Project description
'Gizzard inflammation in broiler chickens and slaughter turkeys'

PART 1: The KMB project

Comments by the project manager by January 2008

Harald Hetland which was responsible for this project at University of Life Sciences (ULS), quit as a researcher at the ULS in the end of 2007. The university was not been able to find a person that could replace him, and decided to drop out as a partner. Since the work at the University of New England (UNE) was very closely linked to Hetland and his work, it was difficult to continue our cooperation with this partner as initially planned. Hence, some minor changes in the project description have been necessary. The main tasks of these two partners were to contribute to the description of the relationship between gizzard function and gizzard inflammation. This is still a sub-goal in the project. To fulfil this sub-goal, samples will be collected from an experimental trial conducted by ULS, UNE and the National Veterinary Institute. We think that the data from this trial will give us more valuable information than data from field material, regarding how the fibre fraction in litter and feed may influence on gizzard inflammation. Further, the analyses of particle size distribution in the duodenum and nutrient analyses of ileal contents will continue as planned. The drop out of ULS and UNE as active partners will as we see it, not influence on the scientific quality of the project. However, the total costs of the project will be reduced by approx. 600 000 NOK (see page 8: 7. Costs incurred by each research performing partner.)

1. Objectives

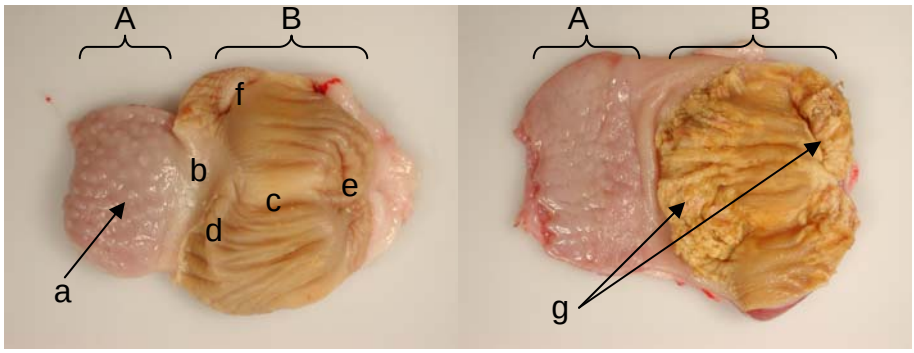
The main objective is to acquire new knowledge about a health problem preliminarily designated 'gizzard inflammation' (GI) in commercial broiler chickens and slaughter turkeys. The knowledge is disseminated to the national and international poultry industry and research community.

Our sub-goals are to

1. describe the pathology, age pattern and variability of gizzard inflammation (GI)
2. compare GI in broiler chickens and slaughter turkeys
3. describe the relationship between potentially causative factors and GI, and generate hypotheses on the etiology of GI
4. describe the relationship between foot health (as an indicator of bird welfare) and GI
5. describe the relationship between gizzard function and GI
6. describe the relationship between GI and productivity
7. investigate if gizzards from birds that die or are killed during the rearing period is a useful indicator of GI occurrence in slaughter turkeys
8. describe the relationship between *Clostridium perfringens* and GI
9. establish a quantitative assay for gizzerosine in feeds

2. Frontiers of knowledge and technology

The stomach of birds consists of two chambers, the proventriculus (glandular stomach) and the gizzard (muscular stomach, ventriculus) [3]. The gizzard of the chicken comprises three segments, the proventricular-gizzard junction (Isthmus), the muscular (proper) gizzard, and the gizzard-duodenal junction (Pylorus) [10]. Some anatomical details are shown in Figure 1.



(Photo: National Veterinary Institute, Oslo)

Figure 1

Left: Opened normal broiler chicken proventriculus and gizzard ; proventriculus (A), gizzard (B), ventricular mucosa with orifices of proventricular glands (a), isthmus (b), proper gizzard (c), cranial blind sac (d), caudal blind sac (e) and pylorus (f).

