SECTION 1.

NUTRITIONAL BENEFITS OF HYDROPONICALLY SPROUTED GRAINS FOR ANIMAL FEEDING

Review of published Scientific Literature

Nutritional changes upon Germination & Sprouting

Chavan and Kadam (1989) concluded that -

“The desirable nutritional changes that occur during sprouting are mainly due to the breakdown of complex compounds into a more simple form, transformation into essential constituents, and breakdown of nutritionally undesirable constituents.”

“The metabolic activity of resting seeds increases as soon as they are hydrated during soaking. Complex biochemical changes occur during hydration and subsequent sprouting. The reserve chemical constituents, such as protein, starch and lipids, are broken down by enzymes into simple compounds that are used to make new compounds.”

“Sprouting grains causes increased activities of hydrolytic enzymes, improvements in the contents of total proteins, fat, certain essential amino acids, total sugars, B-group vitamins, and a decrease in dry matter, starch and anti-nutrients. The increased contents of protein, fat, fibre and total ash are only apparent and attributable to the disappearance of starch. However, improvements in amino acid composition, B-group vitamins, sugars, protein and starch digestibilities, and decrease in phytates and protease inhibitors are the metabolic effects of the sprouting process.”

Increases in Plant Enzyme content

According to the highly respected naturopath and herbalist Isabell Shipard (Shipard, 2005) -

“Sprouts are a tremendous source of (plant) digestive enzymes. Enzymes act as biological catalysts needed for the complete digestion of protein, carbohydrates & fats. The physiology of vitamins, minerals and trace elements is also dependant on enzyme activity.”

"Being eaten whilst extremely young, "alive" and rapidly developing, sprouts have been acclaimed as the "most enzyme-rich food on the planet". Estimates suggest there can be up to 100 times more enzymes in sprouts than in fruit and vegetables, depending on the particular type of enzyme and the variety of seed being sprouted. The period of greatest enzyme activity in sprouts is generally between germination and 7 days of age."

"Grains and legume seeds of all plants contain abundant enzymes. However, while grains and seeds are dry, enzymes are largely inactive, due to enzyme inhibitors, until given moisture to activate germination. It is these inhibitors that enable many seeds to last for years in soil without deteriorating, whilst waiting for moisture. Enzyme inhibitors in some grains and legume seeds (for example *trypsin inhibitors* in raw soybeans and certain other beans and peas) need to be inactivated by heating or other processes, before they can be safely fed. However, heating, cooking and grinding processes can also inactivate certain digestive enzymes within grains and seeds. Fortunately, during germination and sprouting of grains and seeds, many enzyme inhibitors are effectively neutralized, whilst at the same time the activity of beneficial plant digestive enzymes is greatly enhanced."

Increases in Crude Protein content

Morgan et al. (1992) found that -

"The protein content of sprouts increased from the time of germination, as shown below. The absorption of nitrates facilitates the metabolism of nitrogenous compounds from carbohydrate reserves, thus increasing crude protein levels."

Crude protein contents of seed and 4, 6 and 8-day old barley grass mats

	Crude protein (% DM)
Original seed	10.1%
4 day old	10.8%
6 day old	13.7%
8 day old	14.9 %

Source: Morgan et al. (1992)

Increases in Protein Quality

Chavan and Kadam (1989) stated -

"Very complex qualitative changes are reported to occur during soaking and sprouting of seeds. The conversion of storage proteins of cereal grains into albumins and globulins during sprouting may improve the quality of cereal proteins. Many studies have shown an increase in the content of the amino acid Lysine with sprouting."

"An increase in proteolytic activity during sprouting is desirable for nutritional improvement of cereals because it leads to hydrolysis of prolamins and the liberated

amino acids such as glutamic and proline are converted to limiting amino acids such as lysine."

