

Sheep & Goats

Feeding Sprouts to Sheep & Goats

Fresh sprouts grown in a Fodder system offer nutritional advantages for sheep and goats. Fodder sprouting systems allow users to supply appropriate volumes of fresh, spring grass shoots to their sheep and goats for optimal performance.

Advantages for Sheep

Feeding sprouts to sheep offers very dramatic advantages including:

- Improved wool volume & quality
- Faster weight gain
- Less teeth wear
- Higher fertility rate
- Fewer parasites

Sheep Testimonial

We grow approximately 1.2 tons of fresh barley sprouts on a daily basis. These sprouts are rich in vitamins and enzymes and they have quickly become part of our feeding regime. Our stock continue to thrive. The birth rates of our flock have increased from around 120% – 180%. I also think that my sheep will live longer due to less wear and tear on their teeth through eating the succulent fodder.

Highly nutritious sprouts produce healthier goats which in turn offer:

- Higher milk volume
- Increased fertility rate
- Lower infant mortality
- Faster weight gain

Dairy Goat Testimonial

A California Goat Dairy has used sprouts for more than 1 year. The owner, who is an artisanal cheese maker reports:

- Feed bill halved
- Milke volumes up 20% – 50%
- Cheese yield up 40% – 50%
- Kids nursing on moms are "huge"

Sprouts have allowed me to almost double my cheese production per goat.

<https://www.agritom.co/sheep-fodder-replacement-diet-trial/>

Increased Digestive Performance

It can be concluded that 1.50 – 2.25 kg of fodder produced in a Fodder System will adequately replace at least 85% of the concentrate in the diet of a store lamb and produce viable weight gains as normally expected in a lamb of that age.

Sheep Fodder Replacement Diet Trial

Liam McGreevy

Abstract

During March 2012, a sheep farmer agreed to run a trial on his lambs using mats of fresh sprouted barley fodder produced with a Fodder System, to replace a portion of his concentrate ration. When the farmer was happy that the system was running consistently, and the sheep were familiar with the feed, he split a group of them off from the herd in order to feed them separately, and monitor their performance.

Over the course of six weeks, he fed them a portion of one mat of fodder weighing approximately 8Kg produced from 1.2Kg of barley grain, alongside some concentrate. The farmer fed the sheep according to the parameters outlined in the methods section, and weighed the sheep every two weeks. The data used in this report is that recorded by the farmer.

The results provided by the farmer from sheep on the Fodder Replacement Diet, show that while the concentrate feed level drops the sheep show weight gain levels consistent with that expected from their normal diet. Weight gain normally expected from fattening lambs would be between 0.15 – 0.30Kg/day. When results from sheep on the fodder diet are compared to this standard there is no difference in productivity between them.

This confirms that the fresh sprouted barley fodder produced by the Fodder System is capable of replacing the concentrate ration in a sheep's diet without detrimentally affecting their productivity. A longer term trial would be necessary to evaluate the health benefits provided by the feed and benefits to the business as a result of healthier stock.

Introduction

The Fodder Sprouting System produces fresh sprouted barley grass every day. This represents a cheaper, more natural, guaranteed livestock feed source for farmers.

The technical information on feeding livestock recommends feeding a specific amount of dry weight of feed, a percentage of the animals live body weight. This is something that all farmers follow, and for the most part provides farmers with good productivity from their livestock¹.

Where feeding fresh fodder produced in a Fodder System is concerned, the main concern for farmers is the claim that 1 mat of fodder will replace 3-4Kg of concentrate feed. One mat of fodder weighs approximately 8Kg wet, produced from 1.2Kg of barley seed, and the concern is that the drop in dry weight fed will result in a decrease in productivity.

Another issue that farmers have with feeding fresh fodder is that they believe the level of nutrition won't be as good as that in concentrate feed. This report contains feed analysis reports which show the level of protein available within fresh sprouted fodder. Coupled with the fact that some vets support the idea that the live fresh feed improves the digestive performance of the gut, this means that the animal actually digests the rest of their diet more efficiently due to the addition of

fresh fodder to the diet^{2, 3}.

A farmer who was interested in the potential of the feed, was willing to trial it on his sheep. For a period of six weeks 21 lambs were separated from the herd completely. They were then fed 4 mats of fodder, as well as ad-lib silage and some all-purpose concentrate. The farmer holds around 200 sheep in total. The lambs, 9 months old, are normally out at pasture during the day, and brought indoors during the afternoon, when indoors they have access to ad-lib silage.

Hypothesis

Replacing the concentrate in the diet of a sheep with approximately 2Kg of fresh sprouted barley fodder will provide sufficient nutrition to enable the lamb to increase its body weight in a similar timescale to a normal concentrate based diet.

Materials and Methods

Fodder System – Producing 6 mats weighing 48 kg per day. The farmer added 1.2 kg of barley per mat.

Water – Normal tap water, plumbed into the system

Scoop – 2L plastic scoop

Housing – The herds are separated and kept in different sheds of brick construction with metal roofing.

Daily Routine – The sheep being fed on the fodder diet are separated entirely. For the first four weeks they are fed 4 mats per day along with their ad-lib silage, 0.3Kg of concentrate and drinking water. For the last two weeks they were fed 6 mats of fodder plus ad-lib silage, 0.3Kg of concentrate and drinking water.

Sheep – The poorest 21 lambs were selected to be placed on the replacement diet. They varied in weight from approx. 18Kg to 24Kg at selection. Average weights are taken from the other lambs to compare the effectiveness of each diet.

Standard Diet:

Silage – Ad-lib – Concentrate feed – 2Kg – Water – Ad-lib

Fodder Replacement Diet:

Silage – Ad-lib – Concentrate feed – 0.3Kg – Fodder – 1.5Kg rising to 2.25Kg – Water – Ad-lib

Feeding

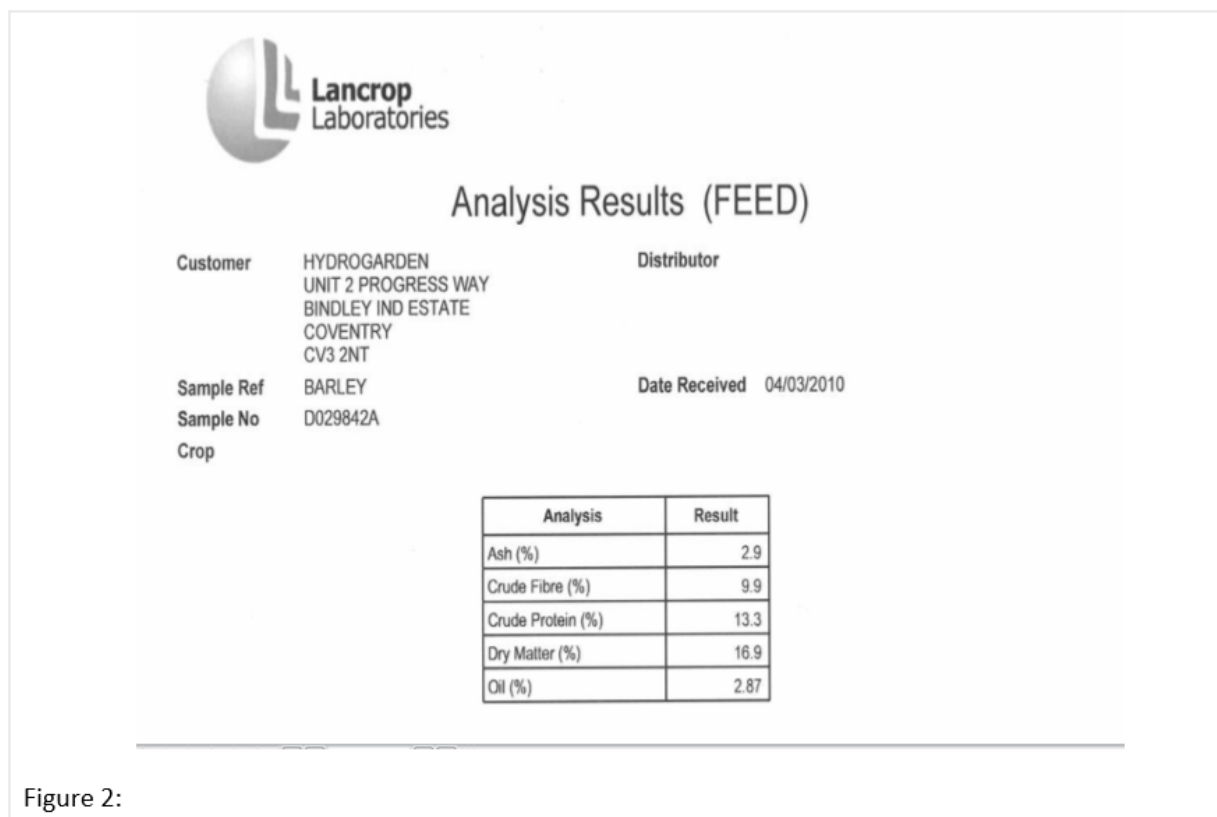
Late Lambs – Born in May or June, they are used to clean the grass left on the grazing pasture over winter plus silage. They are roughly 20Kg in weight when taken into housing for fattening towards the end of January. They are then usually fed concentrate and silage until ready for sale at approximately 45Kg in April. The lambs are sold at approximately 11 months old.

For the purposes of the trial, the lambs were fed 4 mats of fodder between them (1.5Kg/head) from 25/02/2012 up to and including 30/03/2012. From 31/03/2012 they were fed 6 mats of fodder between them (2.25Kg/head) this also coincided with the lambs being put out in a field with no grazing available.



Lab Results

Feed testing results for high germination barley sprouted in a Fodder System.