Right: Proventriculus and gizzard from broiler chicken with severe gizzard inflammation. Note markedly distended proventriculus (A) and isthmus. The koilin layer of the gizzard (B) is fissured, thickened, spongy and discoloured, especially in the blind sacs (g)

In the isthmus, there is a mixture of mucoid and koilin-type glandular secretion. The lining covering the isthmus mucosa, is not as organized as that which is found within the proper gizzard. The mucosa of the proper gizzard is dominated by simple tubular glands, and the secretions form a thick, horny layer (the koilin layer, 'cuticle' or 'keratinoid' layer) lining the lumen. The point of separation between the gizzard and the duodenum is delineated by a constriction of the muscularis mucosae forming a fold of the muscularis and lamina propria. The gastroduodenal cycle ensures a thorough mixing of proventricular, gizzard and duodenal contents, including mixing of digesta with hydrogen ions, digestive enzymes and bile acids. The gizzard contractions also induce mechanical grinding of large and hard feed particles. The thickness of the gizzard muscle, and consequently the gizzard size, is affected by feed structure. The small pyloric region is believed to slow down or prevent the movement of large particles into the duodenum [3,8,9].

In spite of the gizzard's vital functions, our present knowledge about gizzard health problems in commercial poultry is limited and fragmented. Such problems have been described in scientific papers [2,5,7,12,14,20-22,24,25], poultry health atlases [6,26-28] and standard textbooks in poultry medicine [13,15,29]as well as in the layman magazines (for example [4]). The lesions most commonly described have been designated 'gizzard erosion and ulceration', 'ventriculitis', and 'Muskelmagenerosionen'. Many causes of these findings have been proposed. Conditions where mucosal gizzard lesions are a predominant finding are not presented as a separate entity in standard textbooks of poultry diseases (e.g., [13,29]). Further, conditions affecting primarily the proventriculus, but with similar lesions and/or suspected etiology, have been described [1,11].

During our examinations of broiler chickens and slaughter turkeys originating from experiments [16,17]as well as commercial broiler flocks (unpublished preliminary data from research council project No. 155867/110), we have become increasingly aware of how frequent gizzard lesions appear to be in randomly sampled birds without other significant gross lesions. We have also been surprised to find that the intestinal lumen of birds with gizzard lesions may contain whole cereal grains, which suggests that the gizzard may be dysfunctional to a degree that is likely to impair feed utilization substantially. If new knowledge regarding this issue lead to an improvement of average feed conversion ratio, this would imply a total reduction of yearly feed costs of roughly NOK 2,0 million for each per cent improvement in the Norwegian broiler production alone.

On this background we think that the poultry industry and the poultry science community need more knowledge about this condition that appears to be so prevalent and potentially important with regard to production efficiency and bird welfare.

3. Research tasks

Our working definition of the designation 'gizzard inflammation'(GI) is based on findings in Norwegian broiler chickens and slaughter turkeys. The condition is characterized by no overt clinical illness in the flock. Randomly sampled birds show variable degrees of gizzard lesions, but no other consistent gross pathology. The most consistent macroscopic lesion is a thick and roughened gizzard lining. In our experience the visible lesions in mildly affected birds are most often found in the thin-walled blind sacs, whereas more severe changes may affect most of the inner gizzard surface, which may be fissured, thickened, spongy and discoloured (Figure 1). The proventriculus and isthmus may be dilated, and the muscular wall of the gizzard may show atrophy. Our preliminary histopathological studies show inflammatory cells (mainly mononuclear) and oedema that may be found throughout the entire thickness of the mucosa, the upper part of which may show dense granulocytic infiltrates and epithelial desquamation. The designation 'gizzard inflammation' is based on these microscopic findings.

The project intends to study this apparently prevalent, subclinical gizzard health problem in commercial meat type poultry in Norway, and compare the findings with those of related works from other regions and times.

Our work comprises the following major research tasks:

- Study and describe the natural, subclinical disease in commercial slaughter turkeys and broiler chickens and analyze feeds for specific nutrients and toxins
- Generate hypotheses about the cause(s) of gizzard inflammation
- Develop new methodology in order to improve our studies of gizzard inflammation

Our previous findings in commercial broiler chickens (unpublished data) indicate that GI may appear as a prevalent subclinical problem which may be detrimental to bird welfare and productivity. Previous research has not focussed much on these aspects. Rather, research has focussed on one single of several potentially causative factors and its effect on the gizzard. We want to evaluate the role of several factors in a field material.

