Alternative feed ingredients for laying hens

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The two main components of diets for laying hens are firstly a grain base which is essentially the energy platform for the diet and secondly a protein source to supply the necessary amino acids for egg protein synthesis.

In South-East Asia these have been traditionally met with corn and soybean meal. But neither are essential. In fact, layer diets can be comprised of a wide range of different feedstuffs and still deliver excellent results.

With the current pressure on the cost and supply of corn and soybean meal, it is timely to broaden our view and consider what alternative feedstuff could be utilized.

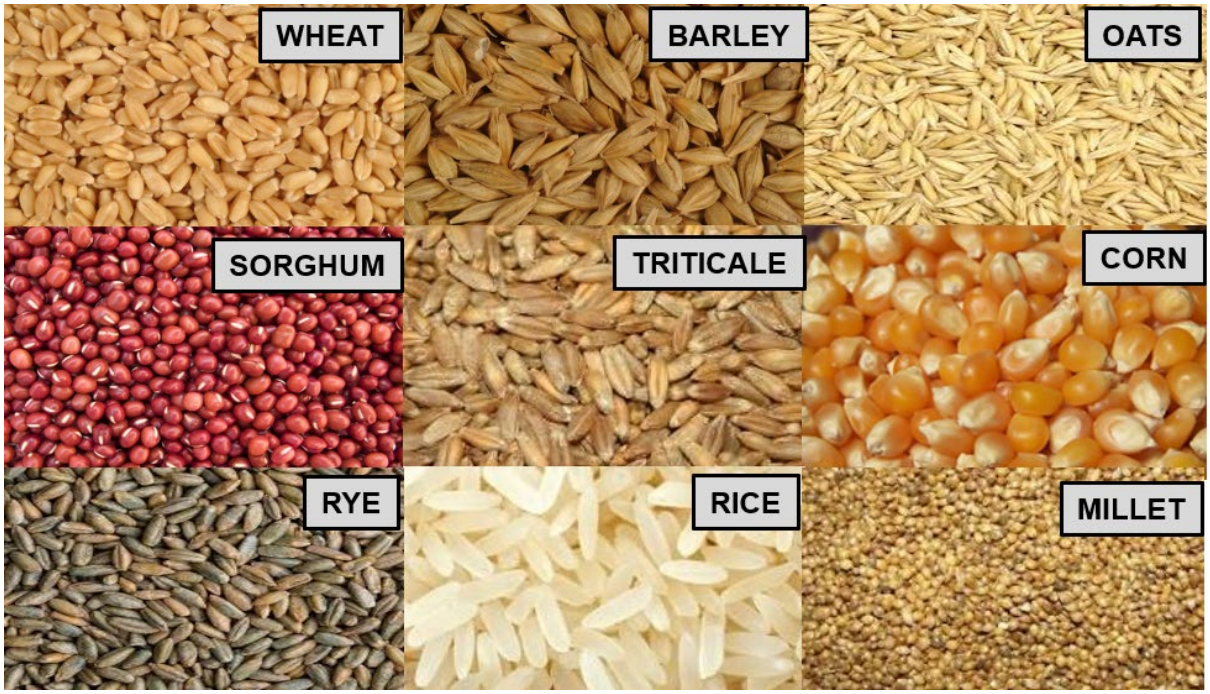

Figure 1. Example of the range of cereal grains used in layer diets around the world