Trial Subjects

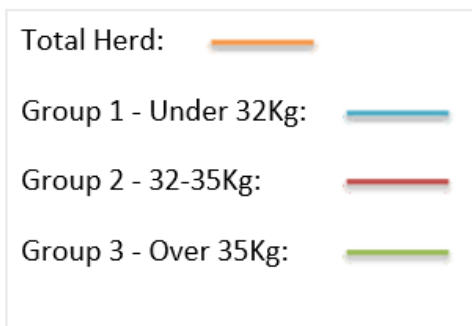
The table below contains details of the lambs used in the trial:

Stock No.	Breed	Born	Start Weight
54-J		May/June	29
68-J		May/June	30
78-A		May/June	30
84-E		May/June	30
52-E		May/June	32
77-H		May/June	33
57-F		May/June	33
72-B		May/June	33
64-A		May/June	33
67-G		May/June	34
53-G		May/June	34
82-H		May/June	34
66-E		May/June	34
81-F		May/June	34
83-A		May/June	36
74-B		May/June	36
80-D		May/June	38
79-C		May/June	38
69-B		May/June	38
65-C		May/June	38
73-J		May/June	38

Figure 3

Results

For the purposes of analysis and presentation of some results, the herd was split into 3 groups based upon their weight at the start of the trial. Demarcation is as follows:



Figures 4 and 5 represent the weight gain of the herd on the Fodder Diet over the total period of the trial. The graphs show a steady increase in weight over the period of the trial, with total herd weight increasing from 715Kg to 1080Kg, and individual weights increasing from between 30-38Kg to 45-55Kg, over the total six-week period. The results give weight gains consistent with that normally expected from fattening lambs fed on a concentrate and silage diet.

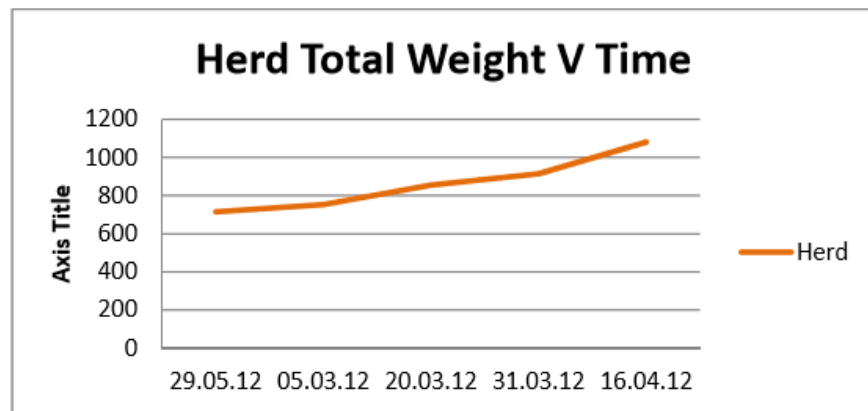


Figure 4

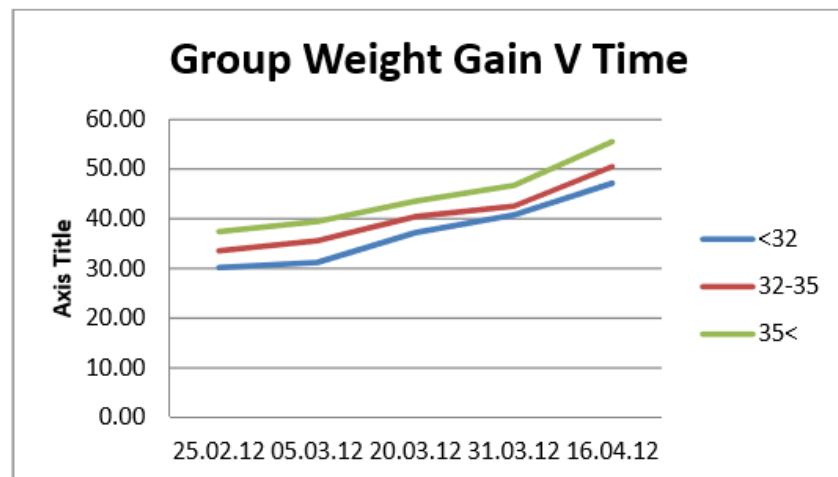


Figure 5

Figures 6 and 7 represent the variation in weight gain of the herd, and each group for each two-week period between weighing. The graph shows a reasonable increase during period 2 between 05.03.12 – 20.03.12, however during this time there weren't any changes in diet or housing. External temperatures weren't monitored, and temperatures were variable. The group benefiting the most during this period is Group 1. While Group 3 show a more even weight gain during the first three periods.

During period 3 weight gains lower, closer to the level in period 2.

During period 4 there is a very marked increase in weight gain. This increase coincided with the increase of the weight of fodder fed to the herd from 1.5Kg/head to 2.25Kg/head. Clearly the increase of 0.75Kg/head/day wet weight (0.11Kg/head/day dry weight) has increased the available nutrition to the level where the lambs are able invest the protein and starch into building muscle tissue.

The Herd average figures show a more balanced increase and decrease between periods 2 and 3, while reinforcing the increase during period 4.

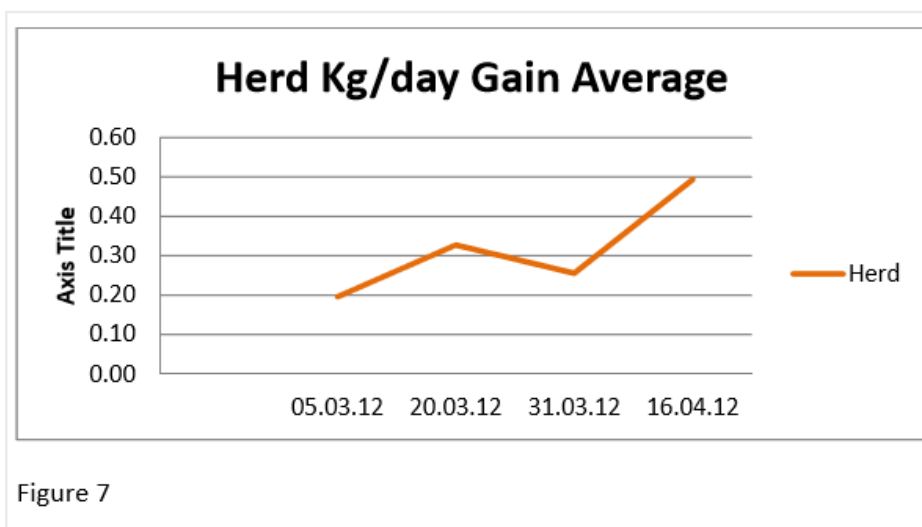
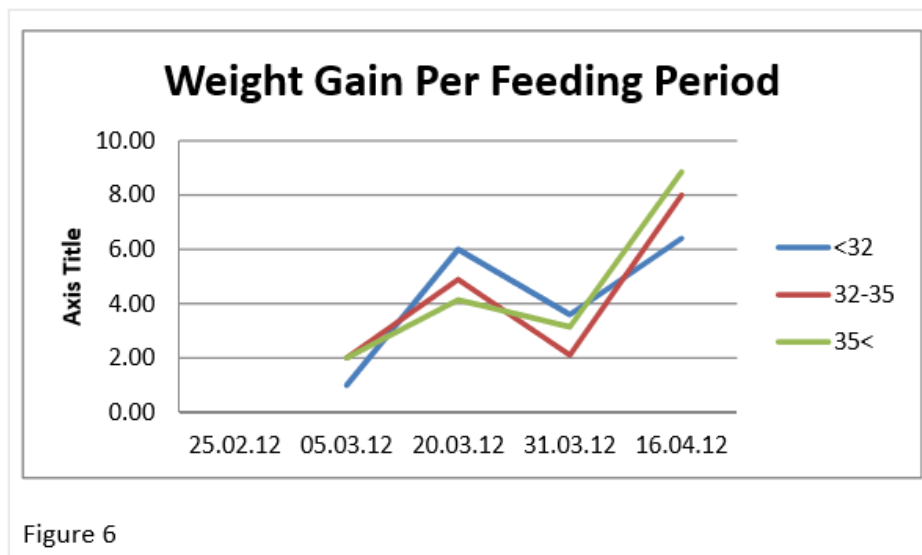


Figure 8 represents the daily weight gain per group during each feeding period. This graph also shows how Group 1 have benefited the most during period two, and when the fodder is increased in period 4, both Groups 2 and 3 benefits hugely while the weight gains in Group 1 remain more consistent.

