联合国粮食及农业组织 | Food and Agriculture Organization of the United Nations | Organisation des Nations Unies pour l'alimentation et l'agriculture | Продовольственная и сельскохозяйственная организация Объединенных Наций | Organización de las Naciones Unidas para la Alimentación y la Agricultura | منظمة الأغذية والزراعة للأمم المتحدة

COMMITTEE ON AGRICULTURE

SUB-COMMITTEE ON LIVESTOCK

Second Session

16 - 18 July 2024

Alternative feeding practices to promote responsible use of antimicrobials

Executive Summary

There is growing concern about antimicrobial resistance (AMR) and the potential risk for the selection of resistant microorganisms and their transfer between animals and humans. Together with good hygiene, welfare and husbandry practices, adequate nutrition and advanced and alternative feeding practices can reduce the need to use antimicrobials in animal production and contribute to phasing out or avoiding the use of antimicrobial growth promoters (AGPs), especially those classified as medically important antimicrobials for human health by the World Health Organization (WHO).[1]

Feeding practices can improve gut health in different ways, not only through direct interaction with the gut microbiota, the main target of AGPs, but also by stimulating additional physiological functions of the intestine, such as gut barrier integrity and intestinal immunological mechanisms, thereby increasing the overall resilience of animals to infections and environmental stressors.

FAO is gathering and sharing information on, as well as supporting the uptake of, advanced and alternative feeding practices, more specifically a combination of feed processing technologies, precision feeding, and feed functional ingredients and additives that increase feed efficiency, animal health and productivity.

Competent authorities are encouraged to support the application of these practices, as well as to establish science-based standards for feed functional ingredients and additives, good manufacturing practices and quality control measures to ensure their efficacy and safety for animals and animal source food.

[1] WHO. 2024. *WHO list of medically important antimicrobials (7th edition)*. Geneva. https://cdn.who.int/media/docs/default-source/gcp/who-mia-list-2024-lv.pdf?sfvrsn=3320dd3d_2

Suggested action by the Sub-Committee

The Sub-Committee is invited to recommend COAG to:

- invite FAO to support Members, at their request, with capacity development regarding responsible antimicrobial use, including phasing out the use of AGPs; and
- recommend FAO to continue knowledge sharing and dissemination of advanced and alternative feeding practices to promote animal health and welfare and to reduce the overall need to use antimicrobials and avoid the use of medically important AGPs.

Queries on the substantive content of the document may be addressed to:

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I. Introduction

1. The discussion document[2] on alternative feed practices to promote responsible use of antimicrobials presented at the First Session of the Committee on Agriculture (COAG) Sub-Committee on Livestock in March 2022 highlighted concerns that have arisen about the potential risk for the selection of resistant microorganisms and their transfer between animals and humans.

2. The COAG Sub-Committee on Livestock recommended COAG to request FAO to "collect scientific evidence on alternative feeding practices to replace the use of medically important antimicrobials used as growth promoters, their effectiveness and safety, and to conduct, in collaboration with OIE (now World Organisation for Animal Health [WOAH]), research and academic institutions, an inventory of these alternative feeding practices and disseminate related knowledge"[3] and to "share successful experiences and good practices, including traditional knowledge, to support Members to reduce the need for antimicrobials, including support for research in the use of traditional remedies such as plant-based growth promoters".[4] The COAG at its 28th Session in July 2022 endorsed the report of the First Session of the COAG Sub-Committee on Livestock and the recommendations therein.[5]

3. This document provides an update on the implementation of the guidance including the information gathered.

II. Process to collect scientific evidence and successful experiences

[2] COAG:LI/2022/7, https://openknowledge.fao.org/handle/20.500.14283/ni009en
[3] COAG/2022/5, para 38 https://openknowledge.fao.org/handle/20.500.14283/ni966en
[4] COAG/2022/5, para 39 https://openknowledge.fao.org/handle/20.500.14283/ni966en
[5] C 2023/22, para 10 https://openknowledge.fao.org/handle/20.500.14283/nj925en

4. In March 2023, FAO issued an open call for data and information[6] with objectives aiming to:

- collect scientific evidence on alternative feeding practices to replace the use of medically important antimicrobials used as AGPs, while maintaining feed efficiency, and to reduce the overall need to use antimicrobials in farm animals, as well as their effectiveness and safety;
- conduct an inventory of these alternative and advanced feeding practices;
- gather successful experiences and good practices, including traditional knowledge (e.g. the use of traditional remedies and natural products enhancing feed efficiency and animal productivity) to reduce the need for antimicrobials in animal production; and
- collect information on measures to phase out or ban the use of medically important AGPs and their impact on animal health, welfare and productivity as well as food safety.

