Annual Report
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TABLE OF CONTENTS

	Page
Scope of Work	3
Research Activities, 2019/2020	4
Teaching, Training and Extension Activities	8
Proposed Activities, 2020/2021	12
Publication List	13

SCOPE OF WORK

Funding of $ 10,000 p.a. is provided by the Poultry Industry Association of New Zealand (PIANZ) for the retention of Poultry Research and Teaching capabilities at Massey University

Terms of reference for the poultry scientists will be to:

- Assist in the strategic direction of poultry research and the preparation of Research and Development submissions for the School of Agriculture and Environment,

- Attract, conduct and/or oversee contract or publicly funded research projects in poultry on behalf of the School of Agriculture and Environment,

- Assist with the development and implementation of liaison groups, facilitating communication about poultry issues between the School of Agriculture and Environment, and

- Involve in poultry teaching programmes of the School of Agriculture and Environment where required but not to the detriment of his research programme.

RESEARCH ACTIVITIES, 2019/20

Barley in broiler starter diets: Influence of enzyme supplementation and conditioning temperature

The present study was conducted to assess the influence of supplemental carbohydrase (Carb) and conditioning temperature (CT) on growth performance and nutrient utilisation of broilers (d 1-21) fed barley-based diets. A completely randomised design was used, with a 2 x 3 factorial arrangement evaluating two levels of Carb (0 and 150 g/tonne of feed) and three CT (60, 74 and 88 °C). Normal-starch hulled barley (cultivar, Fortitude) was ground in a hammer mill to pass through the screen size of 8.0 mm. A basal diet was formulated to meet the Ross 308 strain recommendations for major nutrients for broiler starters (Ross, 2014). The basal diet was then used to develop two feed batches, without and with an NSP-degrading enzyme. Each diet, without and with Carb, was divided into three equal batches and, conditioned at three different temperatures (60, 74 and 88 °C) by adjusting the steam flow rate. Mash diets were steam-conditioned for 30 s and the CT was measured at the outlet (close to the exit point) of the conditioner before the mash feed entered the pellet die. Following conditioning, all diets were pelleted using a pellet mill capable of manufacturing 180 kg of feed/h and equipped with a die ring with 3.0 mm holes and 35 mm thickness. The diets contained 5.0 g/kg of titanium dioxide as an indigestible marker to determine ileal nutrient digestibility.

Addition of Carb increased weight gain (WG; $P < 0.05$) and reduced F/G ($P < 0.001$) by 30 g/bird and 6.5 points, respectively. Regardless of the Carb addition, WG ($P < 0.001$) and F/G ($P < 0.01$) was deteriorated by increasing CT. Birds fed diets conditioned at 60 and 74 °C had a similar ($P > 0.05$) WG but higher ($P < 0.05$) than those fed the diets conditioned at 88 °C. Conditioning at 88 °C increased ($P < 0.05$) F/G compared to the diets conditioned at 60 and 74 °C. Supplemental Carb enhanced ($P < 0.01$) the starch digestibility. Birds offered diets conditioned at 88 °C had lower ($P < 0.05$) digestibility of protein, phosphorus and energy compared to the birds fed diets conditioned at 60 and 74 °C. Diets conditioned at 88 °C resulted in lower ($P < 0.05$) starch digestibility than diets conditioned at 60 °C. Regardless of CT, supplemental Carb increased apparent metabolisable energy (AME) by 0.13 MJ/kg. Steam-conditioning at 88 °C reduced ($P < 0.05$) AME compared to the diets conditioned 60 and 74 °C. In conclusion, the efficacy of the enzyme was similar at each CT as indicated by the lack of significant interactions between supplemental Carb and CT. Supplementation of Carb in barley-based diets improved WG, F/G, starch digestibility and AME in broiler starters. Steam-conditioning diets at 88 °C negatively influenced the WG, F/G, ileal digestibility of protein, starch and AME.

Influence of barley inclusion method and protease supplementation on growth performance and nutrient utilisation in broiler starters

This study investigated the possible interactions between finely-ground, coarsely ground and whole barley inclusion, and protease supplementation on the performance, nutrient digestibility and energy utilisation in broiler starters fed wheat-based diets.