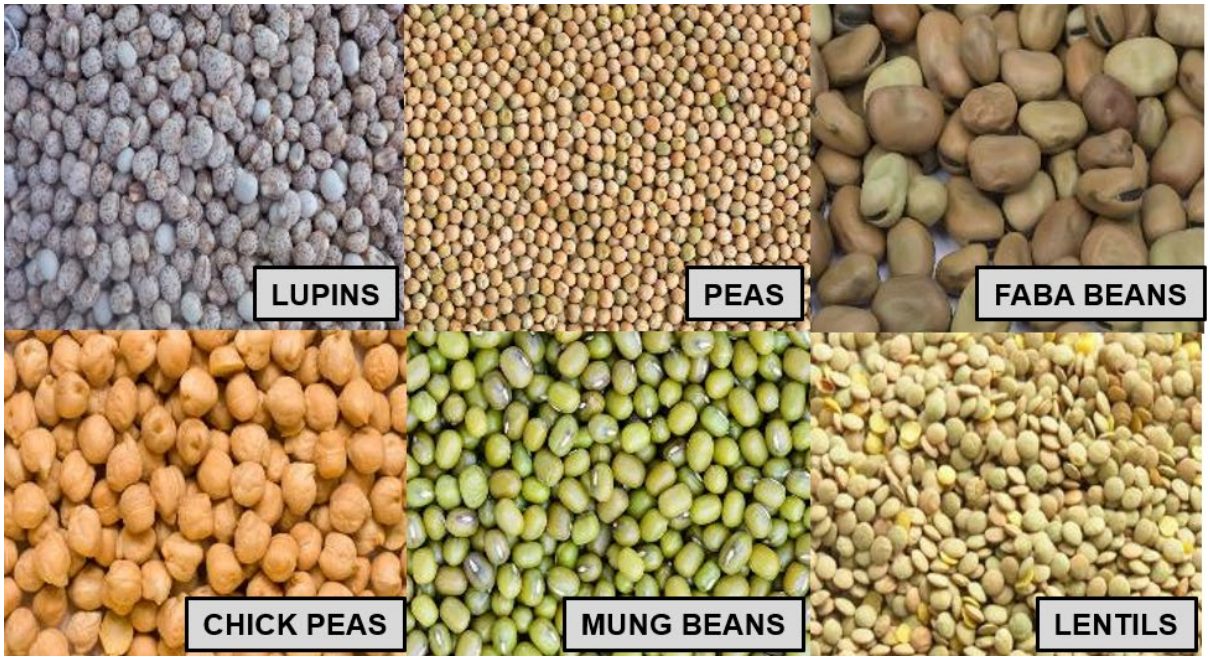

Figure 2. Useful grain legumes used in layer diets around the world

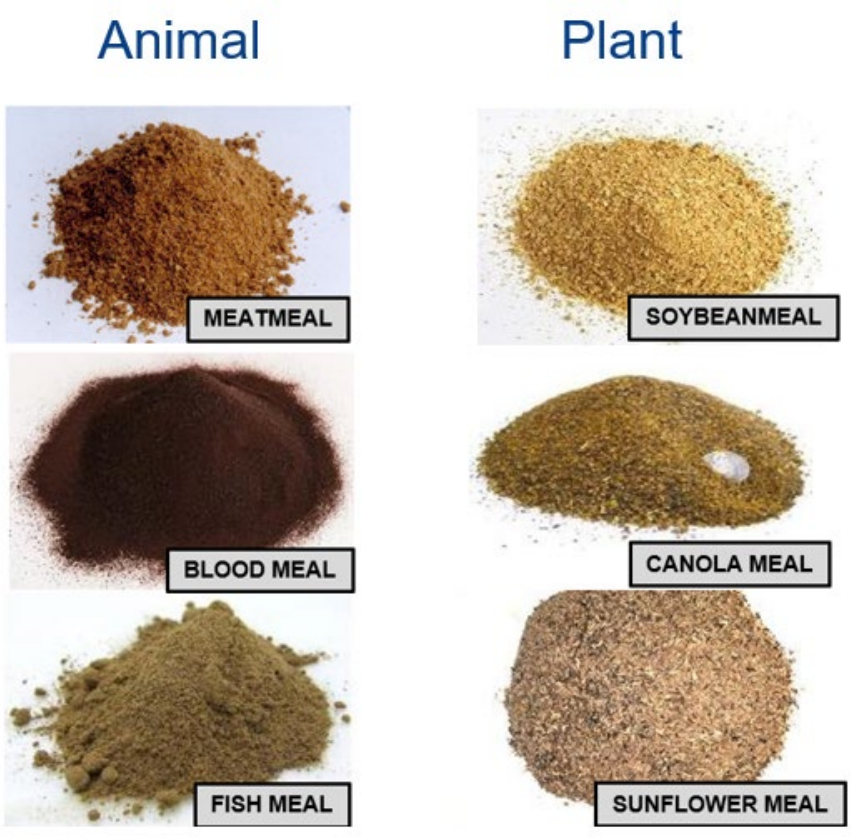

Figure 3. Main protein meals used in layer diets around the world

In Australia, layer diets are based on wheat, sorghum and barley with very little use of corn. The other grains are utilized when economically competitive. The grain legumes are particularly useful being intermediate between cereal grains and protein meals and are used very efficiently by the birds. Soybean meal tends to dominate the protein meal options but other plant options include canola and sunflower meal, and there is also animal protein options such as meat meal and blood meal, and even fishmeal can be used at modest inclusions.