5. The call was open for two and a half months and was distributed widely through social media and relevant websites and mailing lists. In response to the call, 86 scientific publications and technical reports were received. Most of these focused on intensive pig and poultry systems. The documents were reviewed and taken into account for the preparation of a background document that served as a basis for discussion in an expert meeting titled "Alternative and advanced feed practices to promote the responsible use of antimicrobials" that took place at FAO headquarters on 11-14 July 2023.

6. The expert meeting had the same objectives as the open call and it addressed animal feed composition, feed ingredients, feed additives and feeding practices for different farm animal species.

7. The expert meeting was attended by representatives of WOAH and WHO and by 14 experts and resource persons, selected from the 60 people who had replied to the open call, taking into account their expertise as well as criteria related to gender and geographical balance. Main findings of this meeting are presented in Sections IV and V of this document.

8. The results and information gathered are being widely disseminated through FAO communication channels, a series of dedicated webinars and relevant meetings, such as the International Symposium on Pathways to Reduce the Need for Antimicrobials to Support Sustainable Livestock Transformation from 25-26 April 2024 in China[7] and the Global Leaders Group on AMR meeting from 6-7 May 2024 in Sweden.[8] Four FAO webinars are also being organized for Latin America and the Caribbean, Africa, the Near East and North Africa, and Asia and the Pacific in June 2024.

III. Process to share successful experiences and good practices

9. As an integral part of FAO initiatives addressing AMR, such as the Reduce the Need for Antimicrobials on Farms for Sustainable Agrifood Systems Transformation (RENOFARM)[9] initiative, FAO has developed a web-based repository[10] of resources on good practices and success stories on responsible antimicrobial use (AMU) to reduce the need for AMU in agrifood systems. The repository contains information gathered through an open call issued in 2017, which resulted in 312 submissions by more than 70 countries, and the open call issued in March 2023, resulting in 86 submissions. After scoring and evaluation, to date, the repository contains a total of more than 70 entries in English, French

[6] https://openknowledge.fao.org/handle/20.500.14283/cc5091en
[7] https://www.fao.org/newsroom/detail/fao-launches-global-10-year-initiative-to-reduce-the-need-for-antimicrobials-for-sustainable-agrifood-systems-transformation/en
[8] https://www.amrleaders.org/news-and-events/events/item/2024/05/06/default-calendar/the-9th-meeting-of-the-glg
[9] https://www.fao.org/antimicrobial-resistance/background/fao-role/renofarm/en
[10] https://www.fao.org/docs/corporatenavigationlibraries/amr/fao-repository-good-practices-amu.xlsx

and Spanish. The repository is organized in searchable categories, including year of publication, country, animal species, production system, type of practice (e.g. biosecurity, animal feeding) and target users.

10. FAO continues to collect resources through a new call,[11] opened in April 2024, which has been distributed widely through social media and relevant websites and mailing lists. The call asks for people and organizations to submit publications on success stories and good practices, including traditional knowledge, on responsible AMU and on reducing the need for AMU in agrifood systems. The call emphasizes the need to gather information from a wide range of production systems, regions and in different languages to expand the information already gathered in the repository. The call also asks respondents to provide information on the practices' efficacy and safety.

IV. Scientific evidence on main alternative feeding practices to replace the use of medically important AGPs

11. Functional nutrition to promote animal health is one of the tools available to replace medically important AGPs and to contribute to the overall reduction of AMU in animal production. Nutrition affects the critical functions required for host defence and disease resistance. Feeding practices should therefore aim to support these host defence systems and reduce the risk of the presence in feed and water of potentially harmful substances, antinutritional factors and pathogenic bacteria and other microbes. Feed availability and palatable and rapidly digestible diets, utilizing advanced feed technologies, precision feeding and a wide range of functional feed ingredients and additives, improve not only livestock productivity but also animal health and resilience of the individual animals to infectious diseases, thereby contributing to the reduction of the need to use antimicrobials.[12]

A. Functional feed ingredients, feed processing and precision feeding technologies

12. Various functional feed ingredients and additives improve gut health and the innate immune system by direct interaction with the gut microbiota. For example, dietary fibres may stimulate gastrointestinal secretions and motility, lowering the protein content to avoid excessive fermentation of protein in the hindgut.