A completely randomised design was used in this study, with a 3 x 2 factorial arrangement of 6 treatments. Three basal diets, all containing 283 g/kg barley, were prepared either without or with protease enzyme resulting in 6 dietary treatments: (1) Finely-ground barley without protease; (2) Finely-ground barley with protease; (3) Coarsely-ground barley without protease; (4) Coarsely-ground barley with protease; (5) whole barley without protease; and (6) whole barley with protease. The diets were formulated to meet the Ross 308 strain recommendations for major nutrients (Ross 2014). Titanium dioxide was added at the rate of 5.0 g/kg in the diet. All diets were steam-conditioned at 60^{o}C for 30 seconds and pelleted.

Over the whole experimental period (day 1 to 21), the main effect of barley inclusion method was significant ($P < 0.01$) for WG and F/G. Coarse grinding and whole barley inclusion resulted in higher ($P < 0.05$) WG compared to fine grinding. Feed per gain was higher ($P < 0.05$) in birds fed diets containing fine particles compared to those fed diets containing whole barley. The main effect of protease supplementation and interaction between barley inclusion method and protease supplementation were not significant ($P > 0.05$) for WG, feed intake and F/G.

Coarsely ground and whole barley inclusion resulting in higher ($P < 0.05$) digestibility than finely ground barley. Diets made from coarse particle and whole barley had higher ($P < 0.05$) ileal digestible energy values compared to diets made from fine particles. The main effect of protease supplementation was not significant ($P > 0.05$) for nutrient digestibility and energy utilisation.

In conclusion, coarse grinding and whole barley inclusion resulted in enhanced nutrient digestibility and subsequently improved performance in broilers. Exogenous protease supplementation had no effect on broiler performance and nutrient digestibility. The lack of protease effects may hypothetically mirror a low potential for further improvements, due to the phytase and carbohydrase enzymes and high digestible components in the feed.

Measurement of ileal endogenous energy losses and true ileal digestible energy of cereal grains for broiler chickens

Two experiments were conducted to determine the ileal endogenous energy losses (IEEL) and, AMEn and true ileal digestible energy (TIDE) of four cereal grains (maize, sorghum, wheat and barley) for broilers. In experiment 1, a glucose-based purified diet was used to determine the IEEL for correcting the

apparent ileal digestible energy (AIDE) values to TIDE. The diet was randomly allocated to 6 replicates (6 birds per replicate) of male broilers and fed from 18 to 21 days post-hatch. The jejunal and ileal digesta were collected on day 21. The results showed that glucose absorption continued beyond the jejunum, but complete in the terminal ileum demonstrating that endogenous energy losses can be quantified in the ileal digesta of birds by feeding a glucose-based diet. The IEEL were determined to be 347 ± 29.4 kcal/kg DM intake. In experiment 2, 4 experimental diets with similar inclusion (957 g/kg) of grains were developed to determine the AMEn, AIDE and TIDE. Titanium dioxide (5.0 g/kg) was added to all diets as an indigestible marker. Each diet was randomly allocated to 6 replicates (8 birds per replicate) and fed from 14 to 21 days post-hatch and the ileal digesta were collected on day 21. The AIDE was corrected to TIDE using the IEEL value determined in experiment 1. The TIDE of maize, sorghum, wheat and barley were determined to be 3,920, 3,650, 3,138 and 2,885 kcal/kg DM, respectively, and was higher ($P < 0.05$) than the corresponding AMEn values of 3,439, 3,284, 2,576 and 2,371 kcal/kg DM, respectively. No differences ($P > 0.05$) were observed between the AMEn and AIDE. Further studies are warranted to determine the TIDE of a range of ingredients and to investigate the application of TIDE as potential available energy system in poultry feed formulations.