Increases in Crude Fibre content

Cuddeford (1989), based on data obtained by Peer and Leeson (1985), stated -

"In sprouted barley, crude fibre, a major constituent of cell walls, increases both in percentage and real terms, with the synthesis of structural carbohydrates, such as cellulose and hemicellulose". Chung et al. (1989) found that the fibre content increased from 3.75% in unsprouted barley seed to 6% in 5-day sprouts."

Crude Protein and Crude Fibre changes in Barley Sprouted over a 7-day period

	Crude Protein (% of DM)	Crude Fibre (% of DM)
Original seed	12.7%	5.4%
Day 1	12.7%	5.6%
Day 2	13.0%	5.9%
Day 3	13.6%	5.8%
Day 4	13.4%	7.4%
Day 5	13.9%	9.7%
Day 6	14.0%	10.8%
Day 7	15.5%	14.1%

Source: Cuddeford (1989), based on data obtained by Peer and Leeson (1985).

Increases in Essential Fatty Acids

An increase in lipase activity has been reported in barley by MacLeod and White (1962), as cited by Chavan and Kadam (1989). Increased lipolytic activity during germination and sprouting causes hydrolysis of triacylglycerols to glycerol and constituent fatty acids.

Increases in Vitamin content

According to Chavan and Kadam (1989), most reports agree that sprouting treatment of cereal grains generally improves their vitamin value, especially the B-group vitamins. Certain vitamins such as α-tocopherol (Vitamin-E) and β-carotene (Vitamin-A precursor) are produced during the growth process (Cuddeford, 1989).

Vitamin analysis based on single 6-day grass samples (mg/kg DM)

	Barley GRAIN	Barley GRASS
Vitamin-E	7.4	62.4
Beta-Carotene	4.1	42.7
Biotin	0.16	1.15
Free Folic Acid	0.12	1.05

Source: Cuddeford (1989).

According to Shipard (2005) -
"Sprouts provide a good supply of Vitamins A, E & C plus B complex. Like enzymes, vitamins serve as bioactive catalysts to assist in the digestion and metabolism of feeds and the release of energy. They are also essential for the healing and repair of cells. However, vitamins are very perishable, and in general, the fresher the feeds eaten, the higher the vitamin content. The vitamin content of some seeds can increase by up to 20 times their original value within several days of sprouting. Mung Bean sprouts have B vitamin increases, compared to the dry seeds, of - B1 up 285%, B2 up 515%, B3 up 256%. Even soaking seeds overnight in water yields greatly increased amounts of B vitamins, as well as Vitamin C. Compared with mature plants, sprouts can yield vitamin contents 30 times higher."

Chelation of Minerals

Shipard (2005) claims that - "When seeds are sprouted, minerals chelate or merge with protein, in a way that increases their function."

Reduction of Anti-Nutritional Factors

Phytic Acid occurs primarily in the seed coats and germ of plant seeds. It forms insoluble or nearly insoluble compounds with minerals including Calcium, Iron, Magnesium and Zinc, such that they cannot be effectively absorbed into the blood. Diets high in phytic acid and poor in these minerals produce mineral deficiency symptoms in experimental animals (Gontzea and Sutzescu, 1958, as cited in Chavan and Kadam, 1989). The latter authors state that the sprouting of cereals has been reported to decrease levels of Phytic Acid. Similarly, Shipard (2005) states that enzymes of germination and sprouting have the ability to eliminate detrimental substances such as Phytic Acid.

Cattle Feeding Trial in WA

Tudor et al. (2003) examined the feeding of hydroponically sprouted barley on a property in the Gascoyne Pilbara region of Western Australia, involving 17 Droughtmaster steers (15 – 18 months old and averaging 330 kg liveweight) which received low quality hay and barley sprouts over 70 days. These workers reported -

"Over the first 48 days cattle ate 1.9 kg DM/head/day of sprouts (15.4 kg wet weight) and 3.1 kg DM/head/day of poor quality hay and gained 1.01 kg/head/day. Energy intake was 47 MJME/head/day, which was considered by nutrition standards to only be sufficient for low weight gains of up to 200g/head/day. This high performance could not be explained by energy and protein intakes."