13. High protein, insect-rich diets are traditionally used for young chickens and non-digestible oligosaccharides from plants or yeasts are added to the diet of piglets prior to weaning.[13] Antimicrobial peptides produced by insects can protect against a broad array of infectious agents, such as bacteria, fungi, parasite and viruses, thus allowing a decreased use of antimicrobials.[14] Selective use of a combination of functional feed ingredients and feed additives may stabilize the intestinal microbiota and support mucosal barrier function.[15]

14. Feed processing techniques, such as extrusion and pelleting and heating treatments, can play an important role for the nutritional value of feed, by improving digestibility and palatability, as well as contributing to feed safety by destroying pathogens and other undesirable substances. For instance, in

[11] https://www.fao.org/antimicrobial-resistance/news-and-events/news/news-details/en/c/1681112/
[12] FAO. 2021. *Animal nutrition strategies and options to reduce the use of antimicrobials in animal production.* Rome. https://openknowledge.fao.org/handle/20.500.14283/cb5524en
[13] Veldkamp, T. & Vernooij, A.G. 2021.Use of insect products in pig diets. *Journal of Insects as Food and Feed*, 7(5), 781-793. https://doi.org/10.3920/JIFF2020.0091
[14] Li, Y., Xiang, Q., Zhang, Q., Huang, Y., & Su, Z. 2012. Overview on the recent study of antimicrobial peptides: Origins, functions, relative mechanisms and application. *Peptides*, 37(2):207-15. https://doi.org/10.1016/j.peptides.2012.07.001
[15] FAO. 2021. *Animal nutrition strategies and options to reduce the use of antimicrobials in animal production*. Rome. https://openknowledge.fao.org/handle/20.500.14283/cb5524en

pigs and poultry, coarse particle size in feed increases stomach and hindgut acidification, leading to beneficial effects in controlling proliferation of enteric pathogens such as *Salmonella* and *E. coli*.[16] Feed processing may decrease the negative effects of antinutritional factors in feed ingredients, such as trypsin inhibitors, lectins or glucosinolates. Increasing particle size reduces stomach lesions and ulcers in swine and promotes the functioning of the proventriculus and gizzard in poultry.[17] Feeding swine and poultry mash or pellets with coarsely milled cereals decreases the risk of colonization of the gastrointestinal trait by *Salmonella*.[18]

15. Precision feeding refers to nutritional programmes that are tailored not only for a specific animal species, but also for individual age groups and production stages. A typical example is the functional use of high-fibre diets to stimulate gastrointestinal secretions and motility, for example in sows around parturition when resistant starch dietary fibre treatment promotes gut motility and relieves constipation[19] or to lower the protein content of diets to avoid excessive protein fermentation in the hindgut in broilers.[20] Providing controlled-energy diets to meet energy demands and avoid overfeeding in late cow gestation can be used to reduce the risk of developing metabolic diseases such as ketosis.[21]

B. Selected feed additives that improve gut health

16. Prebiotics are compounds that have no nutritive value, but foster growth or activity of beneficial microorganisms in the intestinal microbiota. Their beneficial health effects include improved feed utilization, weight gain and reduced vulnerability to stress. Some soluble fermented fibres, such as inulin, also have prebiotic properties and can be beneficial for gut health and the performances of pigs, poultry and calves.[22] In broilers, prebiotics have been shown to improve growth performance and the gut environment, resulting in better health.[23]

17. Probiotics are live microorganisms which, when administered in adequate amounts, confer health benefits to the host. Their use as dietary supplements in poultry diets has been associated with positive effects on health and growth. For example, they appeared to be effective at reducing *Salmonella enteritidis* prevalence in broilers.[24]

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[16] Kiarie, E.G. & Mills, A. 2019. Role of feed processing on gut health and function in pigs and poultry: Conundrum of optimal particle size and hydrothermal regimens. *Frontiers in Veterinary Science*. 6:19. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6390496/

[17] Amerah, A.M., Ravindran, V., Lentle, R.G. & Thomas, D.G. 2007. Feed particle size: Implications on the digestion and performance of poultry. *World's Poultry Science Journal*. 63:03 https://doi.org/10.1017/S0043933907001560

