# Formulating with Opportunity Ingredients

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## ▪ Introduction

Feed represents the greatest single expense associated with raising pigs to market weight. Over the past 2 years the cost to feed a pig in the grow-finish phase has essentially doubled. This has been the result of a combination of poor harvests in different parts of the world, increasing demand for feed grains from the biofuel sector, and speculative buying by funds. The impact of rising ingredient prices on livestock feed costs have not just been felt here in Canada but in most other parts of the world.

This paper will discuss the use of opportunity ingredients in grow-finish pig diets and what potential they offer to increase margin over feed and facility cost (MOFFC; net return). One must remember that pigs are opportunity feeders and have the ability to consume a range of feedstuffs. There are many existing, and some new, opportunity ingredients that can be used to increase MOFFC but we must understand the nutrients they contain, risks associated with using them and potential economic benefits when formulated correctly into pig diets.

## ▪ Opportunity Ingredients – What are they?

Opportunity ingredients are those ingredients that: a) may not have been commonly used in pig diets in the past due to availability, b) may have been used but at limited quantity due to previous anti-nutritional factors (ANF) or cost. New ingredients pose a bigger challenge and potentially greater risks because a lot less is known about their nutrient content and availability of those nutrients, impact they may have, if any, on feed intake and if they contain ANF. Examples of new opportunity ingredients are: dried distillers grains with solubles (DDGS) and expeller processed canola meal. Existing opportunity ingredients that have been around for some time are canola meal, peas, lentils, faba beans, bakery by-products, Extrapro, stillage, and liquid whey from dairy industry. As we learn more about these ingredients, we can more effectively formulate these into pigs diets to control and/or reduce diet and feed costs while minimizing the impact on animal performance. Steps involved in evaluating a new or learning more about an existing opportunity ingredient are:

- Chemical analysis to determine nutrient content,
- Digestibility study to determine availability of nutrients,
- Feeding trial (with diets formulated on digestible amino acid & NE basis) to determine impact on feed intake, growth, feed efficiency and carcass grading characteristics.

## ■ Risks Associated with Using

When considering the use of new ingredient or modifying maximum inclusion levels of an existing ingredient in diets consider the following points:

- How much information is available on the nutrient composition of the ingredient and variation in its nutrient content within and between suppliers?
- Is nutrient digestibility information available, accurate (large data set) and is it representative of the source you will be using?
- Are there any concerns the ingredient may impact diet palatability and feed intake.
- Does the ingredient contain anti-nutritional factors (ANF)?
- Will animal performance and pork quality be impacted, and if so how, and by how much?
- Will this ingredient increase feed handling costs (bulk density); feed flow in feed bins and inside the barn?
- How much of the ingredient is available and does it warrant its inclusion in diets?

The higher the risk with using opportunity ingredients the greater the return has to be to justify their use and associated risk. To assess in more detail some of the risks involved:

### Understanding and Assessing Variation

It is extremely important that we understand or have some handle on the variability in nutrient content and availability of nutrients to avoid losses in animal performance and overvaluing opportunity ingredients. Not just the composition of the ingredient, but any processing it undergoes can have a substantial impact on nutrient content and availability. A good example of this is with dried distiller's grains with solubles (DDGS), how much syrup is added back to the wet cake before drying will impact the final ingredient nutrient content. Drying temperatures can vary greatly (120-600 $^{o}$C), and if not controlled effectively, over heating can cause significant heat damage to the final DDGS (Payne 2007) and its value.

Working in conjunction with the ingredient suppliers, a quality control testing protocol should be put in place to monitor the variation in nutrient content. Key nutrients, such as moisture, protein, and fat, should be analyzed on a regular basis, while amino acid content and fiber components should be periodically analyzed. It is important to be aware that considerable variation exists between analytical laboratories, thus working with one lab will allow comparisons between samples and remove lab to lab analytical variation. With feedstuffs that undergo heat treatment, such as DDGS, conventional amino acid analysis may grossly overestimate the actual amount of lysine present. New lab-based methods for determining dietary bioavailable lysine have been proposed and have considerable utility in practice (Moughan 2008).

## Anti-Nutritional Factors (ANF)

Anti-nutritional factors are factors in feed ingredients that interfere with nutrient digestibility and utilization. These include trypsin inhibitors, tannins, lectins, glucosinolates and others. Many opportunity ingredients contain ANF, such as glucosinolates or erucic acid in canola, tannins in red lentils, and trypsin inhibitors in raw soybeans. Understanding the ANF type and content allows the assessment of whether these ingredients can be fed and at what inclusion level in the diet. If ingredients are processed to reduce ANF, such as extrusion of soybeans, it is important to ensure that ANF are reduced to a level that will not impact performance and regular testing must be conducted to ensure ANFs remain below critical levels.