Endogenous amino acid flows in broilers are influenced by bird age

This study was carried out to measure the basal endogenous amino acid (EAA) flow in male broilers (Ross 308) at different ages (d 7, 14, 21, 28, 35 and 42), using a nitrogen-free diet (NFD). The NFD was composed of maize starch (842 g/kg), cellulose (50 g/kg), soybean oil (50 g/kg) and mineral and vitamin premix (53 g/kg). Titanium dioxide (5 g/kg) was also added to the NFD as an indigestible marker. Six replicate cages housing 14 (d 1), 12 (d 7), 10 (d 14), 8 (d 21), 8 (d 28), and 6 (d 35) birds per cage was arranged. The NFD was offered for four days prior to ileal digesta collection. The relative basal EAA flow was calculated as grams per kilogram of dry matter intake (g/kg DMI). The relative basal endogenous flow of nitrogen (N) and all individual and total AA (TAA), decreased quadratically ($P < 0.05$ to 0.001) as birds grew older. The relative basal endogenous flows of N and TAA were higher ($P < 0.05$) on d 7, lowest on d 42, being intermediate from d 14 to d 35. The present data suggest that the specific age-related values for EAA flow should be used to standardise AA digestibility coefficients in broilers.

Feed acidification and steam-conditioning temperature influence nutrient utilization in broiler chickens fed wheat-based diets

Two experiments were conducted to examine the effects of conditioning temperature (CT), and the interactive influence of feed acidification (FA) and CT on the performance, coefficient of apparent ileal digestibility (CAID) of nitrogen (N), starch, fat, calcium (Ca) and phosphorus (P), and AME in broilers. In both experiments, each treatment was randomly allocated to 6

cages (8 birds per cage) and fed from 1 to 21 d post-hatch. In Experiment 1, the effect of CT was evaluated using a wheat-based diet at three CT: unconditioned, conditioned at 60 or 90 ºC. All the diets by-passed the pellet press and collected in mash form. Birds fed the diet conditioned at 90 ºC consumed more ($P < 0.05$) feed and tended ($P = 0.087$) to have higher feed per gain (F:G) than those fed the unconditioned diet but similar to those fed the diet conditioned at 60 ºC. A tendency was noted for CT to affect the CAID of N ($P = 0.071$) and starch ($P = 0.093$), with reduced digestibility values in the diet conditioned at 90 ºC. Conditioning at 90 ºC resulted in lower ($P < 0.05$) AME.

In Experiment 2, 3 inclusions of an acidifier (0.0, 7.0 and 10 g/kg) and 2 CT of 60 and 90 ºC were evaluated in a 3 × 2 factorial arrangement of treatments using pelleted diets. The FA increased ($P < 0.05$) the CAID of N, fat and P at both inclusion levels, and of starch at 10 g/kg. Conditioning at 90 ºC reduced ($P < 0.05$) the CAID of starch, fat and Ca, regardless of FA level.

Overall, the present data showed that the application of high CT for broiler feed manufacture can impair nutrient utilisation and, consequently the feed efficiency in broilers. Feed acidification imparts some benefits to nutrient digestibility in broilers fed pelleted wheat-based diets.

True ileal digestibility of calcium in soybean meal and canola meal, without and with microbial phytase, for broiler starters and finishers

Two experiments were conducted, with the primary objective of determining the true ileal digestibility of calcium (Ca) in soybean meal (SBM) and canola meal (CM), without and with microbial phytase, during broiler starter (Experiment 1) and finisher (Experiment 2) periods. Six experimental diets based on SBM and CM, with three phytase doses (0, 500 and 2000 FTU/kg), were fed to broilers from day 18 to 21 (Experiment 1) or 39 to 42 (Experiment 2) post-hatch. A Ca- and P- free diet, with no added phytase, was also developed to determine the endogenous Ca and P losses. Titanium dioxide was incorporated in all diets as an indigestible indicator.

True ileal Ca digestibility coefficients of SBM and CM, without added phytase, were determined to be 0.51 and 0.53, respectively, in starters and 0.33 and 0.22, respectively, in finishers. Increasing phytase doses increased ($P < 0.05$) the true ileal Ca digestibility of CM in both broiler starters and finishers, but Ca digestibility of SBM were increased ($P < 0.05$) only at the super dose (2000 FTU/kg) in broiler finishers. Calcium retention ($P < 0.001$) in starters was higher in CM than in SBM and was increased in both ingredients by increasing phytase doses. In finishers, the Ca retention was increased ($P < 0.001$) by both phytase doses in CM, but only by the superdose in SBM, resulting in an ingredient × phytase interaction ($P < 0.001$).