Further, we want to study the condition in slaughter turkeys. The poultry health literature hardly mentions gizzard lesions similar to GI as a problem in slaughter turkeys, although it has been diagnosed in commercial slaughter turkey flocks at one of our partners' diagnostic laboratory, at the meat inspection authority that is a partner of our project, and in experiments performed by one of the project partners. A description of this health problem in slaughter turkeys therefore seems to be lacking in the scientific literature. Although several specific factors have been associated with GI in broiler chickens, nothing seems to be known about potentially causative factors in slaughter turkeys.

Gizzard lesions have for many years been associated with the use of overheated fish meal [30]. One of the causative factors in such fish meal is histamine, which may induce gizzard lesions at concentrations of 4 mg/kg feed or more [30].

Another compound that has been found in fish meal associated with gizzard inflammation, has been termed gizzerosine [21]. Gizzerosine is formed by a reaction of ε-amino-radical of lysine with imidazolylethyl radical from histidine or histamine during the heating process of fish meat [19]. This compound acts on H_2 –resceptors and stimulates gastric acid secretion. Whereas methods for histamine analysis of feeds are commercially available, more work still is needed to establish and commercialize an analytical method for gizzerosine [18,29]. One of our research partners is in the frontiers of knowledge and technology in this field.

The occurrence of a subclinical disease is best studied by random sampling of live birds several times during the rearing period of a flock. However, the larger the animals, the less

convenient and the higher become the cost of such sampling. This problem becomes particularly clear in slaughter turkeys raised until 18 weeks of age. We therefore want to evaluate another method of screening a slaughter turkey flock for GI.

4. Research approach, methods

The causal factors behind the natural gizzard inflammation (GI) seen in Norway are unknown. Several factors may be involved. It is even possible that the designation GI comprises two or more disease entities with distinct etiologies and pathogeneses. We therefore want to study commercial birds from flocks that are likely to be diverse with regard to potential causal factors. Such diversity may be achieved by studying individuals from flocks associated with different hatcheries, feed mills and farms. Also, because the number of potentially important factors involved is large, and not much is known about the age span of the condition, much work has to be assigned to each flock of birds that is studied. On this background, we want to study a limited number of commercial flocks associated with as many hatcheries, feed mills and farms as practically possible.
The proposed project will utilize data and materials derived from commercial hatcheries, farms and feed mills, and from a processing plant and a regional public meat inspection authority. Materials will be examined at the laboratories of the research consortium, or through purchase of analytical services.

Selection of study flocks

All feed mills and hatcheries associated with broiler and slaughter turkey flocks delivered to the processing plant Nortura avd. Rakkestad will be contacted for collaboration in the study. Selected farms will be invited to participate in the study, on the basis of their relations to hatcheries and feed mills, and type of litter material used as bird bedding. The aim is to maximize the number of combinations of hatcheries, feed mills and farms among the 16 flocks (eight broiler flocks and eight slaughter turkey flocks) that are included in the study. With regard to slaughter turkey flocks, birds from each herd should preferably be sent to the processing plant twice; at approximately 10-12 weeks of age and at approximately 16-18 weeks of age.
A written agreement will be signed between the project and each of the participating poultry farmers.

Collection of feed samples

One sample (1500 grams) per batch of all compound feed used in the study flocks will be collected.

Selection of birds from the study flocks

Ten randomly selected birds are collected at regular time intervals from each flock, and examined immediately following euthanasia or slaughter.
Broiler chickens are examined at approximately 7, 14, 21 and 28 days of age. The broilers are transported live to the National Veterinary Institute before euthanasia.
Slaughter turkeys are examined at 1 and 4 weeks of age, at first slaughter, and at second slaughter. Slaughter turkeys collected at 1 and 4 weeks of age are transported to the National Veterinary Institute before euthanasia. Gizzards and livers from slaughtered turkeys at 12 and 18 weeks of age are collected at the slaughter house, kept cool and sent to NVI for examination the same or the next day.

Selection of subsamples of birds for further examinations

A total of 64 consignments of birds are examined. In each consignment the individuals will usually differ with regard to presence and severity of gizzard lesions. From each consignment, the birds with the lowest and highest inflammation score, are selected for further

examinations. All further sampling is done from these two birds per consignment, a total of 128 birds. All individuals in this subgroup of birds are sampled in the same way. Protocols for sampling and data records will be made.