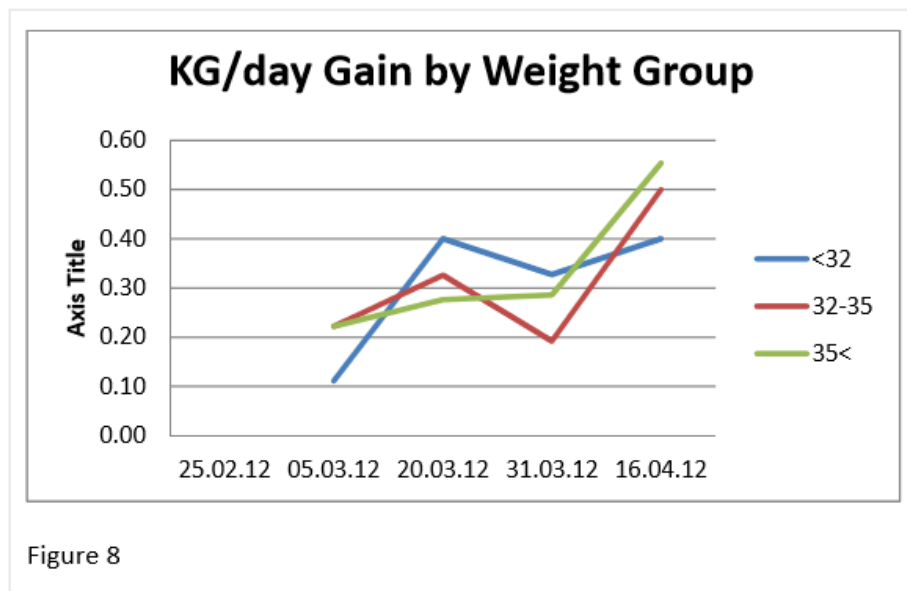
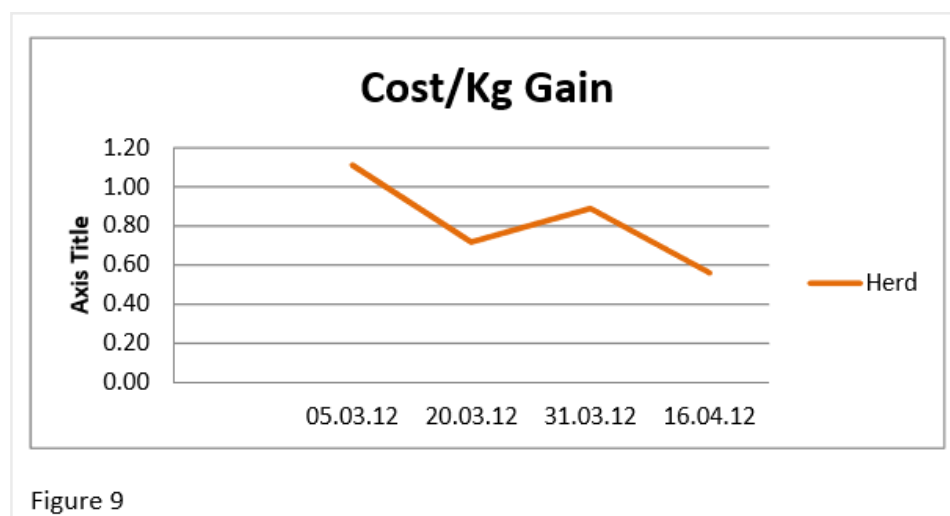
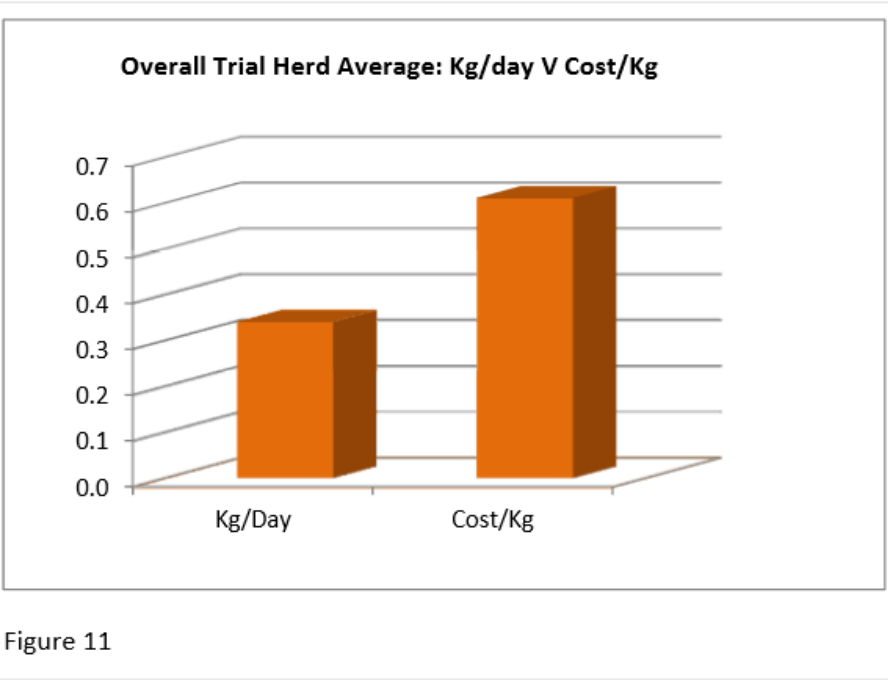
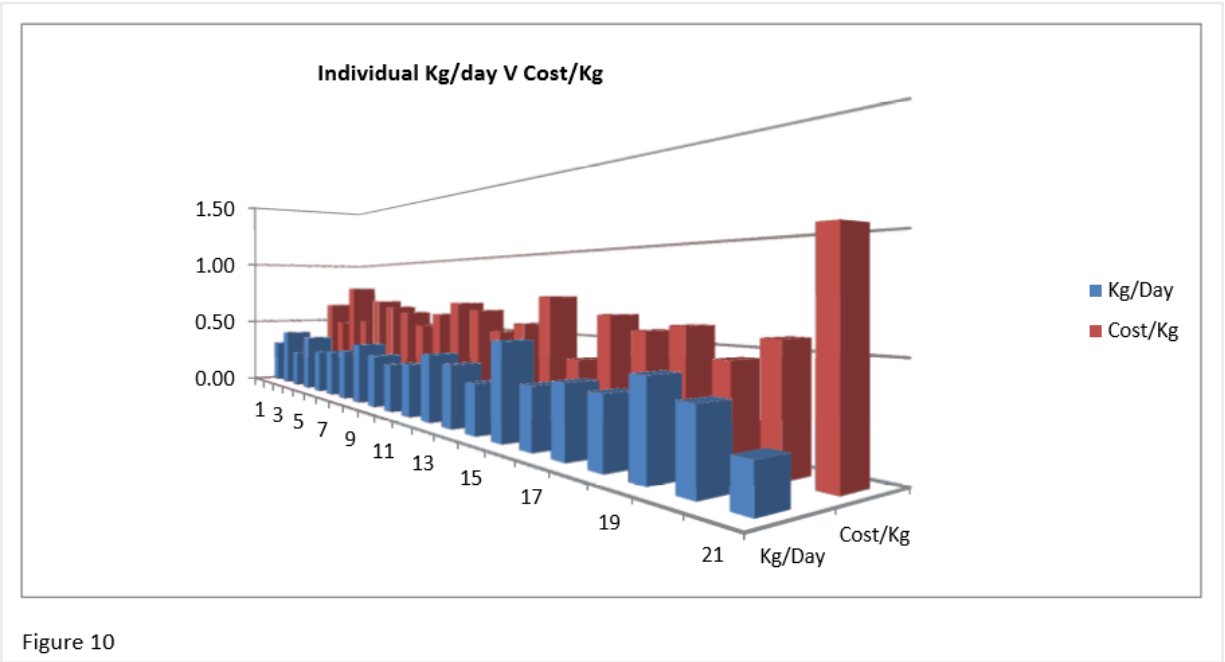


Figure 9 represents the calculation of diet cost against weight gain. The graph shows that over time the cost per Kg gained decreases, but the graph pattern also reflects that of the overall weight gain as the diet cost didn't change during periods 1 to 3. Therefore, suggesting either changing temperatures resulting in the lambs having to spend more energy in temperature regulation, or that perhaps as the lambs are growing they are better able to regulate their body temperature and invest more energy in weight gain, meaning the diet cost becomes more efficient. The increase of fodder during period 4 has obviously resulted in a decrease in the cost/Kg gained. However, the actual cost of the diet in real terms is an increase in £0.06/head/day. If we compare this with the increase in weight gain levels, the average Kg/day weight gain results in Figure 7 show an increase of 0.25Kg/day. This represents excellent value in the terms of a return on investment in the feed as an increase in cost of £0.06 has resulted in the weight gain increasing by 60% on period 2 and 100% on period 3.



Figures 10 and 11 represent the comparison between average Kg/day weight gain, and the real term cost of the weight gain regarding the diet. Figure 10 shows the

results for each individual, while Figure 11 shows the average result for the whole herd over the period of the trial. While we have seen how the weight gain has varied during the different feeding periods, the daily gain figure for the whole trial period, 0.3Kg, is consistent with what is expected from a normal concentrate and silage diet.



The difference in cost between a Fodder Diet and a Standard Diet will vary from farm to farm due to the variation in the cost to the farmer of making the silage, and the price they pay for their concentrate. During this trial we have replaced 1.7Kg of concentrate with 2.25Kg of fodder.

The concentrate price paid by the farmer is £0.217/Kg as per Figure 1. The cost of producing fodder in a Fodder System is £0.06/Kg. Therefore, we have replaced £0.37 of concentrate with £0.14 of fodder, leading to a daily saving of £0.23/head at the higher fodder ration of 2.25Kg/head.

In fact, for the 6 week period of the trial, the farmer has saved a minimum of £200 on the herd of 21 lambs included in the trial. If these figures were extrapolated over a 9-month feeding period, and for a herd of 200 lambs the potential saving would be approx. £12,400. This shows how significant the savings could be.

Conclusions

Based on the testing of our hypothesis, we can conclude that 1.50–2.25Kg of fodder produced in a Fodder System will adequately replace at least 85% of the concentrate in the diet of a store lamb and produce viable weight gains as normally expected in a lamb of that age.

This feeding system is being used in both Australia and United States of America, where farmers successfully feed their sheep with fodder produced in a Fodder System with excellent results, and previous trials have proven improved performance by including fresh sprouted barley in the sheep's diet.

Despite the reduction in dry weight matter fed, the lambs have performed well, and this may be because of a more balanced digestive system, leading to increased digestive performance. The results of the trial confirm there is no detrimental effect in the productivity of the lambs when fattening on a diet based on fresh fodder. Either in the amount of weight gained, or the time taken to gain adequate weight ready for sale. The results section has highlighted the potential benefit from a business perspective, with reduced feed costs leading to increased profits when lambs are sold as the feed can be produced considerably cheaper in a Fodder System.

A possible extension of the hypothesis would be the effect of adding higher protein seeds, such as field beans, which would increase the available protein and potentially increase the weight gain within the same period for marginally increased costs.