## Mycotoxins

Mycotoxins are defined as secondary metabolites of mould growth which are generally believed to be produced in response to stress factors acting on the fungus (Oswelier, 1992). Of particular interest in pigs: vomitoxin causes pigs to refuse feed, zearalone affects the reproductive organs, ochratoxin causes kidney damage and aflatoxin increases susceptibility to disease through their action as immunosuppressant's. It is really important that we have a good handle on their content in co-products such as DDGS in addition to other ingredients included in pig diets. Dried distillers grains with solubles (DDGS) are of particular concern because the mycotoxins are concentrated three fold in the DDGS over the level of the parent grain. Other opportunity ingredients, such as heated canola seed or expeller processed canola seed, where some portion of heat canola seed was used as source ingredient, increase the risk of these ingredients containing mould and mycotoxins. Some steps that can be taken to reduce the potential risks are:

- Have a complete understanding of the mycotoxin testing protocol of source ingredients being used in the process. What mycotoxins are they testing for, frequency of testing, what are the acceptable limits for ingredients, etc?
- Is the final ingredient or co-product being tested for mycotoxins, which ones and how frequently?
- If purchasing co-products, such as DDGS, with higher risk associated with them, request they test samples periodically (weekly, bi-weekly) and include frequency of testing in the contract.

## Feed Handling/Bulk Density

Increasing inclusion levels of certain opportunity ingredients will impact bulk density and flow ability of the final diets. A good example of this is for each 10% corn DDGS that is included in the diet, the volume of the diet will increase approximately 3% compared with a corn-soybean meal diet (Stein, 2007). This has implications for feed haulage costs and on-farm feed storage. If a feed truck has capacity to haul 30 tonne of a conventional corn-soybean meal diet and if we add 20% corn DDGS to the diet this reduces truck feed capacity by 6%, which has implications for total feed cost per tonne and feed cost per pig. If the on-farm bin has the capacity to store 16 tonne of corn-soybean meal diet then it will only be able to hold 15 tonne of a diet with 20% DDGS.

Particle size of corn DDGS was lower than soybean meal (665 vs 754 microns) and was more variable among sources ranging from a low of 127 to high of 1105 microns (Shurson, 2006). Because a lot of feed mills do not grind corn DDGS at the lower end of the particle size spectrum this greatly increases the risk of feed hanging up in feed bins and feeders, resulting in out-of-feed events with associated consequences of lower feed intake and growth rate. Inclusion of high levels of peas in the diet, which tend to grind to a finer particle size than other ingredients, can also pose greater risk for feed flow issues from bins and within the barn when dealing with mash diets.

## ■ Diet Formulation

As a nutritionist working for a pig/commercial feed mill owner I learned in my early days of formulating diets one had to be a formulator in addition to being a nutritionist. Not only did you have to formulate diets to meet specific nutrient requirements of pigs at different stages, consideration had to be given to ingredient inclusion levels and their effects on producing quality diets (feed flow and pellet durability) with a limited number of ingredient bins in the mill. Our objective in formulating diets is to achieve predictable performance while maximizing margin over feed and facility cost. When we formulate diets we **best cost,** as opposed to least cost, formulate diets, because there are distinct differences in achieving our end result of predictable performance with optimal return. Several considerations are included when deciding inclusion level of opportunity ingredients in diets.

### Nutrients

Pigs have requirements for nutrients such as energy and amino acids and not for specific ingredients. Thus when we formulate diets for different stages of growth we formulate to specific nutrient levels, net energy (NE), digestible amino acids, available phosphorous, etc.

### Ingredient Analysis

With the availability today of a vast array of cost effective opportunity ingredients it is very important we have a good handle on the nutrient content they offer so we can cost effectively optimize there use. A clearly defined quality control program for ingredient analysis should be in place to best estimate/predict the key nutrients in specific ingredients. Ingredients that tend to have greater variability in nutrient content, such as DDGS, require more frequent analysis. Most systems will have a fixed budget available to spend on ingredient analysis so the key will be to use this in a cost effective manner to get the most from it. With any co-product, increased sampling and testing must occur to minimize variability in the ingredients delivered and to minimize negative impacts that the variability will have on pig performance.