There is also a broad spectrum of other grain-like alternatives including casava, rice bran (both full fat and extracted), wheat bran and pollard, copra, hominy, bakery waste, etc. and protein alternatives such as the full profile of synthetic amino acids, cottonseed meal, corn gluten meal, DDGS, peanut meal, feather meal, algal proteins and bacterial biomass products. However, many of these have limitations to use which need to be understood to achieve effective utilisation.

Nutrient principles

The birds have no requirement for any specific material. Rather their requirements are in the form of kilocalories of metabolizable energy and milligrams of digestible amino acids per day. These can be derived from many different sources with equal efficacy as long as the materials are appropriately characterised. There are however secondary nutritional and physical properties in some ingredients that limit their inclusion in diets.

As it is not possible to explore all alternative feedstuffs within this short presentation, I will focus on the feed grains available from Australia as these represent the main economic advantage.

These grains (wheat, sorghum, barley) are readily available, they are not by-products and are consistent and well characterised.

Table 1. Comparative analyses of wheat, sorghum and barley relative to corn.

Specification		Corn	Wheat	Barley	Sorghum
Moisture (%)		13	12	12	13
Protein (%)		8	11	11	9.5
Fat (%)		4	2.3	2.6	3.5
Ash (%)		1.15	1.7	2.2	2
Fibre	Crude (%)	2	2	4.8	2.3
	NDF[1] (%)	9	8.5	16.0	8
	ADF[2] (%)	2.2	2.5	5.5	2.5
Starch + Sugar (%)		64.6	63	53.9	63
Linoleic Acid (%)		1.88	1.0	1.09	1.44
Broiler ME MJ/kg (Kcal/kg)		13.45 (3215	12.56 (3000)	11.2 (2677)	13.21 (3157)
Layer ME MJ/kg (Kcal/kg)		13.75 (3285)	13.0 (3105)	11.8 (2820)	13.5 (3227)
Australian Broiler values (Kcal/kg)[3]		3350	3200*	2900*	3300

NB: typical values only- composition can vary widely with different agronomic conditions
*With Non-Starch Polysaccharides (NSP)
NDF[1] = Neutral detergent fibre ADF[2] = Acid detergent fibre
Source: Premier Atlas (2008) [3]T. Walker (2018)

Points to note include:

- wheat and barley tend to be higher in protein than corn by 2-3% units;
- corn is higher in oil than these alternative grains with associated energy and linoleic acid differences;
- barley is higher in fibre than the other grains due to the presence of a hull and is subsequently lower in starch. This results in barley being somewhat lower in energy than the other grains;
- sorghum is similar to corn in most aspects; and
- energy values of wheat and barley can be improved with the use of enzymes.

Table 2. The standardised ileal digestible amino acid composition of the grains at typical protein levels.

	Corn	Wheat	Sorghum	Barley
Crude protein (%)	8	11	10	10
SID Lys	0.22	0.27	0.20	0.31
SID Met	0.16	0.16	0.16	.015
SID Cys	0.16	0.23	0.14	0.19
SID M+C	0.32	0.39	0.30	0.35
SID Thr	0.25	0.27	0.28	0.25
SID Try	0.05	0.12	0.12	0.09
SID Arg	0.33	0.45	0.34	0.40
SID Ile	0.27	0.35	0.35	0.29
SID Leu	0.89	0.66	1.10	0.57
SID Val	0.35	0.43	0.44	0.40

Source: Evonik AminoDat 5.0

This reveals that wheat and barley deliver significantly higher levels of essential amino acids than corn. This is of particular interest currently as it reduces the need for supplementary protein from other sources, particularly soybean meal.

Table 3 reveals the fibre differences between the grains and in particular the non-starch polysaccharide (NSP) content. Corn and sorghum have low levels of soluble NSP fractions. Wheat on the other hand is relatively high in arabinoxylans and barley contains both β-glucans and arabinoxylans. These soluble NSP fractions can cause increased viscosity of ingesta in the gut, interfering with digestion and possibly resulting in wet litter or droppings These however can be effectively dealt with using exogenous enzymes.