References

- 1 – Umberger, S (2009). "Feeding Sheep" Virginia Cooperative Extension Report, Virginia Tech.
- 2 – Dr J. A. Parish, Dr J. D. Rivera, Dr H. T. Boland (2009). "Understanding the Ruminant Animals Digestive System". Mississippi State University Extension Service Report.
- 3 – Chavan, J. and Kadam, S.S. (1989). "Nutritional improvement of cereals by sprouting" Critical Reviews in Food Science and Nutrition, 28(5): 401-437.
- 4 – Eshtayeh, I (2004). "A new source of fresh green feed (Hydroponic Barley) for Awass sheep" An-Najah National University Faculty of Graduate studies.

AGR-100 TECHNICAL SPECIFICATIONS

Container

Dimensions: 3.0m x 1.5m x 1.8m

Insulation: 60mm Antibacterial Fibreglass Panel

Total Grow Area: 7 square meters

Seed to Fodder Ratio

One kilogram of seed will produce approximately 6 to 8kg of hydroponic fodder.

Climate Control

Cooling Capacity: 2kW

Heating Capacity: 1kW

Dehumidification: 0.5 litres / hour @ 19°C, 70% RH

Fans

Circulation: 60 CFM

Air Exchange Rate: Up to 20 / hour

Construction

Internal Framing: Aluminium

Internal Flashing: Stainless Steel

Irrigation

Nozzles: NaanDanJain Hadar 7110

Aeration: 2,200 litres / hour Oxygenator

Tank Capacity: 50 litres

Approx. Water Use: 150 litres / day

Integrated Water Heating

Optional Water Reclamation System

Electrical

Approx. Energy Use: 0.6kW/h

Phases: 1 or 3

Volts: 115v, 230v or 400v.

PLC Controller

Schneider Electric

Optional Remote Monitoring Capability (RMC)

Sterilisation

Integrated Ozone and UV Disinfection

Optional H2O2 Dosing System

Lighting

Red Photosynthetic Wavelength: 660nm

Blue Photosynthetic Wavelength: 450nm

Waterproof Rating: IP67

LED Arrays: 1

LED Ratio: 3 : 1 – red / blue

Wattage: 65

Filtration

Primary: 10" x 4.5" 20 micron sediment filter
Secondary: 10" x 4.5" 5 micron sediment filter
Inline Mesh Strainer

Trays

Daily Trays: 8
Dimensions: 600mm x 375mm x 40mm

Warranty

Five (5) year structural guarantee and one (1) year standard warranty on all mechanical equipment.

The Evidence

Farmers who use hydroponic livestock feed have been seeing and experiencing the benefits of doing so first hand, and now the science is here to back up their claims.

Performance of Dairy Cows when replacing 100% concentrate and 50% grain with Hydroponic Fodder

This paper examines the development of a fundamentally new automated hydroponic system for growing green fodder, which creates a solid fodder base capable to satisfy the need of livestock for nutrients throughout the year with low material costs. The new hydroponic green fodder produced according to the developed technology contained the required nutrients that contribute to the digestion of proteins, fats and carbohydrates into easily digestible organic components (amino acids, fatty acids and simple sugars) which are simpler in their structure. Moreover, it completely replaced compound feed, a mineral supplement in the diet of milking cows, and reduced the amount of fodder needed. In dry matter, compared to fodder barley, the content of protein (128.93%) and fat (196.73%) were higher, and biologically active substances were also formed. The new fodder used the nutrients of the diet more efficiently, increased milk production and reduced fodder costs. When hydroponic green fodder from barley was introduced into the diet of cows with 100% replacement of the compound fodder and 50% replacement of grain mass, milk yield in the experimental group exceeded the yield in the control group by 6%. An additional 549.5 kg was obtained from each cow for lactation, and $549.5 \times 20 = 10990$ kg was obtained from the entire experimental group.

Conclusions: The studies showed that 100% replacement of compound fodder and 50% replacement of grain mass showed that when hydroponic green fodder from barley was introduced into the diet of cows, the milk yield in the experimental group exceeded this indicator in the control group by 6%. Thus, the production of hydroponic fodder based on new technology provides animals with a high-quality supplement with high protein and energy value. Its use significantly improves the

quality of the diet and the resulting milk. In addition it makes it possible to solve the problem of animal health, especially in farms that use highly productive breeds and reduces the cost of fodder.

Read more

<https://www.agritom.co/performance-of-dairy-cows-when-replacing-100-concentrate-and-50-grain-with-hydroponic-fodder/>

Performance of Dairy Cows when replacing 100% concentrate and 50% grain with Hydroponic Fodder

Scientific and Organizational Center of St. Petersburg Agrarian University

Roman Kolesnikov

Vitaly Morozov

Anna Matserushka

Galina Talalay

Margarita Kolesnokova



Abstract

This paper examines the development of a fundamentally new automated hydroponic system for growing green fodder, which creates a solid fodder base capable to satisfy the need of livestock for nutrients throughout the year with low material costs. The new hydroponic green fodder produced according to the

developed technology contained the required nutrients that contribute to the digestion of proteins, fats and carbohydrates into easily digestible organic components (amino acids, fatty acids and simple sugars) which are simpler in their structure. Moreover, it completely replaced compound feed, a mineral supplement in the diet of milking cows, and reduced the amount of fodder needed. In dry matter, compared to fodder barley, the content of protein (128.93%) and fat (196.73%) were higher, and biologically active substances were also formed. The new fodder used the nutrients of the diet more efficiently, increased milk production and reduced fodder costs. When hydroponic green fodder from barley was introduced into the diet of cows with 100% replacement of the compound fodder and 50% replacement of grain mass, milk yield in the experimental group exceeded the yield in the control group by 6%. An additional 549.5 kg was obtained from each cow for lactation, and $549.5 \times 20 = 10990$ kg was obtained from the entire experimental group.

1. Introduction

In modern dairy farming it is extremely important to assess a nutritious diet that can satisfy the need of livestock for nutrients that stimulate the productivity of animals. Moreover, the diet should have a positive effect on the physiological and immune status, reproductive ability and productive longevity of highly productive cows, especially the Holstein breed and its genotypes. [1,2,3]

In this regard, it became necessary to revise the production principles of fodder and both quantitative and qualitative improvement of fodder supply. At the same time, the priority issues include the reduction of the loss of nutrients in fodder based on the use of advanced technologies for feeding.

In the course of our scientific research we revealed a new promising direction for the use of sprout grain in feeding of dairy cattle. During the germination of grain under the influence of enzymes, decomposition of complex organic substances of seeds occurs i.e. proteins decompose to amino acids, polysaccharides to monosaccharides, fats to fatty acids and hydroxy acids [4,5,6,7,8,9].

2. Methods and Equipment

The modular hydroponic unit is designed for year-round, daily production of high-quality, cheap, environmentally friendly, natural protein-vitamin-mineral supplements, regardless of the season, weather and climatic conditions.

Green fodder was grown from barley seeds, the norm per 1 m² of pallet barley was 4.2 kg. For this purpose, we used pure barley grain with a germination rate of 90%.

The hydroponic method of growing green fodder involved preparation, germination of grain and green fodder growing. Weighed dry grain was placed in trays and irradiated with a mercury-quartz bactericidal lamp for 3-10 min (depending on lamp power).

The ultraviolet rays of the lamp destroyed bacteria and germs of fungi on the surface of the grain and prevented putrefactive processes.

After irradiation, the grain was soaked in water for 10-15 minutes. After the

expiration date, the water was drained, the trays were covered with glass, leaving a gap of 1-2 cm wide, and placed on germination. The grain was germinated for 2 days, maintaining a certain humidity and temperature. The optimum temperature for oats germination was 21-23 ° C. [10,11,12].

During the process of germination, it was recommended to inspect the trays at least 2 times a day and, if there was a lack of moisture, it was necessary to moisten the grain, and if there was an excess, we should drain the water. After the sprouts appeared in most of the seeds, the coverings were removed and the trays were placed on cultivation. From this moment the plants were receiving light and nourishment.

For the cultivation of green fodder, fluorescent and white lamps were used. Under the influence of water, heat and light, in the process of photosynthesis, the storage carbohydrate (starch) of cereals was converted into easily absorbed forms, which were necessary and sufficient material for glucose synthesis.

[4,10,11,13]

According to the experiments the more intensive accumulation of nutrients and vitamins in plants occurs when they are illuminated for 18 hours a day. Ready-to-eat green fodder is grass with a height of 10-15 cm.

If necessary, green fodder can be grown from seeds of cereals and legumes by straw or grass cutting for 7-8 days. Such food consists of pieces of mat woven by a root system with green shoots. The thickness of the mat depends on the amount of straw cut used when setting the planting stock.

The hydroponic method allows obtaining from 5 to 12 kg of green fodder from each kilogram of dry grain of cereals and legumes or their mixture.

The primary characteristic of the nutritional value of a fodder is its chemical composition.

1 kg dry matter of new fodder contains: exchange energy, M / J-12.0; crude protein, 136.87 g; lysine, 7.36 mg; methionine, 2.21 mg; sirin, 5.89 mg; cystine, 1.47 mg; sugar, 206.03 g; crude fat, 46.36 g; crude fibre, 123.62 g; crude ash, 33.11 g; calcium, 1.47g; phosphorus, 4.42 g; magnesium, 1.47 g; sodium, 0.25 g; zinc, 54.53 mg; selenium, 0.29 mg; vitamin B1, 3.68 mg; vitamin B2, 8.90 mg; vitamin B6, 8.09 mg; vitamin E, 25.75 mg; carotene, 21.12 mg [4,14,15].

As a result of a comparative assessment of the nutritional value of hydroponics of green fodder, fodder barley, complete fodder for dairy cows (KK-60) and fattening of cattle in the stall period (KK-65), we found that hydroponic fodder exceeded the content of nutrients, vitamins and useful minerals [2,9,13].

