched-chain amino acids (BCAAs).

Approximately 74% of the protein in the control grower diet was provided by skim milk powder. In the grower treatment diets, skim milk powder was replaced with whey protein concentrate and SWGP, which comprised approximately 55% of the protein in the milk replacer. The finisher control diet had skim milk powder comprising about 65% of the protein, and that was replaced with SWGP with or without supplemental BCAAs.

Table 1 shows that overall performance of veal calves was not different ($P > 0.05$) among treatments. Feed intake during the growing phase was higher ($P < 0.0001$) among calves fed SWGP compared to calves fed the control diet, but this did not affect the overall results. Final live weight, carcass weight and dressing percentage were not different among treatments, which demonstrates the protein quality and value of using lower-cost SWGP in milk replacer.

Herd replacements

Kansas State University research (Terui et al., 1996) showed that SWGP was equal to or better than an all-milk protein milk replacer comprised of whey protein concentrate and whey (Table 2).

The research was conducted with 120 calves fed one of five milk replacers. Two milk replacers contained 18% crude protein (CP; either 0 or 33% of the protein from SWGP) and three milk replacers with 20% CP (0, 30 or 50% of the protein from SWGP) in a study lasting six weeks.

Terui et al. concluded, "Soluble, enzyme-modified wheat gluten was a good source of protein for calf milk replacer because growth of calves fed milk replacer containing 20% CP did not differ when wheat gluten was lacking or when it furnished 30 or 50% of CP. Calves tended to gain more bodyweight when 33% of CP was supplied by wheat gluten than when no CP was supplied by wheat gluten. Calves fed 18% CP with 33% of protein from wheat gluten performed as well as calves fed any other milk replacer containing 20% CP."

Economic details of the trial are discussed later.

Nursery pigs

"Using wheat gluten to replace dried skim milk gave equal performance to day 14 and greater performance for the entire nursery period," according to Richert et al. (1994) of Kansas State University.

In a series of three experiments with enzyme-modified wheat gluten, soybean meal, dried skim milk and soy protein isolate fed to weanling pigs, the researchers concluded that wheat gluten use showed better feed utilization and faster gains than when pigs were fed soybean isolate diets. For example, in the third experiment, pigs fed the diet with wheat gluten and soybean meal resulted in 13% greater average daily gain and 9% greater average daily feed intake than pigs fed the dried skim milk-soybean meal diet.

In experiment 1, 72 weaned pigs were fed one of six dietary treatments of casein; flash-dried wheat gluten; spray-dried wheat gluten; spray-dried wheat gluten enzymatically modified to enhance solubility; spray-dried wheat gluten prepared with two enzymatic modifications, or soybean meal.

The results showed that casein had higher apparent nitrogen digestibility, biological value and nitrogen retention than the other treatments. Surprisingly, they found that the enzymatic modification, spray-drying and flash-drying of SWGP affected biological value and apparent nitrogen retention.

A second experiment was conducted with 180 weanling pigs (25 days of age and 13.3 lb. average bodyweight) assigned to either dried skim milk or wheat gluten and lactose diets. Treatment diets during phase 1 were: dried skim milk-whey-soybean meal control, flash-dried wheat gluten protein, spray-dried wheat gluten protein, modified wheat gluten protein and soy protein isolate.

All diets were formulated to 22% CP and 1.4% lysine, and the vegetable-protein diets replaced skim milk in the treatment diets. Diets were fed for 14 days, and a common corn-soybean meal-dried whey based diet was then fed to all pigs during phase 2 from days 14 to 35.

No differences were detected in average daily gain or average daily feed intake during phase 1; however, the efficiency of feed utilization was better ($P < 0.01$) for pigs fed wheat gluten than pigs fed soy protein isolate and was also better for pigs fed spray-dried wheat gluten compared to modified wheat gluten.

During phase 2, pigs fed dried skim milk during phase 1 had lower average daily gains and lower efficiency of feed conversion than pigs fed either wheat gluten or soybean isolate diets. Pigs fed spray-dried wheat gluten performed better than pigs fed modified wheat gluten or flash-dried wheat gluten.

In experiment 3, 108 weanling pigs were fed one of three phase 1 diets and one of two phase 2 diets in a 3 x 2 factorial arrangement. Phase 1 treatments were designed to determine the effects of using wheat gluten to formulate diets without dried skim milk and diets without soybean meal for the early weaned pig. The two phase 2 diets were either a corn-soybean meal-dried whey based diet or a control diet with spray-dried wheat gluten and corn starch replacing the whey on a protein basis.

There were no differences in phase 1 daily gain; however, efficiency of gain was highest ($P = 0.001$) and daily feed intake was lowest ($P = 0.006$) in pigs fed the diet without soybean meal, which contained dried skim milk and wheat gluten.