In conclusion, phytase increases the ileal digestibility and retention of Ca, regardless of ingredient and age of broilers. Superdosing (2000 FTU/kg)

increased the digestibility and retention of Ca in CM and SBM by two-fold compared to the normal phytase dose (500 FTU/kg).

Contract research and feed evaluation

These commitments continued during the reporting period. The total value of feed evaluation services and commercial contracts during 2019/20 was around $90,000. There has been a reduction in number of commercial contracts this year due to COVID-19.

In 2020, we secured NZD432,600 (AUD 420,000 over 3 years, 2020-2023) from Agrifutures, Australia for the project “Effect of broiler age on energy utilisation and amino acid digestibility”. This is a highly competitive peer reviewed research fund and it is the first time AgriFutures Australia funded any research outside Australia in poultry nutrition.

TEACHING, TRAINING AND EXTENSION ACTIVITIES, 2019/20

Postgraduate Research Supervision

Professor Ravi Ravindran, Dr Reza Abdollahi & Dr Fifi Zaefarian

PhD candidates

Perera, W. Nipuna U., Title: Influence of feed processing and enzyme supplementation on performance, nutrient utilisation and gut morphology of poultry fed barley-based diets. Thesis submitted in July 2020.

David, L.S., Title: Studies on the Measurement of Ca Digestibility in Raw Materials for Poultry.

Mahmoud Mohammad Khalil, Title: Influence of broiler age of energy utilisation.

Mukti Barua, Title: Influence of broiler age on ileal nutrient digestibility.

Michelle Taylor, Title: ‘Gut microflora and bee health’ (Co-supervisor: Ravindran). Thesis submitted, June 2020.

Amira Elsayed Abdalla Mahmoud Title: ‘Optimising the use of black soldier fly *Hermeta illucens* L. for animal feed’ (Co-supervisor: Ravindran).

Hadi Goldani, PhD Candidate, 2018. (Co-supervisor, Abdollahi). On-going. Urmia University of Ferdowsi, Urmia, Iran. Strategies to improve nutritional value of maize-based diets for modern broilers.

Zeinab Pourazadi, PhD Candidate, 2018. (Completed in 2020. Co-supervisor, Abdollahi). On-going. Department of Animal Science and food Technology, Khuzestan University, Ahvaz, Iran. Effect of particle size of various types of insoluble fiber and physical form of feed on performance and physiological parameters of broiler chickens fed diets containing barley.

Alireza Jafari, PhD Candidate, 2019. (Co-supervisor, Abdollahi). On-going. Bu-Ali Sina University, Hamedan, Iran. The effect of limestone particle size on performance, calcium digestibility and gene expression of calbindin in broiler chickens and pullets.

MSc candidates

Lindon Tari. Title: Influence of barley particle size and whole barley inclusion in wheat-based diets for broilers. Completed February 2020.

Gayatri Vinod Bhaskare. Title: Metabolisable energy and digestible amino acids of canola meals and canola seed for broilers. Ongoing.

Mohammad Javad Fasihi, 2020. Title: Influence of feed form and pellet quality on growth performance and digestive tract developments in broiler chickens. (Co-supervisor, Abdollahi). Animal Science Department, Agriculture College, Isfahan University of Technology, Isfahan, Iran.

Post-doctoral scientist

Dr Fifi Zaefarian appointment as a post-doctoral scientist was extended for a further 3-year period (from March 2019 to February 2022). Position is being supported by overseas industry funding.

Other activities

- Teaching ‘Poultry Production’ lectures for Veterinary and Agriculture undergraduates, and ‘Animal Care and Nutrition’ lectures for students in Diploma of Veterinary Nursing course. Teaching of advanced units in ‘Poultry Nutrition’ and ‘Poultry Production’ for postgraduates.

- A technical conference (‘Advancing Poultry Production 2020, Massey/Industry Conference’) for the industry supposed to be held in Palmerston North in May 2020, but it was postponed due to COVID-19.

- The Biennial New Zealand Poultry Industry Conference had been planned to be held in Nelson in October 2020. This meeting was also postponed due to COVID-19. The meeting is jointly organised by the World’s Poultry Science Association (NZ Branch) and Massey University.