In order to assess the nutritional value and methods of the use of new green fodder produced from barley, we carried out comprehensive studies on dairy cows of Holstein Friesian cattle in the breeding farm "Polyany" of Vyborg district of Leningrad region. For this purpose, cows were selected according to the principle of paired analogs in the amount of 20 heads in each group after the second calving (daily milk yield was 30 kg). All of them had a live weight of 600 kg and were increasing the milk yield.

All the experimental groups of animals were clinically healthy and were freely kept

in the same conditions. The cows were fed twice a day.

During the development of the diet, physiological characteristics of the fore stomachs of ruminants were taken into account and the special fodder were selected which in its quantity and combination ensured the creation of the most favourable conditions for the vital activity of rumen microorganisms, as well as the cost indicators of the daily intake of feed per 1 head.

Our research showed that proteins in hydroponic green fodder (HGF) had a number of other positive properties. Its cost was significantly lower compared to compound fodder.

Therefore, we made an attempt to replace compound fodder in the diet of milked cows for protein equivalent (HGF) and to study how this replacement affects productivity and nutrient use. The diet of the control group consisted of herb hay, herb and cereal-clover silage, concentrated fodder which together with the premix was fed in the form of compound fodder (10 kg / head. KK 60-19.6 SP), crushed corn (3 kg / head), sunflower cake (2kg / head), crimped barley grain (2kg / head) and mineral supplement (200g / head).

The diet of the experimental group consisted of the same rough fodder and succulent fodder, however 100% of compound fodder, 50% of grain mass, as well as a mineral additive, polysaccharides, propylene glycol were replaced with hydroponic fodder from barley produced according to the developed technology. The daily diet of the experimental group was 80.6 rubles cheaper and the quality indicators were not significantly higher in the control group.

During the entire research period, milk productivity was recorded by means of control milking (once in every 10 days), fat mass fraction, milk protein content, digestibility of nutrients in rations, morphological parameters of blood of lactating cows during lactation at 70, 150, 250 days, and also milk production coefficients, biological usefulness of milk and biological efficiency of cows were calculated.

3. Results

Milk yield is the main criterion by which the effectiveness of the use of the studied additive was assessed according to the proposed technology. During the entire research period, milk production was recorded by means of control milking (every 10 days). The data on milk productivity of cows for 305 days of lactation are presented in Table 1.

The studies showed that the milk yield of cows in the experimental group for 305 days of lactation was higher by 549.5 kg or 6% compared to the cows in the control group. The average daily milk yield of cows in the experimental group exceeded 1.8 kg or 6%, the mass fraction of fat in milk increased by 0.4%, the mass fraction of protein was 0.35%, as a result of which the amount of milk fat and protein in the experimental group increased by 118 kg or 17.5% and 98.9 kg or 19%, respectively.

During the assessment of the consumer qualities of milk, along with the physicochemical properties, an important place is given to the definition of biologically regular relationships between the live weight and the level of

productivity. According to this, the coefficients of milk production, biological value of milk and biological efficiency of a cow were calculated.

The studies showed that the milk production coefficient in the experimental group was 1616.5, and in the peers of the control group it was 1519.4, which was 97.1 points more in favour of the experimental group.

The assessment of the biological usefulness of milk was determined by the content of non-fat milk solids and protein, since these indicators give a more accurate assessment of the usefulness of milk, as well as identify the best animals that give higher quality milk and indicate higher indicators of the coefficient of biological value of cows and biological value of milk.

Thus, the coefficient of biological value of cows in the experimental group was higher by 20.1 or 10.72% than that of analogs of the control group and the coefficient of biological value of milk was higher by 10% or 7.63%.

Consequently, hydroponic green fodder (HGF) produced according to the developed technology contains the required nutrients that contribute to the decomposition of proteins, fats, carbohydrates into easily digestible organic components (amino acids, fatty acids and simplest saccharides) which are simpler in structure and completely replaces compound fodder, mineral supplement in the diet of milking cows and allows a cost saving.

Digestibility is one of the primary indicators of the diet supply with the optimal amount of a particular nutrient.

The research revealed that the digestibility of both dry matter and organic matter was at a high level in animals of both experimental and control groups and ranged from 69.6 to 71.4%, however, there were no significant differences between the groups in the digestibility of the studied substances (Table 2). At the same time, it is necessary to note that the digestibility of crude protein in the experimental group was better than in the control one and amounted to 71.9 and 74.3%, respectively, which led to a significant increase in the digestibility of crude fibre, which was maximum in animals of the experimental group and amounted to 55.2% ($P < 0.05$).

The data on the average daily nitrogen balance is of particular interest, since the productivity of ruminants largely depends on the supply of their diet (Table 3).

The intensity of conversion of nitrogenous substances of fodder into body proteins depends on the quality of the balance of the diet in terms of the quantity and quality of trace elements calcium and phosphorus. They are involved in the absorption, transport and metabolism of organic substances. The average daily balance and the use of calcium for production in the body of cows is presented in Table 4.

The experiments showed that the indicators of calcium balance in the studied groups of animals are positive. According to the amount of calcium taken with food, the experimental animals, depending on the quality of the diet, had some differences. In comparison with the control group, the animals of the experimental group took calcium more by 2.98 g, or 2.01%. Animals receiving hydroponic green fodder as part of the diet excreted less calcium through the gastrointestinal tract.

Thus, the excretion of calcium with faeces in cows of the experimental group was 50.2% of the accepted value, versus 54.8% in the control group. There were significant differences in the amount of digested calcium.

The cows of the experimental group digested calcium more by 8.7 g or (12.41%) compared to the control group. In the experimental group, more calcium was excreted from the body with milk in comparison with the analogs of the control group by 2.01 g or (5.14%). The balance of calcium utilization in cows of the experimental group in comparison with the control was higher (35.4%). Thus, the studies showed the advantage of the experimental group compared to the control animals in terms of calcium utilization rates by 3.04% higher. We also found positive indicators of the balance of phosphorus in experimental animals (Table 5). The most significant amount of phosphorus from the organism of the experimental cows was excreted with milk in the animals of the experimental group. The difference in this indicator in relation to the control was 4.11 g or (16.4%).

The balance of phosphorus use in cows of the experimental group in comparison with the control was 2.33 g or (30.2%) higher.

The indicators of the coefficient of phosphorus utilization in the experimental group exceeded this indicator over the analogs from the control group by (3.16 or (9.2%). Therefore, 100% replacement of compound fodder with hydroponic green fodder from barley in the diets of feeding experimental lactating cows contributed to higher deposition and use in the body of nitrogen, mineral elements (calcium, phosphorus), which ultimately had an impact on the increase of the milk production of cows.

Normally, haematological parameters react most quickly, which, in turn, are closely related to the resistance of the animal's body and milk productivity, since during lactation a significant amount of milk is delivered to the lacteous gland with blood. Thus, it was found that the studied indicators of the morphological composition of the blood of cows were within the physiological norm at all periods of lactation (Table 6).

We should note that a higher content of formed elements of erythrocytes, haemoglobin, leukocytes, lysozyme activity, calcium, inorganic phosphorus, carotene in the blood of lactating cows of the experimental groups during lactation was 70,150,250 days. This indicates to a more intensive metabolism in their bodies and a positive effect of hydroponic green fodder produced from barley in the diet of dairy cows on the digestibility of protein, fat, fibre, free-nitrogen extract. In addition it indicates to the better nitrogen utilization and calcium and phosphorus assimilation.

4. Conclusion

The studies showed that 100% replacement of compound fodder and 50% replacement of grain mass showed that when hydroponic green fodder from barley was introduced into the diet of cows, the milk yield in the experimental group exceeded this indicator in the control group by 6%.

Thus, the production of hydroponic fodder based on new technology allows

providing animals with a high-quality supplement with high protein and energy value. Its use significantly improves the quality of the diet and the resulting milk. In addition it makes it possible to solve the problem of animal health, especially in farms that use highly productive breeds and reduces the cost of fodder.

Table 1

Indicators	Groups	
	Control	Experimental
Number of heads	20	20
Live weight 1 head, kg	599 ± 7.19	597 ± 6.18
Milk yield per 305 days of lactation, per head, kg	9101 ± 65.3	9650.3 ± 56.3
Average daily milk yield, kg	29.84 ± 0.25	31.64 ± 0.25
Gross production, c	1820 ± 20.5	1930 ± 22.7
Dry matter content in milk, %	12.34 ± 0.08	12.84 ± 0.03
Mass fraction of fat, %	3.71 ± 0.037	4.11 ± 0.036
Milk fat content, kg	675.2 ± 4.89	793.2 ± 5.12
Mass fraction of protein, %	2.85 ± 0.018	3.20 ± 0.20
Milk protein content, kg	518.7 ± 4.89	617.6 ± 6.98
Content of nonfat milk solids, %	8.63 ± 0.07	8.73 ± 0.05
Milk factor, %	1519.4 ± 18.7	1616.5 ± 19.2
Biological value coefficient (BVC) of cows	187.5 ± 4.02	207.6 ± 3.99
Biological value coefficient (BVM) of milk	131.1 ± 2.14	141.1 ± 1.99

Table 2

Indicators	Control group	Experimental group
Dry matter	69.6 ± 0.85	71 ± 0.87
Organic matter	70.3 ± 0.83	72.9 ± 0.73
Crude protein	71.9 ± 0.71	74.3 ± 0.89
Crude fat	55.5 ± 2.11	56.2 ± 1.98
Crude fiber	51.2 ± 0.08	55.2 ± 1.76
Free-nitrogen extract	75.8 ± 1.11	78.4 ± 1.11