Table 3. Typical fibre content of wheat, sorghum and barley relative to corn

		Arabinoxylan	B-Glucan	Cellulose	Other NSP[2]	Lignin	Total fibre
Corn	Soluble	0.1					0.1
	Insoluble	5.1		2.0	0.8	1.1	9.0
	Total	5.2		2.0	0.8	1.1	9.1
Wheat	Soluble	1.8	0.4		0.2		2.4
	Insoluble	6.3	0.4	2.0	0.3	1.8	10.8
	Total	8.1	0.8	2.0	0.5	1.8	13.2
Sorghum	Soluble	0.1	0.1				0.2
	Insoluble	2.0	0.1	2.2	0.25	1.1	5.65
	Total	2.1	0.2	2.2	0.25	1.1	5.85
Barley	Soluble	0.8	3.6		0.1		4.5
	Insoluble	7.1	0.7	3.9	0.5	3.2	15.4
	Total	7.9	4.3	3.9	0.6	3.2	19.9

Source: [1] From Choct (2006) and Bach Knudsen (2014)[2] Mannans + Galactans + Uronic Acid

So, when we look at these grain alternatives, wheat and sorghum can be used to completely replace corn. Barley has the potential to partially replace corn. In practical diet formulation many nutritionists believe there is a real advantage in having a mixture of grains.

As Australian grains are harvested very dry and held in good storage, the risk of mycotoxin development is very low.

Points of concern

The alternative grains are different to corn and these differences need to be addressed e.g.:

- Fibre levels
- NSP content - need for enzyme support
- Lack of pigment - need to supply pigments from other sources such as synthetic or natural pigments, corn gluten etc
- Energy density - need to balance with added fat/oil
- Linoleic acid - need to balance with added fat/oil
- Milling properties - e.g. pelleting, may need modification to milling parameters such as grind size, steam conditions, throughput rate, etc

Considering the alternative candidates in more detail:

Wheat

Wheat is the major grain in Australian poultry diets. Diets can be successfully based on all wheat although many nutritionists prefer a mixture of grains. Wheat is classified as a viscous grain due to its soluble arabinoxylan content and hence requires xylanase enzyme support.

Wheat is lower in energy than corn due to its lower fat content, despite having similar starch levels. Wheat is higher in protein and essential amino acids components than corn. Wheat starch and protein are both highly digestible. Wheat starch gelatinises readily and improves pellet quality. Currently available for export from Australia is a large volume of sprouted wheat (germination initiated but arrested prior to shooting) which has high test weight and normal energy values.

Sorghum

Sorghum is used extensively in poultry diets in Australia when priced competitively and regionally available. It is similar in energy and protein to corn. Sorghum can be used as the sole grain but often is used in combination with wheat to improve pellet quality.

Phenols are present in the pigmented seed coat but the level of condensed tannins is very low and represents no impediment to performance.

It is important to recognise however that these pigments are not xanthophylls and hence do not replace the pigmenting aspects of corn. Sorghum is low in both soluble and insoluble NSP's.

Barley

Barley is higher in fibre, lower in starch and hence lower in energy than corn. This need not be a negative aspect. The energy value of the diet can be restored with added fat or the lower energy can be used to regulate excessive weight gain in late lay or to control the growth of rearing birds.

The fibre in barley promotes gut health via physical stimulation and by the delivery of probiotic oligosaccharides. Barley is often included in layer diets for this purpose up to 30% inclusion.

Reducing soybean meal dependence

We can limit our dependence on soybean meal by the use of alternative proteins such as canola, sunflower, meat meal, bloodmeal and legumes. We can also exploit the high amino acid delivery from wheat and barley relative to corn.

There is also the option to extent the use of the full spectrum of synthetic amino acids (lysine, methionine, threonine, isoleucine, tryptophan and valine), as well as taking advantage of protease enzymes to enhance protein utilisation.

Example diets

Table 4 presents a series early lay diets formulated to common nutrient specifications using the various alternative grains and protein sources.