"Traditional nutritional standards for feeding beef cattle cannot explain the liveweight gain observed. There was no obvious weight gain due to gut fill or compensatory growth. The better-than-expected performance may be associated with the readily available nutrients and associated enzymes in the 6-7 day old fodder being very rapidly utilised by the animal, immediately they are formed. They may not be included by the assay when *in vitro* DM digestibility is being measured. These nutrients could result in enhanced microbial activity and growth in the rumen, and consequently, better than expected

utilisation of the poor quality hay that was also fed. Therefore, the fermentation of the young hydroponically sprouted barley may have provided far greater energy than was estimated by the *in vitro* DM digestibility assay."

References

Chavan, J. and Kadam, S.S. (1989). "Nutritional improvement of cereals by sprouting." Critical Reviews in Food Science and Nutrition 28(5): 401-437.

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Summary of Nutritional Benefits upon Sprouting

- When seeds are sprouted, the hydrolytic enzymes breakdown grain storage compounds into more simple and digestible fractions -
  - Starch → Simple Sugars & Soluble Carbohydrates
  - Protein → Soluble Proteins & free Amino Acids
  - Fats → Essential Fatty Acids
  - Minerals chelate (i.e., merge with a protein molecule) in a way that increases their bioavailability.

- Sprouting grains results in -

↑ Protein & Starch Digestibilities

↑ Total Sugars

↑ Crude Fibre %

↑ Protein % and Protein Quality

↑ Lysine %

↑ B-group Vitamins Vitamin-E & Vitamin-A

↓ Anti-Nutritional Compounds such as Phytates & Protease Inhibitors

All these actions greatly enhance the digestibility and nutrient value of sprouted grains, well above the original grain or seed.

SECTION 2.

POSSIBLE NUTRACEUTICAL BENEFITS OF HYDROPONICALLY SPROUTED GRAINS FOR HORSES

Statements from Published Literature

Definition: The term "*Nutraceutical"* was coined in the 1990's by Dr. Stephen DeFelice, who defined the term as:
"A Nutraceutical is any substance that is a food or a part of a food and provides medical or health benefits, including the prevention and treatment of disease."

In view of this definition, it appears reasonable to regard hydroponically sprouted grains and legume seeds as "Nutraceutical feeds", when considering reported claims of characteristics conferring potential health benefits.

1.) Antioxidant Vitamins A, E, and C

As reported by Shipard (2005) -
"Sprouts can be a rich source of antioxidants, in the form of Beta-Carotene (a precursor of Vitamin-A), Vitamin-E, Vitamin-C and related trace minerals such as Selenium and Zinc. Antioxidants play an important role in assisting to protect the body from damage by free radicals. ("Free radicals" are highly unstable oxygen molecules that are increasingly generated under conditions of high physical exertion and also under conditions of poor nutrition.) As physiologically toxic agents, they have the potential to lead to pain and disease. Free radicals travel throughout the body in search of an electron "partner" and can "steal" electrons from healthy cells. In doing so, they have the ability to alter the structure of the vital biological entities DNA and RNA, which are required for the reproduction of cells. Antioxidant vitamins have an ability to neutralise free-radicals, by either taking away or donating electrons, thereby eliminating the unpaired electron."

The highest sources of antioxidant vitamins and minerals are undoubtedly legume seeds such as - **FENUGREEK, ALFALFA, MUNG BEANS, CHICK PEAS and SUNFLOWER SEEDS**. According to Shipard (2005), "Fenugreek is one of the oldest recorded medicinal herbs, highly esteemed by both east and west, and has been regarded as a treatment for just about every ailment known to man. Fenugreek has a beneficial action on cleansing the blood."

Other well accepted roles for Vitamins A and E in equine physiology include:

Vitamin-A:
- Disease resistance,
- Skin & Coat condition,
- Nervous function.