Pathology of selected birds

All birds are inspected for gross lesions of the proventriculus and gizzard. Specimens of the proventriculus and gizzard from both selected birds are collected for histopathological examination. If no mucosal lesions are observed in the proventriculus, specimens will be taken from the middle part of the organ. First samples of the gizzard will be taken from the most representative area in the bird with the highest inflammation score. Specimens from the corresponding gizzard area in the "low score bird" will then be collected. I addition liver specimens from both birds are collected, formalin-fixed and processed routinely for histopathology.

Microbiology of selected birds

Specimens of the proventriculus (if mucosal lesions are present), gizzard, and liver will be collected, frozen and subsequently examined for Aviadenovirus. Mostly serotype 1 aviadenovirus has been associated with gizzard inflammation in Japan by PCR and RFLP [23], and an initial PCR screening with RFLP/sequencing will be performed on a limited number of birds to get indications on the presence and serotype of adenoviruses in the animals. Depending on the initial findings, the association of potential adenoviruses with specific lesions will be further assessed by detection of viral DNA or antigen *in situ*, using either a specific DNA probe, or serotype-specific antibodies, respectively.
Specimens of the gizzard koilin layer will be examined quantitatively for *Clostridium perfringens* (real time PCR and traditional methods).

Parameters of gastrointestinal function

Gizzard contents are examined for pH, and duodenal digesta are analysed for particle size distribution using a laser diffraction method. To correlate gizzard lesions with nutrient utilisation, nutrient analysis of ileal contents is performed. Since birds housed on littered floor consume considerable amounts of litter, the fibre fraction of the digesta consists of one part of dietary fibre and one part of fibre from the litter. To correlate gizzard lesions with fraction of litter in gizzard contents, feed, litter and gizzard contents will be analysed for free sugars, soluble non-starch-polysaccharides and insoluble non-starch-polysaccharides, using the AOAC alditol acetate procedure [31], modified at The University of New England, Armidale, NSW, Australia. The effect of litter and dietary fibers on GI will be investigated in a separate experimental trial. This trial will be conducted in cooperation with University of Life Sciences as a part of another project.

Indicator of bird welfare

A dysfunctional gizzard is likely to affect bird welfare negatively in several ways. This project focuses on foot pad lesions as a welfare indicator, assuming the following chain of events:
Gizzard inflammation and dysfunction> deteriorated faeces quality and litter conditions> increased frequency and severity of foot pad lesions. One hundred foot pads per broiler flock and 40 foot pads per slaughter turkey flock are scored at slaughter for gross lesions in accordance with a designed form.

Chemical analyses of feed and bird tissues

All samples of compound feed are analyzed quantitatively for four thricotecenes (DON, Nivalenol, HT-2 toxin and T-2 toxin), vitamin E, Selenium, vitamin B_6 (pyridoxine), histamine, Copper, Zinc and in-feed anticoccidials that are used by the feed mills. Feeds

containing maize are also analyzed for fumonicin contents. Feeds are analysed quantitatively for gizzerosine [18] if analytical methods become available during the project period.
Samples of liver are analyzed for vitamin E, Selenium, vitamin $B_{6,}$ Copper and Zinc.
The trichotecene analysis is based on a method that has been used in a 'Standard measurement and Testing Program (SMT)' arranged by the EU. Following extraction, the trichothecenes are quantified using mass spectrometry (Finnigan) with selected ion monitoring (SIM) mode. The toxins are separated using gas chromatography (Finnigan). Vitamin E (alpha-tocopherol) analysis is based on a method that is continuously controlled by performance tests (FAPAS, UK). Following extraction, the tocopherol is quantified using reversed phase HPLC with fluorescence detector.
Selenium is determined by using an automated hydride-atomic absorption spectroscopy system. For Copper and Zinc determination, samples are analysed by flame atomic spectroscopy.

Development of a quantitative assay for gizzerosine in feeds
The work is based on previous research at Biosonda Corp.[18], and comprises gizzerosine extraction from feed samples, as well as standardizations, prototype evaluation and field evaluation of the ELISA test.

