Institution:	**Royal Agricultural University**
Unit of Assessment:	**6 Agriculture, Veterinary and Food Science**
Title of case study: Nutrition, health and welfare of stabled horses	

1. Summary of the impact (indicative maximum 100 words)

The domestic horse is often managed in sub-optimal conditions that provide inadequate forage and high levels of starch leading to respiratory, metabolic and behavioural disturbances. Research at the RAU over the past five years has had a significant ameliorative impact upon these welfare reducing phenomena via the development and marketing of the following products:

- Hay steamers HG 1000, HG 600 and HG-GO (Propress Equine Ltd),
- Aquacid foregut buffering supplement (Marigot Ltd)
- Actisaf™ live yeast supplement (Lesaffre Feed Additives Ltd)
- horseRATION iPhone application (Arkuris Ltd)

In addition, impact of both nutritional and behavioural data has been maximised via thorough dissemination of findings to the horse owning populace via scientific reviews and lay publications.

2. Underpinning research (indicative maximum 500 words)

Research carried out by Dr Andrew Hemmings (senior lecturer) and Dr Meriel Moore-Colyer (principal lecturer), both employed throughout the REF period

(i) Hay steamers HG 1000, HG 600 and HG-GO

The results of the Moore-Colyer and Fillery (2012) experiment clearly showed that steaming was significantly more effective than soaking at reducing both microbial contamination and respirable particle numbers in hay. Furthermore this is the first published paper to document the negative impact of soaking hay, which actually increased the bacterial concentration and so compromises the hygienic quality of the fodder. This work has therefore raised the awareness of the negative impact of this commonly used stable management practice for horse owners.

The research involved 5 repetitions x 3 treatments (dry, soaked and steamed) of UK meadow hay. Microbial culturing techniques were used to measure yeast, mould and bacteria concentrations in colony forming units / g. A cyclone sampler was used to measure respirable particles (those < 5 um) numbers from post-treatment agitated hay. This work was conducted in 2011 by Dr Meriel Moore-Colyer, Principal Lecturer at the RAU.

(ii) Aquacid foregut buffering supplement (Marigot Ltd)

The Moore-Colyer *et al.* (2013) experiment was an *in vitro* assessment of a feed supplement designed to reduce acidity in the fore gut of horses suffering from gastric ulceration syndrome. This was the essential initial work to determine if Aquacid had a buffering effect in simulated gastric conditions when combined with a variety of commonly fed diets. The work examined the effect of the buffer in both simulated fore gut and hind gut conditions and found the supplement to be an effective buffer and stimulant for hind gut fermentation. Marketing of the product has been based on these findings. The experiment was carried out in 2010 at RAU laboratories by Dr Meriel Moore-Colyer and BSc student Katherine Wakefield and published jointly with O'Gorman of Marigot Ltd.

(iii) Actisaf™ live yeast supplement to promote fibre degradation in laminitic ponies

Laminitis afflicts 10% of the UK horse population, generating veterinary fees of over £20 million per annum. Affected individuals will suffer significant reductions in both welfare status and usefulness from competition standpoint. The Hale *et al.,* (2012) study was the first to address aetiological factors relating to the hind gut microbiome of laminitic versus control animals. High fibre and high starch feed substrates were incubated with faecal inocula from a group of ponies with a history of laminitis (n=8), and a group of disease free control animals (n=8). The extent and rate of degradation of substrate was measured over a 96 hour period using a standard gas production technique. The laminitic ponies demonstrated significant fibre digestion deficiencies, which highlighted the need for feed supplements that promote cellulolytic degradation. This work was carried out in 2011 at the RAU, by Catherine Hale (Lesaffre) and Dr Andrew Hemmings (RAU).

(iv) horseRATION iPhone application

High starch diets are often cited anecdotally as the primary cause of unwanted behaviours such as hyperactivity and stereotypy. The Hale *et al.,* (2011) work reported herein sought to address this long held belief experimentally. In a randomised cross over design, horses (n=8) were fed both a high fibre and a high starch ration, before measurements of behavioural reactivity and heart rate were performed. A significant increase in both behavioural reactivity scores and heart rate associated with the high starch treatment indicates that starch contributes to behaviours that

detract from manageability. This data has potential to better inform owners of feeding practices which impact negatively on the behavioural profile of domestic equids. This work was carried out at the RAU in 2011, by Catherine Hale (Lesaffre) and Dr Andrew Hemmings (RAU). In addition, similar behavioural advice has been communicated via McBride and Hemmings (2009) to a veterinary audience, and in the lay press to horse owners through two pieces in Horse and Hound magazine (20.08.09 and 16.06.11).