- The scientific programme was organised for Seventh International Broiler Nutritionists’ Conference (Poultry Beyond 2025), supposed to be held in April 2020 Queenstown, New Zealand, but postponed to October 2021 due to COVID-19.

Overseas Linkages

- USSEC Feed Formulation Workshop (**Virtual Webinar**). Invited speaker to present two papers on “Pelleting Broiler Feed: Implications for Efficiency, Digestion and Gut Development” and “Towards a Digestible Phosphorus and Calcium System in Poultry” at USSEC regional technical Seminar, 6-7th August 2020 (**Abdollahi**)

- Bangkok, Thailand. Invited speaker to present a paper on “Pelleting Broiler Feed: Implications for Efficiency, Digestion and Gut Development” at Broiler Feed Quality Conferences (BFQC), 5-6 August and Bali on 10-11 August 2020 (**Postponed to 2021 due to COVID-19**) (**Abdollahi**)

- Queenstown, New Zealand. Invited speaker to present a paper on “Optimal Pellets for Broilers: The Quest Continues” at Seventh International Broiler Nutritionists’ Conference (Poultry Beyond 2025), April 2020 (**Postponed to October 2021 due to COVID-19**) (**Abdollahi**)

- Bangkok, Thailand. Invited speaker to present a paper on “The interactive effect of nutrient density and feed form on the growth performance and feed efficiency in broilers“ at International Feed Technology Conference (IFTC, Asia 2020), 24 March 2020 (**Postponed to January 2022 due to COVID-19**) (**Abdollahi**)

- Sydney, Australia. Title: Standardised ileal amino acid digestibility of ingredients for broiler chickens is influenced by feed form. 31st Australian Poultry Science Symposium, February 2020 (**Abdollahi**)

- Seoul, South Korea. Invited speaker to present two papers on “Pelleting Broiler Feed: Implications for Efficiency, Digestion and Gut Development” and “Alternative Feed Ingredients for Poultry Diets: Challenges and Prospects” at AB Vista Feed Intelligence Conference, 18-19 September 2019 (**Abdollahi**)

- Barcelona, Spain. Invited speaker to present a paper on “Influence of Feed Processing on the Gastrointestinal Tract Development and Gizzard Physiology in Broilers” at First International Fibre Summit, 19-21 November 2019 (**Abdollahi**)

- Armidale, New South Wales, Australia. Invited speaker to present a paper on “Maximising pelleting benefits for the feeding of modern broilers’’ at Recent Advances in Animal Nutrition (RAAN), 23-25 October 2019 (**Abdollahi**)

- USSEC Feed Formulation Workshop (**Virtual Webinar**). Invited speaker to present a paper on “Energy systems for poultry feed formulations: The challenges” at USSEC regional technical Seminar, 6-7th August 2020 (**Ravindran**)

- USSEC Feed Formulation Workshop (**Virtual Webinar**). Invited speaker to present a paper on "An overview of fat digestion in poultry – Limitations and strategies to improve fat utilisation" at USSEC regional technical Seminar, 6-7th August 2020 (**Zaefarian**)

- Queenstown, New Zealand. Invited speaker to present a paper on "Feed evaluation beyond 2025" at Seventh International Broiler Nutritionists' Conference (Poultry Beyond 2025), April 2020 (**Postponed to October 2021 due to COVID-19**) (**Ravindran**)

- Queenstown, New Zealand. Invited speaker to present a paper on "Rapid methods in feed evaluation techniques: Limitations and potentials" at Seventh International Broiler Nutritionists' Conference (Poultry Beyond 2025), April 2020 (**Postponed to October 2021 due to COVID-19**) (**Zaefarian**)

Appointments

Member, Editorial Boards of the following International Journals (**Ravindran**)