Gizzards from slaughter turkey flocks collected during the growing period
From all slaughter turkey flocks involved in the study, all (a maximum of 3 per day and 5 per week from each flock) gizzards with the proventriculus from birds that die or are killed during the growing period are collected, stored frozen and scored for gross lesions in a simplified way compared to gizzards from birds sampled at random alive. Variation and level of gizzard scores are compared statistically, in order to evaluate the agreement between the two screening methods.

Collection and storage of data
Field data collected during the rearing period will be based on several sources:
(a) Feed mills: Informative labels from every compound feed bacth used during the rearing of the flocks are collected. These labels include contents of sulphur-containing amino and types and amounts of copper and zinc supplements..
(b) Copies of a form ('Day-list') that all farmers are obliged to fill in.
(c) Type, concentration and duration of usage of drinking water supplements (for example disinfectants, vitamins, antibiotics) during the rearing period are recorded.
(d) Production performance data from the slaughterhouse (broilers and slaughter turkeys)
(e) Health data from the meat inspection authority (condemnation figures, condemnation causes)
(f) Data from suppliers of day-old chicks/poults regarding hybrid, age of parent flock(s), treatment at the hatchery, numbers of birds delivered, date of delivery.

Field data as well as laboratory data are collected and stored in a project data base established at the National Veterinary Institute.

Data analyses
Data are recorded at the flock level as well as the individual level. Descriptive statistics will be used to analyse all data that are instrumental in the achievement of study objectives. Because of the low number of flocks involved in the study, flock level data are unlikely to allow for analytical statistics. Depending on the results of the initial analyses, analytical statistics will be used to investigate the relationships between variables recorded at the individual level.
The research partners possess satisfactory statistical expertise.

Project organisation and management

Partners name (abbreviation)	Partners role and competence
Animalia-Centre for Poultry Science (CPS)	**Active – financial.** Representing the whole poultry industry.
National Veterinary Institute, Section for pathology (NVI-pat)	**Active – executive**, project manager. Research group devoted mainly to gastrointestinal health in poultry. *Top competence*: Pathology and project management
NVI, Sections for chemistry and toxicology (NVI-chem/tox)	**Active – executive.** Collaboration with Biosonda in development of a gizzerosine assay. *Top competence*: Analyzing feed and tissues for vitamins, minerals and mycotoxins.
NVI, Section for virology and serology (NVI-vir)	**Active – executive.** Responsible for the Adenovirus- work General virology. *Top competence*: Molecular virology.
Biosonda, Chile	**Active – executive**. Immunology and biotechnology. *Top competence:* Gizzerosine analyses of feed
Norwegian Food Research Institute (Matforsk)	**Active – executive.** Molecular bacteriology. *Top competence*: Real time PCR for *Clostridium perfringens*
Nortura, Rakkestad	Owner of slaughter house. Provide field data, assist in selection of study flocks, responsible for sampling of organs at slaughter.
The Norwegian Food Safety Authority – District Office Indre Østfold and Follo (Mattilsynet)	Provide condemnation data.
Norgesfôr (NF)	One major supplier of poultry feeds in the study region. Ensure that the project is provided the data and assistance needed from their feed mills in the area.
Felleskjøpet fôrutvikling AS (FF)	The other major supplier of poultry feeds in the area. Ensure that the project is provided the data and assistance needed from their feed mills.