[18] Visscher, C.F., Winter, P., Verspohl, J., Stratmann-Selke, J., Upmann, M., Beyerbach, M. & Kamphues, J. 2009. Effects of feed particle size at dietary presence of added organic acids on caecal parameters and the prevalence of *Salmonella* in fattening pigs on farm and at slaughter. *Journal of Animal Physiology and Animal Nutrition*, 93(4): 423–430. https://doi.org/10.1111/j.1439-0396.2008.00821.x

[19] Lu, D., Pi, Y., Ye, H., Wu, Y., Bai, Y., Lian, S., Han, D. *et al.* 2022. Consumption of dietary fiber with different physicochemical properties during late pregnancy alters the gut microbiota and relieves constipation in sow model. *Nutrients* 14:12. https://doi.org/10.3390/nu14122511

[20] Qaisrani, S.N., Van Krimpen, M.M., Kwakkel, R.P., Verstegen, M.W.A. & Hendriks, W.H. 2015. Dietary factors affecting hindgut protein fermentation in broilers: A review. *World's Poultry Science Journal* 71:01. https://doi.org/10.1017/S0043933915000124

[21] Andersson, L. 1988. Subclinical ketosis in dairy cows. *Veterinary Clinics of North America: Food Animal Practice*, 4(2): 233–251. https://doi.org/10.1016/S0749-0720(15)31046-X

[22] Verdonk, J.M.A.J., Shim, S.B., van Leeuwen, P., Verstegen, M.W.A. 2005. Application of inulin-type fructans in animal feed and pet food. *British Journal of Nutrition*. 93(S1):S125-S138. https://doi.org/10.1079/BJN20041355

[23] Leone, F. & Ferrante, V. 2023. Effects of prebiotics and precision biotics on performance, animal welfare and environmental impact. A review. *Science of The Total Environment.* 901. https://doi.org/10.1016/j.scitotenv.2023.165951

18. Postbiotics are bioactive substances derived from the metabolic processes of beneficial microbes. Given to swine, poultry and ruminants, these products improve gut health, resulting in increased animal productivity and resilience to infectious diseases.[25]

19. The production of probiotics and postbiotics requires advanced technical knowledge, and regular control measures are needed to monitor any undesirable contamination of the fermentation broth used in the production process.

20. Organic acids build a first barrier against pH-sensitive bacteria. Lowering the pH in crops and in the stomachs of monogastric animals reduces the transfer of undesirable bacteria such as *E. coli*, *Salmonella* spp. and other enteropathogenic bacteria in the intestinal tracts.[26] In veal calves, acidified milk prepared using formic acid improves gastrointestinal health.[27] Commercial products are generally blends of different organic acids to ensure that under variable pH conditions, an optimal balance between dissociated (pH-lowering) and non-dissociated (direct antimicrobial) effects are achieved. Medium chain fatty acids exert beneficial effects on the intestinal microbiome by increasing microbial diversity. They exert an antimicrobial activity by direct disturbance of the bacterial cell wall, and there is a clear synergetic effect when combined with short chain fatty acids. Long chain fatty acids serve as energy sources, but also have well-recognised anti-inflammatory and immunostimulatory properties. It has been reported that the pH-lowering effect of acids on feed undergoing digestion in the first few hours after ingestion supports the barrier function in the foregut and helps prevent colonization of the gastrointestinal tract by pathogens.[28]

21. Enzymes, such as phytases, non-starch polysaccharides, proteases and mycotoxin-degrading enzymes, improve feed digestibility and safety and are valuable ingredients in advanced feeding practices. Live yeasts and buffering agents are the most commonly used feed additives in dairy cattle nutrition.[29] Normally the enzymes are not considered as typical replacements for AGPs. However, through improvement of gut health, they contribute to animal health and the overall resilience of animals to diseases. This was shown in pigs, where the supplementation of phytase and non-starch polysaccharide degrading enzymes improved the gut health of pigs by modulating the intestinal morphology and microbiota.[30]

22. The use of medicinal plants and ethnoveterinary medicine has a long tradition and recognition in all geographic regions. The list of medicinal plants used for therapeutic purposes varies, depending on the local flora and geographic and climatic conditions. Traditional remedies may consist of fresh or dried leaves, whole plants, fruits, roots, barks and flowers or extracts thereof, including water and alcohol