Table 3

Indicators	Control group	Experimental group
Nitrogen received from the diet	637.02 ± 3.12	615.70 ± 15.15
Nitrogen excreted in feces	188.55 ± 4.33	173.86 ± 7.10
Digested	498.47 ± 0.68	562.51 ± 11.64
Digestibility coefficient,%	72.30 ± 0.68	74.93 ± 0.75
Daily milk yield, kg	29.84 ± 0.85	31.64 ± 0.85
Nitrogen excreted in urine	299.02 ± 1.79	283.79 ± 10.80
Nitrogen excreted in milk	168.99 ± 3.57	180.62 ± 1.30
Nitrogen excreted in milk:% of taken	24.2 ± 0.52	27.30 ± 0.65
% of digestible	33.93 ± 0.40	36.92 ± 0.73
Body deposition	7.33 ± 0.27	8.10 ± 0.12
Assimilated nitrogen, g	166.31 ± 3.50	178.72 ± 1.25
% of accepted	25.31 ± 0.50	28.6 ± 0.07
% of digested	35.49 ± 0.36	38.08 ± 0.93

Table 4

Indicators	Control group	Experimental group
Calcium taken with feed, g	145.09 ±	148.07 ±
Calcium excreted in feces, g	79.51 ±	74.32 ±
Digested calcium, g	65.58	73.75
Calcium excreted in urine, g	6.01 ±	6.45 ±
Allocated calcium in milk, g	39.08 ± 0.6	41.09 ± 0.8
Allocated total, g	124.6 ±	121.86 ±
Calcium balance, (±)	20.49 ±	26.21 ±
Calcium used for products,%	26.93 ±	27.75 ±

Table 5

Indicators	Control group	Experimental group
Phosphorus taken with feed, g	78.97 ± 0.40	83.27 ± 0.49
Phosphorus excreted in feces, g	43.30 ± 0.23	41.07 ± 0.19
Phosphorus excreted in urine, g	0.81 ± 0.04	0.90 ± 0.04
Allocated phosphorus with milk, g	27.15 ± 0.011	31.26 ± 0.38
Allocated total, g	71.26 ± 0.67	73.23 ± 0.85
Phosphorus balance, (±)	7.71	10.04
Phosphorus used for products,%	34.38	37.54

Table 6

Indicators	Groups					
	Control			Experimental		
	Lactation periods, days					
	70	150	250	70	150	250
Hemoglobin, g%	9.10 ± 2.7	10.0 ± 3.09	9.60 ± 2.8	9.30 ± 2.9	10.87 ± 3.1	10.03 ± 2.99
Erythrocytes, mln	4.20 ± 0.12	4.38 ± 0.14	4.94 ± 0.17	4.78 ± 0.28	4.91 ± 0.31	5.04 ± 0.40
Leukocytes, thous.	7.20 ± 0.28	6.97 ± 0.22	8.21 ± 0.32	7.52 ± 0.26	7.12 ± 0.29	8.89 ± 0.38
Lysozyme activity,%	32.30 ± 3.7	28.50 ± 3.6	30.00 ± 3.0	33.09 ± 4.1	29.5 ± 3.99	30.8 ± 4.5
Calcium, mg,%	11.01 ± 2.14	11.22 ± 2.01	11.83 ± 2.9	11.89 ± 3.12	11.99 ± 3.46	12.6 ± 4.2
Inorganic phosphorus, mg,%	3.34 ± 0.07	4.61 ± 0.011	4.51 ± 0.16	3.86 ± 0.27	4.98 ± 0.37	4.77 ± 0.49
Carotene, mg,%	0.369 ± 1.12	0.454 ± 1.09	0.789 ± 1.08	0.388 ± 1.67	0.501 ± 1.87	0.815 ± 2.15

1 – Matserushka, A. R. (2016). The Biological Value of Hydroponic Green Feed from Barley Grain in Feeding Dairy Cows. Legal Issues in Veterinary Medicine, vol. 4, pp. 217-222.

2 – Naik, P. K., Swain, B. K. and Singh, N. P. (2015). Production and Utilization of Hydroponics Fodder. Indian Journal of Animal Nutrition, vol. 32, issue 1, pp. 1-9.

3 – Gebremedhin, W. K. (2015) Nutritional Benefit and Economic Value of Feeding Hydroponically Grown Maize and Barley Fodder for Konkan Kanyal goats. IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS), vol. 8, issue 7. pp. 24-30.

4 – Kruglyakov, Y. A. (1991). Equipment for Continuous Hydroponic Cultivation of Green Forage (vol. 6). Moscow: VO Agropromizdat, p. 79.

5 – Matserushka, A. R. and Tuz, D. V. (2015). Hydroponic Feed based on New Technology. Livestock in Russia, vol. 1, pp. 44-45.

6 – Rosselkhoz (2006). Methodological Recommendations Grain Germination and Hydroponic Green Fodder Production. Sergiev Posad: Izdatelstvo Rosselkhoz,

7 – Gaikwad, D., and Maitra, S. (2020) Hydroponics Cultivation of Crops In Gaikwad, D., Shankar, T., and Maitra, S. (eds.) Protected Cultivation and Smart Agriculture, New Delhi: New Delhi Publishers.

8 – Aii, T., Kurihara, M. and Kume, S. (1990). The Effect of Feeding Calcium Soap of Fatty Acids and Sodium Acetate on the Physiological Responses of Dairy Cows Japan. Journal of Zootechnical Sciences, vol. 61, issue 10, pp. 959-962.

9 – Rajkumar, G., et al. (2018). Evaluation of Hydroponics Fodder as a Partial Feed

Substitute in the Ration of Crossbred Calves. Indian Journal of Animal Research, vol. 52, issue 12, pp. 1809–1813.

10 – Kostyuchenko, V. A. (2010). Agromechanical Substantiation of Machines for the Production of Hydroponic Green Fodder. Kirovograd: Monograph, p. 320.

11 – McKenzie, R. A., et al. (2004). *Aspergillus Clavatus* Tremorgenic Neurotoxicosis in Cattle Fed Sprouted Grains. Australian Veterinary Journal, vol. 82, pp. 635–638.

12 – Reddy, G. V. N., Reddy, M. R. and Reddy, K. K. (1988). Nutrient Utilization by Milch Cattle Fed on Rations Containing Artificially Grown Fodder. Indian Journal of Animal Nutrition, vol. 5, pp. 19–22.

13 – Tuz, D. V., Macerushka, A. R. and Artyuhova, V. R. (2015). Profitability Rations in Dairy Cattle. Digest International VET Istanbul Group Congress Saint-Petersburg, p. 439.

14 – Barkema, H. W., et al. (1998). Incidence of Clinical Mastitis in Dairy Herds Grouped in Three Categories by Bulk Milk Somatic Cell Counts. Dairy Science, vol. 81, issue 2, pp. 411–419.

15 – Zotthamer, K. H. (1994). Fruchtbarkeit, Gesundheit der Rinder. Ulmer: Springer, pp. 247–252.

Hydroponic Green Forage in Diets of Growing Pigs

The importance of conducting studies on the use of hydroponic green corn fodder (HGCF) is because, the productive and economic impact on the feeding of pigs in the region of the Coast of Oaxaca has been poorly evaluated. The objective of the study was to evaluate the productive behaviour in growing pigs with HGF as a supplement, with diets based on commercial feed and including HGCF. The research was conducted during the months of August to November 2017. Four treatments were evaluated [T1: control, T2: 85/15%; T3: 70/30% and T4: 55/45% of food trade and HGCF respectively], under a completely randomized design with four repetitions per treatment. 16 dewormed and vaccinated pigs were used, with an initial weight of 10.41 kg. Total feed consumption (TFC), feed conversion (FC), total weight gain (TWG), and cost-benefit ratio (CBR) were evaluated. The data obtained were analysed by Proc. SAS GLM. The averages were compared with the Tukey test. Differences ($p < 0.05$) were found in the TFC, where the highest value was 110 kg. The highest TWG was 42.67 kg. As for CBR, the productive parameters are improved as the HGCF percentage increases (45%) In the diet of pigs. It is concluded that the inclusion of 30% of HGCF in the diet of growing pigs improves their productive behaviour.

Conclusions: The inclusion of hydroponic green forage from corn in feed diets of fattening pigs in this study demonstrated significant results; since, as the percentage of HGCF increased in the evaluated treatments, it was reflected in the reduction in consumption of these, the daily and total weight gain increased, as well as the food conversion and the cost benefit ratio in the treatments whose

HGCF content was higher. The use of 55% of commercial balanced feed and 45% of hydroponic green forage from corn is recommended.

<https://www.agritom.co/hydroponic-green-forage-in-diets-of-growing-pigs/>

Hydroponic Green Forage in Diets of Growing Pigs

Pedro Cisneros Saguilán

Herminio Aniano Aguirre

Ricardo Martínez-Martínez

Armando Gómez Vázquez

María de los Ángeles Maldonado Peralta

Marco Antonio Ayala Monter



National Technology of Mexico-Technological Institute of Pinotepa. Av. Tecnológica S/N, Col. Dispensario, Pinotepa Nacional, Oaxaca, Mexico. CP. 71600.
University of Guadalajara-University Center of the South Coast Autlán de Navarro. 151 National Independence Avenue, Centro, Jalisco, Mexico. CP. 48900.
Academic Division of Agricultural Sciences – Autonomous Juárez University of Tabasco. Villahermosa-Teapa highway km 25, Teapa, Tabasco, Mexico. CP. 86280.
Faculty of Veterinary Medicine and Animal Husbandry no. 2-Autonomous University of Guerrero. Acapulco-Pinotepa National Highway km 197. Cuajinicuilapa, Guerrero, Mexico. CP. 41940.