3. References to the research (indicative maximum of six references)

Hale, C.E. Warren, H. and **Hemmings, A**. (2012). The fermentation of hay and starch when incubated in vitro with faecal inoccula from either normal healthy horses or horses with a history of laminitis. In: *Forages and Grazing in Horse Nutrition*. European federation of Animal Science EAAP publication No. 132. Ed. M.Saastamoinen, M.J. Fradinho, A.S. Santos and N. Miraglia. 357 - 361 **DOI: 10.3920/978-90-8686-755-4**

Hale, C.E. **Hemmings, A.** and Bee, S. (2011). The effects of a high starch, cereal-based diet compared to a low starch, fibre-based diet on reactivity in horses. In *Applied Equine Nutrition and Training.* Wageningen Academic Publishers. 227-231. **DOI 10.3920/978-90-8686-740-0_17**

McBride, S.D and **Hemmings, A**. (2009). A neurologic perspective of equine stereotypy. *Journal of Equine Veterinary Science*. 29 (1) 10-16. **DOI 10.1016/j.jevs.2008.11.008**

Moore-Colyer, M.J.S. and Fillery, B.G. (2012) The effect of three different treatments on the respirable particle content, total viable count and mould concentrations in hay for horses. In: *Forages and grazing in horse nutrition*. European federation of Animal Science EAAP publication No. 132. Ed. M.Saastamoinen, M.J. Fradinho, A.S. Santos and N. Miraglia. Pp 101-107 **DOI 10.3920/978-90-8686-755-4**

Moore-Colyer, M.J.S., O'Gorman, D.M. Wakefield, K. (2013) An *in vitro* investigation into the effects of a marine-derived, multi-mineral supplement in simulated equine stomach and hind gut environments. *Journal of Equine Veterinary Science* (published online Sept. 2013) **DOI10.1016/j.jevs.2013.07016**

4. Details of the impact (indicative maximum 750 words)

(i) Hay steamers HG 1000, HG 600 and HG-GO

impact

The research provided essential evidence on the efficacy of the products. It has allowed Propress Equine Ltd to produce marketing literature citing the proven effects of the products to the consumer. Propress Equine Ltd use the research in statements on their web page – 'Only Haygain has published scientific research to support these gains' / supported by science, used by professionals' and PDFs of both the research archive and a brief summary of the findings in the annual review of the RAU can be downloaded from this webpage (http://www.haygain.co.uk/haygain-hg-1000.php accessed 5/11/2013) .Thus the work cited here underpins their marketing and advertising.

The research has been disseminated in academic journals, popular articles, through web sites, leaflets and at shows via trade stands. The work has also been delivered via technical talks at veterinary CPD days in Edinburgh and Nottingham Veterinary Schools and the Royal Veterinary College. This has meant that the steamers are now recommended by many vets when advising their clients on strategies to reduce respiratory disorders in stabled horses.

The company has benefitted from the research in that it can support its marketing statements with proven findings. Horse owners have benefitted by being able to reduce the negative effects of dust in the stable and so improve horse performance. Both are evidenced by testimonial statements on the Haygain web site www.haygain.co.uk. (accessed 5/11/13)

timeline and delivery specifics

2011 Haygain fund research on respirable particle and microbial content of dry, steamed and soaked hay lead by Dr Moore-Colyer (**Moore-Colyer** and Fillery, 2012)

2012 Based on the results of the 2011 work Moore-Colyer in collaboration with Haygain do further studies on the effect of different wetting treatments on the microbial content of hay (award winning presentation: , European Equine Health and Nutrition Congress, 2013); and the effect of steaming on bacteria, yeast and mould concentrations in haylage for horses (Leggatt and **Moore-Colyer,** *Proceedings of the British Society of Animal Science.* Nottingham UK, April 2013). Results of both studies used in marketing literature and as the basis for further work.

(ii) Aquacid foregut buffering supplement (Marigot Ltd)
impact
The positive buffering effect reported in the Moore-Colyer *et al.* (2013) paper has been the major supporting evidence for the recent re-launch in 2013 of this product internationally under the name EquMinPlus. The incidence of gastric ulceration syndrome in performance horses is > 80% and most professional riders use ant-acid supplements to counteract the negative effect that ulcers can have on performance. The extended period of buffering achieved by this product will make it an extremely useful addition to any performance horse diet.
timeline and delivery specifics
2009 *In vitro* study Funded by Marigot Ltd
2010 Paper delivered at European Workshop on Equine Nutrition
2013 Re-launch of product based on research published (**Moore-Colyer,** O'Gorman and Wakefield, 2013)

(iii) Actisaf™ live yeast supplement (Lesaffre Feed Additives)
impact
Hale *et al.* (2012) reported a lower microbial fibre digestion capacity in the laminitis prone phenotype and linked this deficit to disease pathogenesis. Other groups have discovered that live yeast fed to ruminants increases fibre digestibility via proliferation of fibre digesting bacteria. Therefore Lesaffre Feed Additives (world's largest manufacturer of live yeast) used the Hale *et al.(*2012) finding as a primary justification for feeding a live yeast product (Actisaf) to laminitic horses, in order to increase fibre digestion capacity in these animals. Indeed, the seminal work evidenced herein has given rise to additional *in-vitro* and *in-vivo* efficacy trials which extend the Hale *et al.* (2012) work, now featuring live yeast treatments fed to laminitic prone equids.
timeline and delivery specifics
2011 - Lesaffre fund research an in vitro fermentation kinetics study, led by Catherine Hale (Lesaffre) and Dr Andrew Hemmings (RAU)
2012 – On the strength of the significant differences uncovered, Lesaffre begin additional investigation involving live yeast supplements (Actisaf™)
2013 – Lesaffre (a company new to the equine feeds market) use data as part justification for more general expansion into the equine feed supplementation sector