During phase 2, there was a significant carryover effect of phase 1 diet, with pigs previously fed dried skim milk and soybean meal having lower average daily gains ($P < 0.08$), poorer feed efficiency ($P < 0.005$), lower apparent dry matter digestibility ($P < 0.01$) and lower apparent nitrogen digestibility ($P < 0.008$) than those fed diets with spray-dried wheat gluten.

Pigs fed the diet with wheat gluten and soybean meal had 13% greater average daily gain and 9% greater average daily feed intake than pigs fed the dried skim milk-soybean meal diet.

Digestibility factors

Research showed that SWGP has a high level of digestibility with no known anti-nutritional factors and a very good amino acid composition. Tolman and Demeersman (1991) estimated that SWGP has digestibility coefficients of 95% for dry matter, organic matter and crude protein. Other researchers noted that SWGP did not negatively affect the digestibility of fat, which is unlike the decrease in fat digestibility known to occur when soy is incorporated in milk replacer diets (Xu et al., 1997).

SWGP is also unlike soy, which has well-known antigens and other anti-nutritional factors (Sissons and Pedersen, 1991; Tolman, 1991). SWGP is apparently free of compounds that reduce animal performance (Terui et al., 1996; Ortigues-Marty et al., 2003; DeLaporte and Demeersman, 1991).

Both protein level and protein

source affect nutrient flow and absorption in the intestinal tract of calves. Montagne et al. (2003) fed veal calves skim milk powder, soy protein concentrate, partially hydrolyzed soy isolate or potato protein concentrate and concluded that the hydrolysis and absorption of peptides may be a limiting step in the digestion of plant proteins. This limitation does not appear to be present with SWGP, as evidenced by its very high digestibility of greater than 95% (Tolman and Demeersman, 1991).

Ortigues-Marty et al. (2003) studied plasma amino acid profiles, insulin, glucose, lactate, hemoglobin, beta-hydroxy butyrate, non-esterified fatty acids, triglycerides, urea and ammonia levels as well as energy metabolism enzymes in semitendinosus muscle when SWGP replaced skim milk powder with or without supplemental BCAAs.

Calves receiving the SWGP diets had no metabolic disorders based on acid-base status, plasma lactate and plasma ammonia concentrations. Even with this high inclusion rate, whereby SWGP replaced all skim milk powder in the diets, only valine, histidine and isoleucine were marginally deficient in the diets. Despite this, the inclusion of SWGP allowed calves to reach similar growth and carcass performances as skim milk protein.

Nutritional composition

SWGP contains more than 80% protein and has a calculated metabolizable energy (ME) content of 17,327 kJ/kg. It is very low in fiber (less than 0.5%) and ash (less than 2.5%); however, it is naturally low in lysine relative to other protein sources and relative to calf requirements. In order to meet the calves' nutritional requirements, it is recommended to add 7-10 lb. of synthetic lysine for each 100 lb. of SWGP.

According to De Laporte and Demeersman (1991), a general rule of thumb is to replace three parts of skim milk powder with one part of SWGP and two parts of whey powder plus lysine. These authors reported that "an ideal pattern of essential amino acids can be obtained if synthetic lysine is added."

Physical characteristics

SWGP is a creamy-white powder with neutral taste and odor (De Laporte and Demeersman, 1991). SWGP manufacturers enzymatically convert remaining starches to sugar, which enhances solubility, digestibility and acceptability by calves. The resulting product has excellent physical characteristics for milk replacers.

Although physical and nutrient composition is similar among wheat gluten protein products, some characteristics are defined by the manufacturing and drying method each manufacturer employs. For example, spray-dried SWGP has a higher wetability and higher solubility than products dried with other methods.

Economics

Under current economic conditions, milk replacers made with SWGP for replacement calves could save calf producers $4-6 per bag of milk replacer without sacrificing calf performance. This estimate is based on SWGP replacing 33% of the protein from whey protein concentrate and whey (Table 2, page 12). Additionally, unlike milk ingredients that have wide price swings, SWGP does not have great price variability from month to month or between years.

Table 2 shows performance of calves in the Kansas State University research with replacement calves (Terui et al., 1996). Calves were fed milk replacer only until four weeks of age. Calf performance was not different among treatments through four weeks of age. However, total gain through six weeks of age favored calves fed 20% protein with 50% of the protein derived from soluble wheat gluten.

Notably, calves fed only 18% protein with one-third of the protein from soluble wheat gluten had equal performance to calves fed 20% protein milk replacers.