Abstract

The importance of conducting studies on the use of hydroponic green corn fodder

(HGCF) is because, the productive and economic impact on the feeding of pigs in the region of the Coast of Oaxaca has been poorly evaluated. The objective of the study was to evaluate the productive behaviour in growing pigs with HGF as a supplement, with diets based on commercial feed and including HGCF. The research was conducted during the months of August to November 2017. Four treatments were evaluated [T1: control, T2: 85/15%; T3: 70/30% and T4: 55/45% of food trade and HGCF respectively], under a completely randomized design with four repetitions per treatment. 16 dewormed and vaccinated pigs were used, with an initial weight of 10.41 kg. Total feed consumption (TFC), feed conversion (FC), total weight gain (TWG), and cost-benefit ratio (CBR) were evaluated. The data obtained were analysed by Proc. SAS GLM. The averages were compared with the Tukey test. Differences ($p < 0.05$) were found in the TFC, where the highest value was 110 kg. The highest TWG was 42.67 kg. As for CBR, the productive parameters are improved as the HGCF percentage increases (45%) in the diet of pigs. It is concluded that the inclusion of 30% of HGCF in the diet of growing pigs improves their productive behaviour.

Pig farming is a livestock activity that has increased worldwide in recent years, with China being the main producer of pork. In Mexico, one of the problems that pig producers have is the high cost of feeding, ranging from 60 to 70% of their livestock production system.

However, pig farming tends to increase in the coming years, as per capita consumption has increased more than 12.8 kg (SIAP, 2015). In the particular case of the state of Oaxaca this problem is not the exception; however, an advantage that it has is its participation at a national level of 4% in meat production, which makes pig farming an attractive activity for producers in the region (Torres-Novoa and Hurtado-Nery, 2007).

However, the high feed costs mean that most pork producers are limited to carry out this livestock activity. Therefore, an alternative to reduce production costs is the use of new alternatives, such as the use of hydroponic green forage (HGF) in pig feed (Müller et al., 2005; Herrera et al., 2007), since it has been mentioned that with this technology the production cost is reduced and a harmless meat is obtained (Osorio et al., 2007; Romero, 2009).

The production of HGF consists of germinating grass or legume seeds such as oats, corn, wheat, alfalfa, among others, until seedling growth, under conditions of light, humidity and temperature suitable for each crop species (Albert et al., 2016). Unlike the conventional grazing-based feeding system, the HGF represents an alternative animal feeding, where the leaves, stems and roots are used; that is, the complete plant (Ramírez and Soto, 2017).

Making use of hydroponic green forages has several advantages, one of the advantages of using HGF is that it can be produced throughout the year and in small areas of soil or in trays using straws, husks of grass grains, coconut fiber, tezontle, etc., as a substrate, using a controlled irrigation system, where the necessary water is supplied with the essential nutrients for each crop (Rodríguez et al., 2009).

Another advantage is the short forage production time, since in a period of 15 to 20 days forage can be available for animal feed and in this case for pigs (FAO, 2001). Among the most used grasses as HGF is corn (*Zea mays* L.), since it presents high forage yields ranging from 3 91 to 4 64 kg m⁻² and the dry matter content of 25.5 and 19.24% at 10 and 12 days, respectively (Albert et al., 2016; Naik et al., 2012; García-Carrillo et al., 2013).

In the coast of Oaxaca region, there are no studies or the use of hydroponic green corn fodder (HGCF) in the diet for the production of pork is not well documented, as well as the cost-benefit of this alternative food. Therefore, the objective of the present study was to evaluate growing pigs, diets based on commercial feed and with the inclusion of hydroponic green maize forage, where total feed intake (TFC), feed conversion (FC), weight gain (TWG) and calculate the cost-benefit ratio (CBR).

Study Area Description

The research was carried out during the months of August to November 2017, at the facilities of the Technological Institute of Pinotepa, Experimental Unit 'San José Estancia Grande' of the Department of Agricultural Sciences, located in the municipality of San José Estancia Grande, Oaxaca, km 26.5 of the Pinotepa National Highway, Oaxaca-Acapulco, Guerrero, at 16° 22' north latitude and 98° 13' west longitude (García, 2004).

The climate in this region is warm sub-humid with rains in summer, with an average annual temperature and precipitation of 26.9 °C and 800 mm, respectively and at 70 masl (García, 2004).

Treatment and Experimental Design

The treatments evaluated were: T1 (control): 100% commercial balanced feed, T2: 85% commercial balanced feed + 15% HGCF; T3: 70% commercial balanced feed + 30% HGCF and T4: 55% commercial balanced feed + 45% HGCF. A completely randomized design was used, with four repetitions per treatment, where the experimental unit consisted of one pig, giving a total of 16 pigs.

Variables Evaluated

The total food consumption (TFC) expressed in kilograms was evaluated, it was calculated by subtracting the food not consumed from the food offered during the day. The total weight gain (GTP) of the pigs was obtained by the difference between the final weight and the initial weight. The feed conversion (FC) was obtained by dividing the total consumption by the increase in live weight of each animal. While the cost-benefit ratio (CBR) was obtained by dividing the income from the sale of the GTP in the local market, by the costs of the food consumed during the production cycle.

Experiment Development

The study lasted 12 weeks. Sixteen weaned pigs of the Landrace breed were weaned with an average initial weight of 10.41 kg and an approximate age of three months. Prior to the start of the experiment, they were administered vitamins and antiparasitic against endoparasites and ectoparasites.

The pigs were housed in individual pens provided with feeders and troughs with *ad libitum* water, where they had an adaptation period of 10 days, providing the pigs with the proposed diets for commercial feed and HGCF in the respective feeders in a restricted manner and the consumption according to what they left daily in the feeders.

The diets used were based on the commercial balanced feed of the Api-Aba Premium line, for the growth-fattening stage. The HGF used in the present study was produced at the same Technological Institute, using a local variety of corn seeds, with a yield of 3.5 kg of HGCF per 600 g of corn

Statistical Analysis

The data obtained from the evaluated variables were subjected to an analysis of variance using the GLM procedure of the SAS program (2002). Tukey's test was used for comparisons between treatments, with a significance of 0.05. Total weight gain Statistical differences were found between treatments ($p < 0.05$) for the variable total weight gain (Table 1), where the highest value (42.67 kg) was obtained with treatment T4, a value that was different and higher ($p < 0.05$) to that registered with the T3 treatment, with an average of 35.81 kg. These results are different from those reported by Cunuhay (2013), who found that the highest total weight gain was obtained in pigs with 100% commercial balanced feed, reaching a final weight gain of 46.4 kg and less weight gain when 45% of HGCF was included in the diet with a weight gain of 36.3 kg.

Table 1. Productive behavior in pigs fed with commercial diet and different inclusions in the HGCF diet.

Variables	Treatments				Average	EE
	T1	T2	T3	T4		
Live weight (kg)						
Initial	6.75 c	9.63 b	12.88 a	12.38 a	10.51	0.54
Final	38.29 c	42.05 c	49.69 b	55.05 a	46.38	1.17
Total weight gain (kg)	31.54 c	32.42 c	36.81 b	42.67 a	35.86	0.98
Daily weight gain (g day ⁻¹)	375.47 c	385.95 c	438.3 b	508.06 a	426.94	0.011
Total feed consumption (kg)	110.14 a	110.23 a	108.45 b	107.51 b	109.15	0.27
Total consumption (kg day ⁻¹)	1.22 a	1.22 a	1.2 b	1.19 b	1.21	0.03
Food efficiency (g kg ⁻¹)	287.5 c	295 c	34 b	395 a	329.37	0.0087
Food conversion	3.51 a	3.4 a	2.95 b	2.52 c	3.09	0.091
Benefit-cost ratio	0.86 d	1.02c	1.39 b	1.99 a	1.31	0.031

In Figure 1, the behavior in the total weight gain per week of the pigs fed with diets based on commercial feed and different percentages of inclusion of hydroponic green forage from corn is shown. Weight gain in pigs on an HGF-based diet improves by offering them '*ad libitum*'. In this study, as the HGF was increased, weight gain was improved, making it a feeding alternative for pigs.

It is also known that the HGF provides the pig with proteins, minerals and vitamins which are more assimilable to the animal as they are soluble, which is not the case

with dry grain. Vitamins are of great importance in the fertility and productivity of animals, which is reflected in the weight gain of pigs

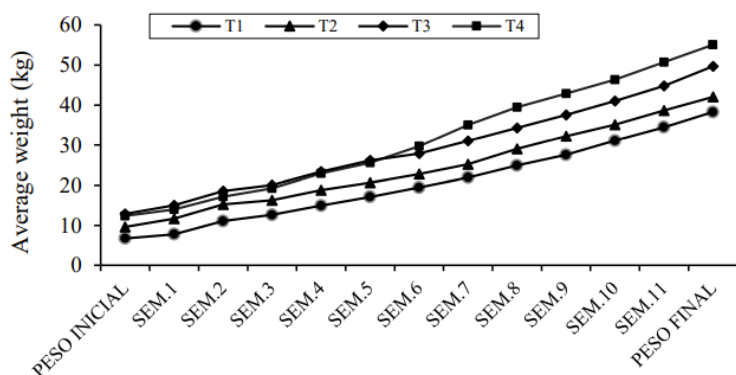


Figure 1. Weekly weight gain of pigs fed different levels of commercial feed plus hydroponic green maize forage.

Among the first studies done in this regard (Sánchez and Escalante, 1998) reported better weight gain in pigs fed on HGF. And this research confirms this by adding different levels of HGCF to the diet.

Total Food Consumption

Statistical differences were found for the TFC variable ($p < 0.05$), where the highest consumption (110.23 kg) was obtained in treatment T2, a value that was similar ($p > 0.05$) to that obtained with T1 (110.14 kg), but different and greater than ($p < 0.05$) to the values obtained with the T3 and T4 treatments. Similar results to those found in the present study were reported by Cunuhay (2013).

Who found that the total average food consumption registered significant statistical differences, where the highest consumption occurred with diets where 100% of food was commercially balanced (131.34 kg), with total average food consumption of 2.34 kg animal⁻¹ day⁻¹.

While the lowest total food consumption was found in T3 containing 45% of HGCF in the diet, the registered consumption was 1.72 kg animal⁻¹ day⁻¹. This technology of producing HGF is complementary and not competitive with that used in conventional forage production, making it a good alternative for feeding animals such as cattle, goats, sheep, equines, birds and pigs.