Vitamin-E:
- Immune system competence & Disease resistance,
- Heart, skeletal & respiratory muscle function,
- Oxygen utilization,
- Possible role with Selenium in preventing Muscle Tie-up syndrome.
- Nervous function.

Possible roles for Vitamin-C include:

- An involvement in blood capillary strength and fragility, thereby potentially assisting in the reduction of pulmonary bleeding in racehorses.

2.) Alkalising Effect on Body Cells

According to Shipard (2005) -
"Sprouts help to "**alkalise**" the body and neutralise acidic wastes, thus assisting the body to heal itself and develop a stronger immune system. Just as most plants grow well in neutral pH soils, so too can animals be more productive if given alkaline feeds. It is believed that in an acid state, body cells cannot adequately take in nutrients and oxygen, and they cannot effectively expel toxins. An overly acid state reduces the amount of oxygen and nutrients that the cells can receive. When a cell is oxygen deprived, various types of serious health problems may be created."

In racehorses and other performance horses kept in stabled or yarded environments, where access to fresh grass or pasture legumes is not possible, **Ulceration of the Gut**, as well as **Laminitis** and **Founder** diseases are thought to increase in prevalence under conditions of excessively acidic cellular states.

These conditions are most likely induced by a lack of salivary buffering brought about by inadequate grazing, low roughage intakes, high grain intakes and the stresses of high intensity training and stable life.

Shipard (2005) continues to state -
"Healthy cells are alkaline. An alkaline body is a clean system that is able to play a vital role in maintaining natural immunity and optimum health. Feeds are classified as "acid" or "alkaline" according to the chemical nature of the ash residue that remains following digestive processes. "Ash" relates to the mineral content of feed."

"Generally, all seeds, grains, legumes and nuts are acidic in nature. However, following germination, sprouts develop a richness of essential minerals that are alkaline in nature. Therefore, it is in the action of seeds sprouting, that they change from "acid" seeds to "alkaline" sprouts. Enzyme-rich feeds are also generally alkaline in chemical nature."

Anecdotal reports suggest that the feeding of sprouts may have a benefit in preventing the occurrence of, and possibly assisting in the treatment of, Gastric Ulceration in Horses.

Several thoroughbred trainers have reported that Gut Ulcers can be prevented in their racehorses by the feeding of 5 - 10 kg per day of sprouts for the duration of the training preparation.

FODDERsolutions will be contracting the University of Queensland to undertake controlled trials with racehorses later in the year to properly examine this extremely interesting claim.

3.) Source of Chlorophyll

According to Shipard (2005) -
"Sprouts are a good source of Chlorophyll, which plays an important role in blood cleansing and building, as well as helping to regenerate the liver, detoxify and invigorate the body and energise the immune system. Chlorophyll has been found beneficial for strengthening the heart, intestines, vascular and lymphatic systems, lungs, glands and reproductive organs."

Additional sources of chlorophyll become increasingly important under conditions of drought and where poor quality hays or roughages form a large portion of the diet.

Reference

Shipard, I. (2005). "How Can I Grow and Use Sprouts as Living Food ?" Stewart Publishing.

SECTION 3.

OBSERVATIONS & EXPLANATIONS FROM THE FEEDING OF SPROUTED GRAINS TO RUMINANTS & HORSES

Reported Observations from Livestock Owners

Horses

- Reduced **recovery time** after hard work.
- Stimulation of **appetite**, especially during conditions of heat stress.
- Reduction in the incidence of **Gut Ulcers** in racehorses.
- Reduction in the incidence of **Laminitis** in working horses.
- Improvements in **behaviour,** ie, reduction of **"fizz"** in working horses.
- Great improvements in general **appearance & coat gloss**.
- Substantial improvements in **hoof quality & strength** (reported by farriers).
- Improved **conception rates** in broodmares on poor quality pastures.
- Improved performance of **young foals** on mares in poor paddocks.