In terms of cost savings, SWGP has about half of the cost of protein from whey protein concentrate (Table 2). Estimated retail prices of milk replacers were calculated using current prices for whey, whey protein concentrate, 7/60 dry fat and SWGP plus normal transportation and manufacturing costs for milk replacer manufacturers. Estimated cost of gain was calculated based on the estimated milk replacer price, starter feed consumption from the study (Teriu et al., 1996) with starter feed estimated at $400 per ton and total calf gain through six weeks of age reported in the study.

Furthermore, although the estimated price of a 20% CP milk replacer is higher than the estimated price of the 18% CP milk replacer, the cost of gain was less ($1.94 versus $2.49/lb., respectively).

Replacing protein from whey protein concentrate with protein from soluble wheat gluten at the rate of 30% reduced the price of milk replacer by about $4 per bag, from $43.99 to $40.00, and reduced the cost of gain from $1.94 to $1.88/lb. Replacing 50% of the protein further reduced the price of milk replacer to $37.35, $6.64 per bag less than the 20% crude protein control all-milk milk replacer.

Cost of gain was reduced to $1.59/lb., which represented a savings of $6.90 per calf because calves fed the milk replacer with 50% of the protein from soluble wheat gluten gained slightly more weight with slightly less starter feed consumed.

SWGP has greater economic advantage in high-protein milk replacers than in low-protein milk replacers. Replacing 33% of the protein in a milk replacer with only 18% protein reduces the price of a bag of milk replacer by about $4.00; however, when 33% of the protein is replaced in a milk replacer containing 24% crude protein, the savings is about $5.40 per bag.

In milk replacers with very high levels of protein (26-28%) and high fat content (20%), the manufacturer typically must use high-protein ingredients because of formula space limitations when 34% whey protein concentrate is used. Soluble wheat protein fits well into high-protein milk replacers because it contains 80% protein and creates formula space.

Conclusions

Research has shown SWGP to be a high-quality and highly digestible source of soluble protein, yielding equal or better performance in calves and nursery pigs versus all-milk protein (skim milk and whey protein concentrate) or soy protein supplements in milk replacers and with substantial cost savings.

SWGP has an amino acid profile complementary to whey and whey protein concentrate. Animal performance is excellent because SWGP does not apparently contain anti-nutritional factors and causes no observed reduction in feed

desirability. It is also ideal for milk replacer applications due to its high solubility.

With an increasing need for producer cost savings, increasing interest in higher protein milk replacers and ongoing demand for more efficient calf performance, American farmers are finding SWGP to be an attractive and cost-effective alternative to the high cost of milk proteins.

References

De Laporte, A., and M. Demeersman. 1991. Soluble wheat protein in milk replacer for veal calves. In: J.H.M. Metz and C.M. Groenstein (eds.). New Trends in Veal Calf Production. EAAP Publication Vol. 52, p. 222-226.

Montagne, L., I. Crévieu-Gabriel, R. Toullec and J.P. Lallès. 2003. Influence of dietary protein level and source on the course of protein digestion along the small intestine of the veal calf. J. Dairy Sci. 86:934-943.

Ortigues-Marty, I., J.-F. Hoquette, G. Bertrand, C. Martineau, M. Vermorel and R. Toullec. 2003. The incorporation of solubilized wheat proteins in milk replacers for veal calves: Effects on growth performance and muscle oxidative capacity. Reprod. Nutr. Dev. 43:57-76.

Richert, B.T., J.D. Hancock and J.L. Morrill. 1994. Effects of replacing milk and soybean products with wheat glutens on digestibility of nutrients and growth performance in nursery pigs.

Sissons, J.W., and H.E. Pedersen. 1991. Nutritional significance of dietary soy antigens in milk substitutes for calves. In: J.H.M. Metz and C.M. Groenstein (eds.). New Trends in Veal Calf Production. EAAP Publication Vol. 52, p. 237-240.

Terui, H., J.L. Morrill and J.J. Higgins. 1996. Evaluation of wheat gluten in milk replacers and calf starters. J. Dairy Sci. 79:1261-1266.

Tolman, G.H. 1991. Soya antigens and anti-soya-antibody formation in calves. In: J.H.M. Metz and C.M. Groenstein (eds.). New Trends in Veal Calf Production. EAAP Publication Vol. 52, p. 241-246.

Tolman, G.H., and M. Demeersman. 1991. Digestibility and growth performance of soluble wheat protein for veal calves. In: J.H.M. Metz and C.M. Groenstein (eds.). New Trends in Veal Calf Production. EAAP Publication Vol. 52, p. 227-233.

Xu, C., T. Wensing, R. Van der Meer and A.C. Beynen. 1997. Mechanism explaining why dietary soya protein vs. skim-milk protein lowers fat digestion in veal calves. Livestock Prod. Sci. 52:219-277.