In this study where it was observed that pigs consume forage very well and useful in periods of forage shortages. The supplementation of hydroponic green corn fodder in the pig ration is a technological alternative for feeding pigs, which is why the consumption of this HGF is not a limitation for pigs since they accept it and consume it for good forage palatability (Naik et al., 2015).

Food Conversion

Currently, the fattening pig feeding system requires that they have good feed conversion; that is, if we say that a pig gives a feed conversion of 2, it indicates that for each pound or kilogram of live weight it gained, its consumption was 2 kg of feed. In this regard, there are few studies and in this investigation a significant

difference ($p > 0.05$) was found in terms of AC, where the best conversion was from T1 and T2, while the lowest AC was found by T4 and T3 (Table 1).

The results found in this investigation coincide with the data obtained by Cunuhay (2013), who found that the best dietary conversion is when 45% of HGF is added to the diet with 2.67. Coincides with what was found by Adebiyi et al. (2018), who observed that in pigs weaned and fed with HGF the feed conversion was improved.

Cost Benefit Relation

In this study, the RBC ratio was better when the inclusion percentage of HGCF was increased in the diets of growing pigs and under the environmental conditions already described in the methodology (Table 1). This may be due to the low cost of HGCF production due to the fact that local seeds were used and its high yield, since 600 g of corn produced 3.5 kg of HGF; therefore, a higher level of substitution of HGCF in the pig's diet substantially improves CBR.

The above is in agreement with the literature Arriaga-Jordan et al. (2002), documented that feeding HGCF reduces production costs in feeding pigs as long as hydroponic forage occurs. Therefore, the lowest profitability is found when the diet is 100% commercial food this is logical due to the high cost of inputs. Another advantage is that by including more than 15% of HGCF in the pig diet, weight gain is favoured and it also has a positive impact on profitability. The results found agree with those of Romero (2009), who mentions that the diet with the best CBR was when more than 40% of HGF is included.

Conclusions

The inclusion of hydroponic green forage from corn in feed diets of fattening pigs in this study demonstrated significant results; since, as the percentage of HGCF increased in the evaluated treatments, it was reflected in the reduction in consumption of these, the daily and total weight gain increased, as well as the food conversion and the cost benefit ratio in the treatments whose HGCF content was higher. The use of 55% of commercial balanced feed and 45% of hydroponic green forage from corn is recommended.

Cited Literature

- Adebiyi O. A.; Adeola, A. T.; Osinowo, O. A.; Brown, D and NG'Ambi, J.W. 2018. Effects of feeding hydroponics maize fodder on performance and nutrient digestibility of weaned pigs. *Appl. Ecol. Environ. Res.* 16(3):2415-2422.
- Albert, G.; Alonso, N.; Cabrera, A.; Rojas, L. y Rosthoj, S. 2016. Evaluación productiva del forraje verde hidropónico de maíz, avena y trigo. *Compendio de Ciencias Veterinarias.* 6(1):7-10.
- Arriaga, C. M.; Albarrán, B.; Espinoza, A.; García, A. and Castelán, O. A. 2002. On-farm comparison of feeding strategies based on forages for small-scale dairy production systems in the highlands of central México. *Expl Agric.* 38(1):375-388.
- Cunuhay, P. O. R. 2013. Niveles de forraje verde hidropónico de maíz en la dieta alimenticia enengorde de cerdos mestizos en el cantón Maná. Tesis. Universidad Técnica de Cotopaxi. 192 p.
- FAO. 2001. Organización de las Naciones Unidas para la Agricultura y la

Alimentación. Oficina Regional de la FAO para América Latina. Manual técnico: forraje verde hidropónico. Santiago, Chile. 68 p.

García, E. 2004. Modificaciones al sistema de clasificación climática de Köppen. Universidad Nacional Autónoma de México, Instituto de Geografía. México. 91 p.

García-Carrillo.; Salas-Pérez.; Esparza-Rivera.; Preciado-Rangel y Romero-Paredes. 2013. Producción y calidad fisicoquímica de leche de cabras suplementadas con forraje verde hidropónico de maíz. Agron. Mesoam. 24(1):169-176.

Herrera, A. A.; De Pablos, A. L. A.; Maduro, R. L.; Benezra, S. M. A. y Ríos, de A. 2007. Degradabilidad y digestibilidad de la materia seca del forraje hidropónico de maíz (zea mays). Respuesta animal en términos de consumo y ganancia de peso. Rev. Científ. FCVLUZ. 17(4):372-379.

Müller, L. M. P. A.; Santos, O.S.; Sandro, L. P.; Medeiros, V. H.; Durval, D. N.; Evandro, B. F. and Bandeira, A. H. 2005. Growth and bromatologic composition of hydroponic corn fodder in different dates of harvest and sowing densities. Zootecnia Tropical. 23(2):105-119.

Naik, P. K.; Swain, B. K. and Singh, N. P. 2015. Production and utilization of hydroponics fodder. Indian J. Animal Nutr. 32(1):1-9.

Naik, P. K.; Dhuri, R. B.; Swain, B. K. and Singh, N. P. 2012. Nutrient changes with the growth of hydroponics fodder maize. Indian J. Animal Nutr. 29(2):161-163.

Osorio, W. A.; Lara, P. E.; Magaña, M. A.; Sierra, A. C. y Sanginés, J. R. 2007. Morera (Morus alba) fresca o en forma de harina en la alimentación de cerdos en crecimiento y engorde. Rev. Cubana Cienc. Agríc. 41(1):61-65.

Ramírez, V. C y Soto, B. F. 2017. Efecto de la nutrición mineral sobre la producción de forraje verde hidropónico de maíz. Agron. Costarric. 41(2):79-91.

Rodríguez, R. G.; Hernández-Acosta, D. L.; Flores-Sáenz, I. C.; Quintero-Ramos, A.; SantanaRodríguez, V. y Rodríguez-Rodríguez, S. M. 2009. Cascarrilla de avena y paja de trigo utilizados como sustrato para la producción de forraje verde hidropónico. Tecnociencia Chihuahua. 3(3):160-185.

Romero. 2009. Evaluación de dos niveles de reemplazo de ingredientes en dietas tradicionales por forraje hidropónico de maíz para cerdos confinados en la fase de crecimiento y acabado, Escuela Superior Politécnica del Litoral. 146 p.

Sánchez, del C. F. y Escalante R. 1988. Hidroponia. 3ª. edición. PATUACH. Universidad Autónoma Chapingo. Chapingo, México. 194 p.

SAS. 2002. Statistical Analysis Sistem. SAS Proceeding Guide, Version 9.0 SAS Institute. Cary NC. USA.

SIAP. 2015. Sistema de Información Agroalimentaria y Pesca. Producción Ganadera. Información estadística de la producción ganadera nacional y pecuaria. <https://www.gob.mx/siap/acciones-y-programas/produccion-pecuaria>.

Torres-Novoa y Hurtado-Nery. 2007. Análisis de parámetros de desempeño zootécnico en la fase de cría en una porcícola comercial del departamento del Meta. Orinoquia. 11(12):59-65.

Increased Enzymic Activity

Given all the facts, 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.

Benefits of Sprouts for Feed

Greg Willis (MScAgr)

Review of Published Scientific Literature

Section 1: Nutritional Benefits of Hydroponically Sprouted Grains for Animal Feeding

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."



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."



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 a-tocopherol (Vitamin-E) and beta-carotene (Vitamin-A precursor) are produced during the growth process (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. Chung, T., Nwokolo, E.N., and Sim, J.S. (1989). "Compositional and digestibility changes in sprouted barley and canola seeds." Plant Foods for Human Nutrition 39: 267- 278. Cuddeford, D. (1989). "Hydroponic grass." In Practice 11(5): 211-214. Morgan, J., Hunter, R.R., and O'Haire, R. (1992). "Limiting factors in hydroponic barley grass production." 8th International Congress on Soilless Culture, Hunter's Rest, South Africa. Peer, D.J., and Leeson, S. (1985). "Feeding value of hydroponically sprouted barley for poultry and pigs." Animal Feed Science and Technology 13: 183-190. Shipard, I. (2005). "How Can I Grow and Use Sprouts as Living Food ?" Stewart Publishing. Tudor, G., Darcy, T., Smith, P., and Shallcross, F. (2003). "The intake and liveweight change of droughtmaster steers fed hydroponically grown, young sprouted barley fodder (Autoglass)." Department of Agriculture Western Australia.

Summary of Nutritional Benefits upon Sprouting



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

Vitamin-E:

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

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.) Alkalisng 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.

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.

References

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
- Stimulation of **appetite**, especially during conditions of heat
- Reduction in the incidence of **Gut Ulcers** in
- Reduction in the incidence of **Laminitis** in working
- Improvements in **behaviour**, ie, reduction of “fizz” in working
- Great improvements in general **appearance & coat gloss**.
- Substantial improvements in **hoof quality & strength** (reported by farriers).
- Improved **conception rates** in broodmares on poor quality
- Improved performance of **young foals** on mares in poor

Beef Cattle

- Surprisingly good **weight gains** when feeding moderate quantities of sprouts to animals with a very low quantity & quality of alternative feed.
- Improved **conception rates** in heifers and cows on poor quality.
- Improved **weaning rates** in herds on poor quality.
- Great improvements in general **appearance & coat gloss**.

Dairy Cattle

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

Sheep and Goats

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

Possible Explanations for Observations Reported

From Section 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 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
- Grains and legume seeds contain abundant 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 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

- 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
- Despite sprouted feed having a very low dry matter content (commonly 80-85% moisture), when feeding sprouts in the magnitude of approx **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 &
- At this level of feeding – for example a **400 kg mare** receiving **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 $12.0 \text{ kg} \times 15\% \times 20\% = \mathbf{360 \text{ grams of crude protein}}$. 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.

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.