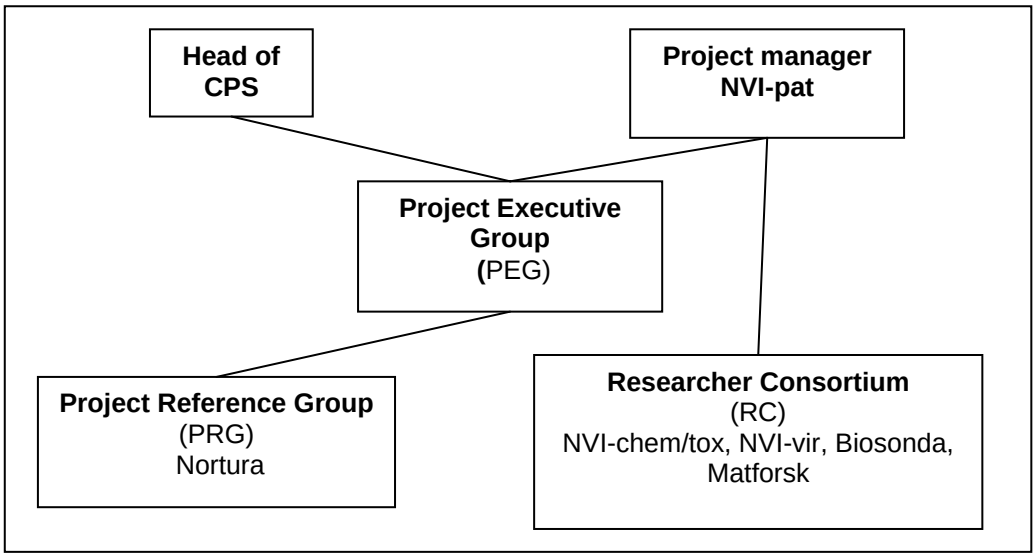


Figure 1. Project management

PEG meets whenever requested by one of its members, or if major deviation from the project plans seems necessary or desirable without any delay. Such changes can only be implemented if both members of the group agree. **PRG** and **RC** must be consulted if disagreement in **PEG** and in case of all major deviations from the plans. The consultation should preferably take place before any major deviations are implemented, and at the latest within one month following the implementation. If the **PEG** cannot agree on a major issue in spite of

consulting the **RC** and the **PRG**, a voting process with all active partners (one vote per active partner) is organized. In case of equal numbers of votes, the vote of the project manager is conclusive. Meetings may be organized as telephone meetings, physical gatherings or by e-mail correspondence.

5. International co-operation

NVI is involved in European collaboration through an EU-project (www.replace-eu.com) and network projects (www.genusclostridium.net and www-afac.slu.se). We have not found any partners in these networks with competence within the field of gizzerosine analysis of feeds. But we will communicate our results to our networks, and hopefully find European collaborators also within the field of gizzard health.

6. Progress plan - milestones

Deliverables and milestones	**From**	**To**
	Year Quarter	Year Quarter
Establish project organization	2006 3	2006 4
Make forms, instructions, data bases	2006 3	2006 4
Collect data and samples first broiler flock	2006 4	2006 4
Report and meeting on first broiler flock	2006 4	2006 4
Collect data and samples first turkey flock	2006 4	2007 1
Report and meeting on first turkey flock	2007 1	2007 1
Establish PCR method *Aviadenovirus*	2006 3	2007 2
First report development gizzerosine method	2006 3	2007 3
First year report sampling and data collection	2006 3	2007 3
Establish *in situ* detection *Aviadenovirus*	2007 2	2007 4
First report on sample analyses	2006 3	2008 1
Second year report sampling and data collection	2007 3	2008 3
Second report development gizzerosine method	2007 3	2008 3
Experimental trial: Effect of litter/dietary fibres	2007 3	2008 1
Completion of sampling and data collection	2008 3	2009 1
Third report development gizzerosine method	2008 3	2009 3
Completion of sample analyses	2008 1	2009 4
Completion of data analyses	2006 3	2010 1
Final project report	2010 1	2010 1
Publication of results	2010 1	2010 3

7. Costs incurred by each research performing partner

Costs incurred in NOK 1.000 ,-

Research partner	Personnel- and indirect costs	Equipment	Other costs[1]	Total costs
NVI[1]	3235	50	2017	5302
ULS[2]	162		0	162
Matforsk	317		79	396
Biosonda	653		184	837
UNE[2]	0		0	0
Total costs	4367	50	2280	6697

[1]Costs incurred by purchase of services from non-research partners and research institutes are shown as Other costs incurred by the National Veterinary Institute (NVI). These costs are incurred by services from Nortura Rakkestad (the processing plant), from the research institute analyzing feeds and tissues for vitamin B_6 and histamine (Nasjonalt institutt for ernærings- og sjømatforskning), from the poultry rearers participating in the study, from the laboratory analyzing feeds for ionophorous anticoccidials (Norwegian School of Veterinary Science). From 2008 these costs also are incurred by services from the laboratory analyzing duodenal ingesta for particle size and ileal contents for nutrient utilisation (University of Life Sciences, kr. 44 000,-). Further the

experimental trial conducted to investigate how the fibre fraction in litter and feed may influence on gizzard inflammation, involve an increase in personell- and direct costs at the NVI (kr. 125 000).
[2]University of Life Sciences (ULS) decided to drop out of the project in October 2007. According to the agreement they got 130' from the project and 30' from their own funding. Since the activities at University of New England (UNE) was closely related to SLU, this partner also dropped out of the project.