### Palatability

We need to understand the impact ingredients can have on diet palatability and feed intake as this will directly impact growth rate and barn throughput. In general, there are few ingredients that pigs will not eat, although feeding increasing levels of some ingredients can have subtle and significant impacts on feed intake. A simple feeding trial using graded levels of the ingredient will allow us determine the impact of feeding increasing levels on feed intake, growth and feed efficiency. It is very important that an accurate nutrient profile of the ingredient is available to ensure diets can be balanced correctly and a difference in feed intake is truly associated with palatability and not a diet nutrient imbalance. Opportunity ingredients that negatively impact diet palatability can result in similar feed disappearance as opposed to feed intake but lower growth and poorer feed efficiency as a result of pigs foraging through feed and resulting in greater feed wastage. A recent feeding trial conducted by Senevirante et al. (2008; **Table 1**) with graded levels of expeller pressed canola meal found that with increasing dietary inclusion levels, feed intake and growth rate decreased, however, income over feed cost (IOFC) increased. Thus it was cost effective to feed higher inclusion levels than those that maximized biological performance. It is important to have continuity between diets in terms of ingredient inclusion levels and to avoid large swings in diet composition between phases because this may negatively impact feed intake.

**Table 1. Effect of increasing expeller canola meal level on biological and economic performance.[a]** (Senevirante, R. et al., 2008)

| | Expeller canola meal, % | | | | | | P < | |
|---|---|---|---|---|---|---|---|---|
| **Item** | **0** | **7.5** | **15** | **22.5/ 18** | **Graded[b]** | **SEM** | **Lin** | **Quad** |
| Day 0 to 90[c] | | | | | | | | |
| ADG, g/d | 974 | 958 | 929 | 912 | 933 | 15.8 | 0.01 | 0.01 |
| ADFI, kg/d | 2.57 | 2.52 | 2.40 | 2.35 | 2.45 | 0.037 | 0.01 | 0.01 |
| Feed:gain | 2.64 | 2.63 | 2.59 | 2.57 | 2.62 | 0.032 | 0.14 | 0.03 |
| Feed cost, $/kg[d] | 0.670 | 0.649 | 0.629 | 0.618 | 0.648 | 0.0077 | 0.01 | 0.01 |
| IOFC, $/pig[e] | 40.2 | 41.3 | 42.3 | 42.2 | 41.4 | 1.01 | 0.05 | 0.02 |

[a] A total of 1100 pigs housed 22 per pen with 10 replications per treatment.
[b] Stage 1 – 22.5/18%; Stage 2 – 15%; Stage 3 – 7.5%, Stage 4 – 0%.
[c] Initial weight was used as a covariate.
[d] Average ingredient costs: wheat $205, barley $195, corn $210, soy $420, expeller canola $210, wheat:corn DDGS $175, lysine $1900, tallow $700.
[e] Income over feed cost (IOFC) = ((ADG × 90 d × 78.5% × Index × $1.3/kg) – (ADG × 90 d × Feed cost/kg gain)).

## Pellet Quality/Feed Flow Ability

When formulating diets, we must consider the impact ingredients have on final diet quality such a feed flow and pellet quality. Out-of-feed events resulting from feed that is ground too finely or high inclusion level of co-products with poor flow characteristics (high fat content, very fine particle size) can result in greater cost at barn level if growth rate is reduced and days to market are increased; this may more than offset the diet cost savings. Our objective in pelleting diets is to allow finer grinding of ingredients to smaller particle size to achieve higher nutrient digestibility, capture feed efficiency benefits and avoid feed flow concerns. However, if high inclusion levels of opportunity ingredients (high in fat) results in excessive fines, and < 70% pellets at feeder, the benefits of pelleting rapidly disappear. Thus, in formulating diets one must bear in mind the impact each ingredient has on pellet quality and durability otherwise the benefit of pelleting can rapidly disappear and become only an added cost.

### Formulate for Maximum Margin over Feed Facility Cost (MOFFC)

In the past diet formulation strategies were to formulate for maximum growth because the highest margin over feed costs was associated with diets that maximized growth rate due to low diet cost and most barns being short on space. Because diet energy costs have increased dramatically, increases in diet energy level have become much more expensive. Formulating diets to lower energy levels that lower growth rate and result in poorer feed efficiency will become more economical now due to the high cost of energy. It is very important that we under stand the impact of changing diet energy levels on growth rate, feed efficiency, and MOFFC for the genetic lines and barns we work with. Opportunity ingredients can be used to reduce diet cost but may consequently reduce feed intake, growth rate and/or result in poorer feed efficiency but it is very important we understand the net economic impact they have for the barn or system. We must remember the producers we work with manage large agri-businesses thus net economic return is what should dictate the use and optimum inclusion levels of ingredients rather than maximum biological performance.