Richard Kinnon, Longreach, Qld - highly respected horse & cattleman:

- *"Feeding it's a breeze."*
- *"Takes the worry out of heating up in the legs, plus the fizz."*
- *"I regard it as a Tonic - either for horses or the cattle."*
- *"Using the sprouts, my feeding costs are about half what they were last year."*
- *"I can't speak highly enough of it regarding performance and what it's doing."*

Beef Cattle

- Surprisingly good **weight gains** when feeding moderate quantities of sprouts to animals with a very low quantity & quality of alternative feed available.

> **Flavio Raccanello, Toowoomba, Qld - businessman & experienced cattleman:**
>
> ***Daily feeding of 1.0 kg Barley, germinated to yield 7.0 kg fresh weight of Sprouts, to Angus cross heifers (200 kg BW) in a badly drought-affected paddock of Rhodes grass for 100 days yielded 0.75 kg/day ADG.***
>
> ***This equates to 0.5% BW Grain or 3.5% BW Sprouts, as a supplement to poor paddock feed.***

- Improved **conception rates** in heifers and cows on poor quality pastures.
- Improved **weaning rates** in herds on poor quality pastures.
- Great improvements in general **appearance & coat gloss**.

Dairy Cattle

- Improved **milk yields** in herds with a very low quantity & quality of alternative feed available.
- Improvements in **milk fat levels**.
- Improved **conception rates** in milking heifers and cows on poor quality pastures.
- Fewer **herd health** problems.
- Greatly improved performance of **calves** reared on sprouts + milk replacer + poor quality forage.

Sheep and Goats

- Good **weight gains** on poor quality pastures.
- Improved **conception rates** in ewes and does.
- Improved **weaning rates** in herds on poor quality pastures.
- Fewer **herd health** problems.
- Improved **milk yields** in milking goats.
- Improved appearance of **fleece** in fibre goats.

Possible Explanations for Observations reported

From Sections 1 and 2 above, we can appreciate that …….

Sprouted Grains are highly digestible, highly nutritious and succulent feeds, largely due to the greatly enhanced activity of hydrolytic ENZYMES.

Increased enzymic activity results in Sprouts having the following improvements over the original grains …

NUTRITIONAL IMPROVEMENTS:

- **Higher in Total Sugars, Soluble Carbohydrates & Soluble Proteins,**
- **Improved Starch & Protein Digestibilities,**
- **Improved Protein Quality & Lysine %,**
- **Increased Crude Fibre %,**
- **Increased contents of Essential Fatty Acids,**
- **Increased contents of B-group Vitamins,**
- **Chelation of Minerals, and**
- **Reduction in certain enzyme inhibitors and some other Anti-Nutritional Compounds.**

NUTRACEUTICAL IMPROVEMENTS:

- **Increased contents of Antioxidant Vitamins A, E and C, especially in spouted legume seeds such as Fenugreek & Alfalfa,**
- **Sprouts have an "Alkalising" effect on body cells, with a consequential pH buffering of rumen or stomach contents, and**
- **Sprouts are a source of Chlorophyll, deficient in droughted pastures, but important for health of the vascular and immune systems.**

1.) Importance of Enzymic Activity in Feeds during times of Drought

- Animals are normally provided with a good supply of endogenous enzymes. The pancreas produces fluid which contains amylase to digest carbohydrates, lipase to digest fats and protease to digest proteins. Ruminants and horses also possess vast numbers of bacteria, protozoa and fungi throughout their digestive tracts to digest carbohydrates via fermentative processes. However, under conditions of stress - such as during periods of drought, or for horses, during weaning or periods of boredom or intense training or racing (especially when constantly stabled without access to fresh green pasture), the efficiency of feed digestive processes can decline. Feeds may not be fully digested and effectively utilized under such conditions, and the immune system may suffer as well.