- Associate Editor, *Animal Production Science* (published by the CSIRO, Australia)
- Section Editor, *Animals*
- Senior Editor, *Animal Feed Science and Techno*logy (Elsevier, the Netherlands).
- Section Editor, *British Poultry Science* (Published by British Poultry Science Association)
- Editorial Board, *Journal of Animal Science* (official Journal of the American Animal Science Association).
- Editorial Board, *Journal of Applied Animal Nutrition* (Cambridge Press, UK).
- Editorial Board, *Journal of Applied Poultry Research* (official Journal of the American Poultry Science Association).
- Editorial Board, *Asian-Australasian Journal of Animal Science* (Published by the Asian-Australasian Association of Animal Production)

Member, Editorial Board of the following International Journal (**Abdollahi**)

- Associate Editor, *Animal Nutrition*

- Section Editor, Animals

Member, Editorial Board of the following International Journal (**Zaefarian**)

- Associate Editor, *Animals*

Organising committee of the following conferences (**Ravindran & Abdollahi**)

- 'Advancing Poultry Production XXII – Massey Poultry Technical Conference', Palmerston North, May 2020. (**Postponed to 2021 due to COVID-19**)

- 2020 New Zealand Poultry Industry Conference, Nelson, October 2020. (**Postponed to 2022 due to COVID-19**)
- Seventh International Broiler Nutritionists' Conference (Poultry Beyond 2025), April 2020. (**Postponed to 2021 due to COVID-19**)

PROJECTED ACTIVITIES SEPTEMBER 2020 – AUGUST 2021

Research Activities

Evaluation of different inclusion of whole barley in poultry diets

Digestible calcium assessment in poultry
These studies will form part of the PhD programme of Ms. Laura David.

Influence of age of broilers on protein digestibility in different grains and protein sources
These studies will form part of the PhD programme of Mrs. Mukti Barua

Influence of age of broilers on metabolisable energy
These studies will form part of the PhD programme of Mr. Mahmoud Khalil

Metabolisable energy and digestible amino acids of canola meals and canola seed for broilers

This study will form part of the MSc programme of Ms. Gayatri Vinod Bhaskare.

Teaching, Training and Extension Activities

- Postgraduate supervision and training; teaching of undergraduates and postgraduates – poultry nutrition and production.
- New Zealand Poultry Industry Conference to be held in Nelson. October 2020. (**Postponed to 2022 due to COVID-19**)
- Advancing Poultry Production 2020, 22nd Massey/Industry Conference' to be held in Palmerston North. May 2020. (**Postponed to 2021 due to COVID-19**)
- Poultry Beyond 2025, Seventh International Broiler Nutritionists' Conference to be held in Queenstown, New Zealand, 27 April to 1 May 2020. (**Postponed to 2021 due to COVID-19**)

Overseas Linkages

- USSEC Workshop (Virtual Workshop): Recent advances in feed evaluation, September 2020 (**Ravindran, Abdollahi, Zaefarian**)
- Sydney, Australia to attend and present papers at the Australian Poultry Science Symposium, February 2021 (**Abdollahi & Zaefarian**)

- Queenstown, New Zealand, to attend and present invited papers at the Seventh International Broiler Nutritionists' Conference, 2021 (**Ravindran, Abdollahi & Zaefarian**)
- Paris, France, to attend and present a paper at World Poultry Conference, August 2021 (**Abdollah**i & **Zaefarian**)

PUBLICATION LIST, 2019/2020

Book Chapter

Zaefarian, F., Abdollahi, M. R. and Ravindran, V. 2019. Influence of feed processing on the gastrointestinal tract development and gizzard physiology in broilers. In: G. Gonzalez-Orits et al. (ed.), The value of fibre-engaging the second brain for animal nutrition. Wageningen Academic Publishers 2019. DOI:10.3920/978-90-8686-893-3_13.

Journal Articles

Hamungalu, O., **Zaefarian, F., Abdollahi, M. R., Ravindran, V.** (2020) Performance response of broilers to feeding pelleted diets is influenced by dietary nutrient density. Animal Feed Science and Technology (Invited research paper for Special Issue). (Published online)

Pourazadi, Z., Salari, S., Tabandeh, M. R., **Abdollahi, M. R.** (2020) Effect of particle size of insoluble fibre on growth performance, apparent ileal digestibility and cecal microbial population in broiler chickens fed barley containing diets. British Poultry Science. (Published online)