## ▪ Ingredient Procurement/Purchasing

Identifying opportunity ingredients that present feed cost savings to your barn or system is the first step in the process of attaining those cost savings. Evaluating the different sources in terms of available supply, nutrient content and variation, are key components in determining the true value of these ingredients. For example, there are 5 to 8 ethanol plants you can source corn DDGS from in the Northern US States, however there are vast differences in proximate analysis (moisture, protein, fiber, fat), total and available nutrient content between these sources. In addition, there are some big differences in the drying methods (temperature, time, etc) each plant uses which has a big impact specifically on total and available amino acid content of the DDGS. It is clearly important to realize that all sources of ingredients are not equal and this becomes more important when dealing with co-products that undergo heat treatment. Building a data base of ingredient nutrient content over time allows one understand the variation associated with specific ingredients and sources.

Many suppliers of ingredients fail to understand the variation that exists between sources, especially heat-treated co-products, and they value each source similarly, thus a cheaper source is simply taken as a better deal. This is simply not the case for pigs and we have been working with suppliers of DDGS to educate them with regard to the differences between sources in terms of nutrient content and value in pig diets. Once nutrient content and variation (or testing protocol to established variation) has been established the true nutrient value an ingredient is offering to pig diets can be evaluated relative to other ingredients. Periodic value analysis should be conducted to determine the on-going value that new ingredients offer to diets. Typically we like to see a minimum return of $0.30/pig with a new opportunity ingredient to warrant its use. For ingredients that have greater variation in nutrient content, and thus pose greater risk to animal performance, the minimum net return required to justify their use will be greater.

## ▪ Optimizing Use of Current Ingredients

In addition to diet formulation and ingredient changes, better management of your current ingredients and diet formulation present an opportunity. With the high cost of ingredients each incremental improvement in feed efficiency will reduce total feed required and cost to feed a pig to market. Many factors impact feed efficiency; some of the factors are outlined in **Figure 1**.

**Figure 1. Guide to trouble shooting feed efficiency** (Tokach et al., 2008).

**Feed Efficiency**

| ▼ | ▼ | ▼ |
|---|---|---|
| **High feed disappearance** | **Low ADG** | **Other factors** |
| ► Genetics | ► Disease | ► Particle size |
| ► Feed wastage | ► Genetics | ► Diet form |
| ► Low diet energy level | ► Feed availability | |
| ► Feed delivery | ► Water availability | |
| ► Diet deficiency (amino acid) | ► Diet deficiency | |
| ► Mortality | ► Temperature | |
| ► Temperature | | |

Particle size of ingredients has a direct effect on how efficiently feed is converted to available nutrients. For every 100 microns we reduce particle size, feed efficiency improves 1.2%. Thus, if we can effectively manage mash diets with ground ingredient portion of mash diets at 600 vs. 800 microns, net economic benefit is in excess of $1.5/pig. It is extremely important that a particle size monitoring program is in place at your feed mill, because what we do not measure, we cannot manage. Record keeping of hammer and screen replacement schedules, and roller and disc mill adjustments are essential to achieve target particle size of ground or rolled ingredients. As it becomes more cost effective to use more co-products and to grind ingredients to finer particle size (500-600 microns), it may be cost effective to use pelleted feeds (depending on charge for pelleting) to avoid out-of-feed events and capture feed efficiency benefits and feed cost savings of using higher co-product inclusion levels.

All ingredients contain moisture; however, the amount varies between suppliers and from year to year. A 2% higher moisture content of grains at receiving will impact feed efficiency and cost per pig significantly. Using today’s ingredient costs, 2% lower moisture content in ingredients is worth $1.5/pig in feed cost in grow-finish phases. All grains should be moisture tested before unloading. Other ingredients should also be moisture tested periodically, especially those that undergo a drying process. Drier ingredients are simply easier to grind and very cost effective in improving feed efficiency.

## ▪ Conclusion

Opportunity ingredients can offer significant diet and feed cost savings if formulated correctly into diets. However there are risks associated with using them. The risks can be mitigated by acquiring as much information on the ingredient as possible prior to using such as nutrients it brings to the diet, impact on diet palatability and diet handling characteristics. As the demand for traditional feed ingredients increases we will be forced to use more opportunity ingredients in diets and optimize the use of current ingredients if we are to control feed costs and remain competitive.

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