- Especially important when animals are under conditions of stress is that all feeds offered must be highly digestible, and together with this will often come a necessity for a good contingency of plant digestive enzymes within the pasture, forage, hay, grain or other form of feed offered.

- Grains and legume seeds contain abundant enzymes. However, while grains and seeds are dry, enzymes are largely inactive, due to "*enzyme inhibitors*", until given moisture to activate germination. Enzyme inhibitors in some grains and legume seeds (for example *trypsin inhibitors* in raw soybeans and certain other beans and peas) need to be inactivated by heating or other processes, before they can be safely fed to ruminants and horses (and, more particularly, monogastrics such as pigs, poultry, dogs or humans). However, heating, cooking roasting, extrusion, steam-flaking and grinding processes can also inactivate beneficial digestive enzymes within grains and seeds. Fortunately, during germination and sprouting, many of the undesirable enzyme inhibitors are neutralized, whilst at the same time the activity of beneficial digestive enzymes is enhanced.

- All fresh grasses, legumes, plants, fruits & vegetables contain enzymes needed for the digestion of their own nutrients. However, enzyme concentrations vary dramatically with the state of health of the material - with stress factors such as water deprivation and drought, nutrient deprivation, frosting or disease severely depressing enzyme levels.

- When feeding freshly sprouted grains and seeds, we are providing animals with "living feed" which has a rich supply of enzymes which results in all nutritional components being highly digestible and extremely nutritious.

- Sprouts have been acclaimed as the "most enzyme-rich food on the planet". Some human nutritionists estimate that there can be up to 100 times more enzymes in sprouts than in fruit and vegetables. The period of greatest enzyme activity is generally between germination and 7 days of age.

2.) Importance of Highly Nutritious Feeds during times of Drought

- When feeding freshly sprouted grains and seeds to ruminant livestock or horses, we are providing these animals with a rich supply of highly digestible nutrients in an appealing, succulent, high moisture alkaline form which stimulates appetite and rapidly improves metabolic processes throughout the entire body.

- Despite sprouted feed having a very low dry matter content (commonly 80-85% moisture), when feeding sprouts in the magnitude of approx **3.0 - 4.0% of Body Weight** (equating to approx **0.5% BW of grain** before being sprouted), we are supplying the microbial populations within the rumen of cattle and sheep or the digestive tract of horses with naturally pH balanced feed containing rapidly available:
    - Simple Sugars,
    - Soluble Proteins & Carbohydrates,
    - Amino Acids,
    - Essential Fatty Acids,
    - Soluble & Insoluble Fibre, as well as,

- B-group and other important Vitamins and bioavailable Minerals which all assist in overall digestion & metabolism.

- At this level of feeding - for example a **400 kg mare** receiving **3.0% BW**, or **12.0 kg** of sprouted barley (**15% DM**) per day - when assuming **20% CP** (DM basis) - we are supplying the microbial populations within the equine small & large intestine & ceacum with 12.0 kg x 15% x 20% = **360 grams of crude protein**. This is in addition to significant metabolisable energy, plus other nutrients as stated above, all in a highly utilisable form which should also assist in pH buffering of gut contents.

  This supply of crude protein is approx 50% of stated daily requirements and very important to stimulate microbial digestive processes. With small amounts of additional forage supplied - as either pasture or hay, etc - it can be appreciated how sprouted feeds can significantly boost animal performance, despite their very high moisture contents.

3.) Improved Efficiency of Animal Metabolism during times of Drought

- It should be recognized that when feeding ruminant livestock and horses during times of drought or other conditions of sub-optimal feed availability, it is an interesting biological fact that all metabolic processes become highly efficient. When animals are losing body fat, they can utilise dietary energy with very high efficiency, meaning that responses to supplied feedstuffs is often greater than will be predicted from conventional feed response calculations.

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Given all the above, it should be understandable as to why sprouted feeds can greatly improve animal performance, despite their very high moisture contents, especially under conditions of drought, or when animals are on poor quality roughage based diets.

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