(iv) horseRATION iPhone application
Impact
Data from Hale *et al.,* (2011) was used to inform development of the iPhone application horseRATION. (available from the App Store; 2232 downloads by Nov 2013; 187 purchases of the full product) Based on the owners assessment of a particular horses behavioural profile (see figure 1), a suitable balance of fibre versus starch is recommended, according to the animals foreseen workload. Currently on licence to Arkuris Ltd, the app was developed at Aberystwyth University with support from Centre of Excellence in Mobile Applications and Services (CEMAS) – an initiative of *the European Regional Development Fund (ERDF)*

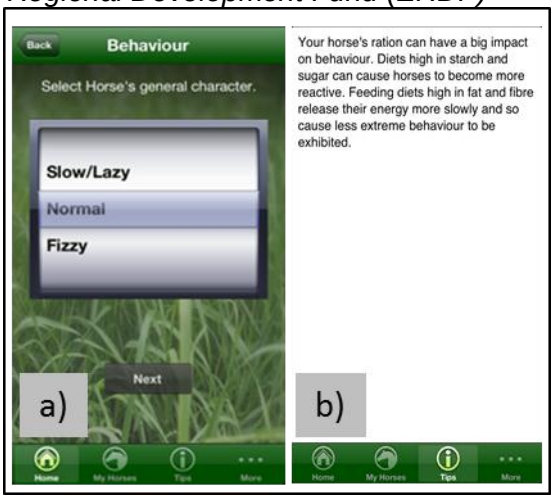

Figure 1. horseRATION behavioural profiling screen a) input unit b) owner feedback example

Aside from iPhone application development, research into the linkage between feeding and behaviour has been widely disseminated to the end user via publication in veterinary journals (e.g. McBride and Hemmings 2009) and two articles (20.08.09 and 16.06.11) commissioned for the leading UK equestrian lay publication ''Horse and Hound'' (circulation~50,000 weekly), thereby ensuring well targeted impact.

timeline and delivery specifics

2011- Feeding trials into high and low starch diets conducted, led by Dr Andrew Hemmings (RAU) and Catherine Hale (Lesaffre)
2012- horseRATION iPhone application development begins, with Catherine Hale leading the nutritional aspects of the project, and Arkuris managing programming and marketing strategy
2012- horseRATION iPhone application launched at the Royal Welsh Show
2013- horseRATION wins **British Equine Trade Association Award for Innovation** award.

5. Sources to corroborate the impact (indicative maximum of 10 references)

Hay steamers HG 1000, HG 600 and HG-GO
Evidence of the use of the research can be found on the Haygain web site http://www.haygain.com/haygain-hg-1000.php which shows a summary of all the work done at RAC, photographs of microbial culture plate (from the research) a list of publications, and testimonial statements from horse owners. Also leaflet citing the RAU work?? produced by the company available on request.

Aquacid foregut buffering supplement – letter from R&D Manager Marigot Ltd, Co. Down)
"further to the recent acceptance of your work on EquMin Pus in the Journal of Veterinary Science, I wanted to write and let you know just how much of a difference this will make you our company profile. The value of peer-reviewed publications is enormous in this market place and outs Marigot Ltd in a different league from other companies who do not publish. We will use this publication to develop our customer base, to develop our marketing materiel and a literature for our customers both veterinarians and horse owners"

Actisaf™ live yeast supplement - letter from R&D Director Lesaffre Feed Additives, France
"The work as reported by Hale et al., (2012) co-authored by Dr Andrew Hemmings, (Royal Agricultural University) has provided a vital starting point, with regards to Lesaffre's push into the equine market place. More specifically, this data shows considerable potential for Actisaf TM, to act as a promoter of hind gut health, with reference to the debilitating metabolic condition known as laminitis. Indeed, an extensive in-vivo feeding trial featuring Actisaf TM has already been undertaken with laminitis susceptible ponies, and an additional field trial is currently underway".

horseRATION iPhone application
"As manager of mobile application development at Aberystwyth University, I can confirm that research contributed to by staff of the Royal Agricultural University (Dr Andrew Hemmings) has informed the development of ration formulation software for horses at our university. Specifically, the iPhone application horseRATION™, on license to Arkuris Ltd, utilises findings from the Hale et al., (2011) high / low starch study to properly advise owners on feeding for optimum behavioural output. Furthermore, as testament to the quality of this product, horseRATION ™ recently won the coveted BETA Innovation Award 2013" Technology Transfer Officer; Research, Business & Innovation Visualisation Centre, Aberystwyth.

Web link, attesting to the success of this iPhone application at the British Equestrian Trade Association 2013 awards ceremony: http://cemas.mobi/projects/horse-ration