Example diet - Phase 1 layer (17-32 weeks)					
AUD$/T	Raw material	Corn/soy	Wheat (Alt. proteins)	Sorghum (Canola/meat)	Barley (Canola/meat)
$420	Corn 8%	60.88			30.76
$380	Wheat 11.5%		49.18		
$360	Sorghum 9%			60.15	
$320	Barley 10%				30.0
$1,000	Soybean meal 46%	26.8		13.4	13.8
$450	Peas		15.0		
$500	Canola meal (exp) 36%		10.0	10.0	10.0
$400	Sunflower meal 30%		8.0		
$845	Meat meal 50%		3.6	3.9	3.4
$1,200	Blood meal		1.3		
$1,500	Canola Oil	0.5	2.5	2.5	1.8
$220	Salt	0.3	0.2	0.2	0.25
$1,000	Bicarb Soda	0.15	0.22	0.2	0.2
$141	Limestone	4.3	3.8	3.5	3.6
$141	Lime Grits	5.5	5.5	5.5	5.5
$910	Monocalphos	1			
$2,000	Lysine HCl	0.05	0.14	0.17	0.14
$3,520	DL Methionine	0.26	0.25	0.29	0.26
$2,200	Threonine		0.04	0.03	0.02
$12,000	Tryptophan	0.1	0.01	0.01	0.01
$18,000	Isoleucine	0.04	0.14	0.02	1.0
$10,000	Valine	0.03		0.01	0.04
$1,500	Choline Chloride	0.07			
$100,000	Yolk Colour Pigments	0.0065	0.01	0.01	0.01
$20,000	Xylanase/Beta-glucanase		0.005	0.005	0.005
$20,000	Phytase	0.0035	0.0035	0.0035	0.0035
$8,000	Vitamin + Mineral Premix	0.1	0.1	0.1	0.1

	Corn/soy	Wheat	Sorghum	Barley
Analysis				
ME KcaL/kg	2730	2740	2880	2730
Protein (%)	17.5	18.4	17.5	17.5
SID Lysine(%)	0.83	0.83	0.83	0.83
Calcium (%)	4.0	4.1	4.0	4.0
Av. Phos (%)	0.42	0.41	0.41	0.42
Linoleic Acid (%)	1.65	1.40	1.4	1.57
Cost AUD $/Tonne	$594	$484	$525	$539

The first diet is a sample corn-soy diet as a reference point.

The second diet offers wheat and a series of alternative proteins (peas, canola, sunflower, meat meal and bloodmeal) and at the prices assumed results in the total replacement of the corn by wheat and the total replacement of the soybean meal by the other proteins. Points of interest in this diet are the added oil, additional yolk pigments and supplementing enzyme support. At the prices nominated this diet matches the specifications of the corn-soy diet but involves a saving in excess of A$100/t.

The third diet offers sorghum but only canola and meat meal as the alternative proteins. This results in the total replacement of the corn by sorghum but only a partial replacement of the soybean meal. The same features highlighted for the wheat diet apply but the need for NSP enzyme support is less critical.

The fourth diet offers barley, canola and meat meal. There is a limit on the barley inclusion of 30% so this is only a partial replacement of the corn, and similarly with only canola and meat meal on offer, it is only a partial replacement of the soybean meal. The yolk pigment addition and the need for a β-glucanase / xylanase enzyme support is highlighted. Although there is only partial replacement of the corn and soy components, the cost saving is still significant.

Important point

To be able to utilize these alternative materials, we need to understand them thoroughly. However you can have confidence that these grains are used extensively in other countries very successfully. In the case of wheat and barley it is very important that adequate enzyme support is provided (e.g. Xylanase, β-glucanase, phytase and possibly protease). It is important to balance all aspects of the diets and avoid simple substitutions.
When transitioning to new diets in existing flocks, it is best to do this gradually to avoid any disruption to the intestinal microbiome. Layers generally perform best on a diet prepared as a coarse mash. These alternative grains (wheat, barley, sorghum) can also be included partly in the diet as whole grains to stimulate gizzard formation.

Conclusions

The economics of livestock production including layer hens is under intense pressure from escalating feed costs.
It is timely that alternative materials be considered. However, any move to alternative materials must involve a thorough understanding of their nutritional value and diets must be formulated to accommodate these differences.

Productivity is the key to profitability. Hence any move to alternative materials that compromises production is unlikely to be cost effective even if it reduces feed cost.