8. Financial contribution by partner

Financial contribution in NOK 1.000,-.

Funding partner and Research Council	**2006**	**2007**	**2008**	**2009**	**2010**	**Total**
Centre for Poultry Science (Fagsenteret for fjørfe)	200	400	400	400	200	1600
Biosonda Corp., Santiago, Chile	16	16	16	16	16	80
National Veterinary Institute	48	108	81	113	50	400
University of Life Sciences (dropped out of the project Oct. 2007)	11	21				32
Matforsk	5	10	10	10	5	40
Research Council (NFR/Fondet)	600	1200	1200	1500	600	5100

PART 2: Exploitation of results

9. Relevance for knowledge-building areas

This project has relevance for the knowledge–building fields of
a. BIOPRODUCTION: New knowledge likely to improve productivity will be disseminated directly to the involved industry partners. The multidisciplinary and international collaboration of this project is likely to induce positive synergy allowing for long-term development of competence that is useful to the whole value chain.
The consumers' image of the poultry meat production, and therefore poultry meat, is likely to benefit if the industry can improve bird welfare, which is important in itself. Another important aspect of this research is related to the poultry industry's efforts to abandon the usage of in-feed antimicrobial additives. Preliminary data suggest that GI is more pronounced in flocks offered feed without such additives. A better understanding of the causes behind GI may therefore be important also with regard to the possibilities of raising healthy meat type poultry without in-feed antimicrobials.
b. BIOTECHNOLOGY: Biosonda Corp. and the NVI intend to develop an ELISA kit for quantification of gizzerosine in feeds. This work contributes to improved skills at the NVI within separation and extraction technology as well as immunology.
Four of the active partners are involved in teaching and training of university students and scientists within animal nutrition, veterinary medicine and biotechnology. Research is an important basis for good teaching at this level. The multidisciplinary knowledge acquired during the project is likely to benefit all partners involved in teaching, and also benefit their students.

10. Importance to Norwegian industry

The project is designed to investigate possible links between feed and gizzard inflammation. Such information is vital to the involved feed manufacturers.
The Norwegian poultry meat industry needs to increase its efficiency due to increasing international competition. This project focuses on one aspect that will help improve

productivity at the primary production level. Norwegian consumers are increasingly aware of the conditions under which the food is produced. Improved gizzard health is likely to improve health and welfare of the birds, and therefore the consumers' confidence in Norwegian poultry meat. Improved efficiency at the primary production level and improved consumer confidence will benefit the Norwegian food industry as well.

11. Relevance for Innovation programmes

This project has relevance for the programmes
a. MATNORGE, as it will give basic knowledge to implement cost savings in primary production, and improve the possibilities of marketing value added products based on adaptation to consumer concerns. In 2006 the Norwegian Agricultural Authority gives a specific funding priority to projects that increase knowledge in the field *gastro-intestinal health in poultry*. This project is definitively within that area.
b. FORNY, as one of the research institutes (NVI) intends to participate in the commercialization of an ELISA kit for gizzerosine analysis. This will contribute to a professional organization of commercialization of research findings at the NVI, and contribute to similar future collaborations between the institute and commercial companies.

12. Environmental impact

An improved feed efficiency would reduce the amount of faeces produced per kg of poultry meat. Improved digestibility would imply reduced faecal moisture and therefore reduced litter usage and reduced energy expenditure for ventilation of the poultry house.

13. Information and dissemination of results

We intend to present our results to the involved industry partners, to the national and international poultry industry, and to the national and international research community. The findings will be presented as oral presentations or posters at meetings, at websites of the active partners (e.g. www.vetinst.no, www.fjorfe.org), as articles in periodicals for the industry as well as peer-reviewed papers in international, scientific journals.

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