Abdollahi, M. R., Zaefarian, F., Hall, L., Jendza, J. A. (2020) Feed acidification and steam-conditioning temperature influence nutrient utilization in broiler chickens fed wheat-based diets. Poultry Science. (Published online)

Perera, W. N. U., **Abdollahi, M. R., Zaefarian**, F., Wester, T. J., **Ravindran, V.** (2020) The interactive influence of barley particle size and enzyme supplementation on growth performance, nutrient utilization and intestinal morphometry of broiler starters. Poultry Science. (Published online)

Perera, W. N. U., **Abdollahi, M. R., Zaefarian, F.,** Wester, T. J., Ravindran, G., **Ravindran, V.** (2020) The effect of graded inclusions of waxy starch hull-less barley and a multi-component exogenous carbohydrase on the growth performance, nutrient digestibility and intestinal morphometry of broiler chickens. British Poultry Science. (Published online)

David, L. S., **Abdollahi, M. R.,** Bedford, M. R., **Ravindran, V.** (2020) Effect of age and dietary crude protein content on the apparent ileal calcium digestibility of limestone in broiler chickens. Animal Feed Science and Technology. (Published online)

Cowieson, A. J., Sorbara, J. O. B., Pappenberger, G., **Abdollahi, M. R., Ravindran, V.** (2020) Toward standardized amino acid matrices for

exogenous phytase and protease in corn/soy-based diets for broilers. Poultry Science 99: 3196-3206.

Abdollahi, M. R., Zaefarian, F., Ravindran, V. (2019) Maximising the benefits of pelleting diets for modern broilers. Animal Production Science 59: 2023-2028.

Conference Papers

Perera, W. N. U., **Abdollahi, M. R., Zaefarian**, F., Wester, T. J., **Ravindran, V.** (2020) Barley particle size and supplemental enzymes: influence on growth performance and nutrient utilisation of broiler starters. Proceedings of the Australian Poultry Science Symposium 31: 40-43. Sydney, Australia.

Khalil, M. M., **Abdollahi, M. R., Zaefarian, F., Ravindran, V.** (2020) Feed form affects the apparent metabolisable energy of individual ingredients to different extents in broiler chickens. Proceedings of the Australian Poultry Science Symposium 31: 44-47. Sydney, Australia.

Barua, M., **Abdollahi, M. R., Zaefarian, F.,** Wester, T. J., Channarayapatna, G., **Ravindran, V.** (2020) Standardised ileal amino acid digestibility of ingredients for broiler chickens is influenced by feed form. Proceedings of the Australian Poultry Science Symposium 31: 48-51. Sydney, Australia.

Whitehouse, T. H., **Zaefarian, F., Abdollahi, M. R., Ravindran, V.** (2020) Dietary fat inclusion decreases endogenous amino acid losses in broiler chickens endogenous amino. Proceedings of the Australian Poultry Science Symposium 31: 61. Sydney, Australia.

Barua, M**., Abdollahi, M. R., Zaefarian, F.,** Wester, T. J., Channarayapatna, G., **Ravindran, V.** (2020) Endogenous amino acid flows are influenced by age of broiler chickens. Proceedings of the Australian Poultry Science Symposium 31: 62. Sydney, Australia.

Abdollahi, M. R., Zaefarian, F., Ravindran, V. (2019) Maximising the benefits of pelleting diets for modern broilers. Proceedings of the Recent Advances in Animal Nutrition (RAAN), Animal Production Science 59: 2023-2028. Armidale, New South Wales, Australia.

Proceedings Edited

1. **Abdollahi, M. R.** 2020. 'Advancing Poultry Production', Proceedings of the Massey Technical Update Conference, Volume 22, Monogastric Research Centre, Massey University, Palmerston North, 4 May 2020. 100 pp. (**Postponed to 2021 due to COVID-19**) (ISBN 0-476-00678-3).
2. **Abdollahi, M. R.** and **Ravindran, V.** 2020. Proceedings of the Seventh International Broiler Nutritionists' Conference (Poultry Beyond 2025), Volume 7, Poultry Industry Association of New Zealand and Monogastric Research Centre, Massey University, Queenstown, April-May 2020. (**Postponed to 2021 due to COVID-19**) (ISBN 978-0-473-24924-3).