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[24] Mountzouris, K.C., Balaskas, C. Xanthakos, I., Tzivinikou, A. & Fegeros, K. 2009. Effects of a multi-species probiotic on biomarkers of competitive exclusion efficacy in broilers challenged with *Salmonella enteritidis*. *British Poultry Science*, *50*(4), 467-478. https://doi.org/10.1080/00071660903110935

[25] Zhong, Y., Wang, S., Di, H., Deng, Z., Liu, J. & Wang, H. 2022. Gut health benefit and application of postbiotics in animal production. *Journal of Animal Science and Biotechnology, 13(38).* https://doi.org/10.1186/s40104-022-00688-1

[26] Suiryanrayna, M.V. & Ramana. J. 2015. A review of the effects of dietary organic acids fed to swine. *Journal of Animal Science and Biotechnology, 6(45)*. https://doi.org/10.1186/s40104-015-0042-z

[27] Todd, C.G., Leslie, K.E., Millman, S.T., Bielmann, V., Anderson, N.G., Sargeant, J.M. & De Vries, T.J. 2017. Clinical trials on the effects of a free-access acidified milk replacer feeding program on the health and growth of dairy replacement heifers and veal calves. *Journal of Dairy Science*, 100:713-725 https://doi.org/10.3168/jds.2016-11401

[28] Hansen, C.F., Riis, A.L., Bresson, S., Højbjerg, O. & Jensen, B.B. 2007. Feeding organic acids enhances the barrier function against pathogenic bacteria of the piglet stomach. *Livestock Science*, 108(1–3): 206–209. https://doi.org/10.1016/j.livsci.2007.01.059

[29] FAO. 2021. *Animal nutrition strategies and options to reduce the use of antimicrobials in animal production.* Rome. https://openknowledge.fao.org/handle/20.500.14283/cb5524en

[30] Liu, F., Li, J., Ni, H., Azad, M.A.K., Mo, K. & Yin, Y. 2023. The effects of phytase and non-starch polysaccharide-hydrolyzing enzymes on trace element deposition, intestinal morphology, and cecal microbiota of growing–finishing pigs. *Animals, 13(4):549*. https://doi.org/10.3390/ani13040549

extracts of non-water-soluble organic compounds, like essential oils. With the increasing concerns about AMR, many traditional remedies are currently being re-evaluated and their value increasingly recognized. For instance, several research studies and publications address traditional Chinese medicine, traditional Indian medicine (Ayurveda) and traditional European medicine while numerous other collections of ethnoveterinary medicine from other continents and regions exist in dedicated publications and in orally-transmitted knowledge.[31] The anti-inflammatory and/or antioxidant effects of phytogenic feed additives, also denoted as phytobiotics, result in improved animal health and performance.[32] Administration of some of these compounds at a relatively low dose has been shown to produce significant changes in mucosal immunity in *in vivo* pig rearing trials.[33]

V. Requirements for the adoption of specific feeding practices and use of feed additives

23. Despite increasing scientific evidence and support for advanced feeding practices allowing an effective replacement of AGPs and the overall reduction of antimicrobials in livestock systems, additional efforts in knowledge dissemination and adaptation of these practices to the needs of a wide range of production systems are required.

24. Most feed ingredients and additives that improve gut health have a history of safe use and are generally recognized as safe (GRAS). Nevertheless, it is recommended to develop science-based internationally agreed standards for licensing and evaluating the safety and efficacy of such compounds.

25. Locally available feed ingredients and traditional remedies based on herbal products should be integrated into feeding strategies. Also, for such traditional products and other phytogenic feed additives, minimum requirements regarding their standardization, safety and efficacy in target animal species should be defined.

26. As the improvement of gut health is one of the main targets for many feed additives replacing AGPs, standardized testing protocols, including quantifiable markers of gut health, should be developed to assist and predict the outcome on feed utilization, animal performance and resilience to physiological and environmental stressors and infectious diseases of such health-promoting products.

27. For feed additives, competent authorities should be encouraged to establish good manufacturing practices and quality control measures to also ensure the safety of products for the target animals, the animal source food, the feed operators and the environment.

[31] Goyal, S., Thirumal, D., Algin Yapar, E., Soenmez Gurer, E., Kumar, A., Babu, M.A. & Sindhu, R.K. 2023. Asian veterinary medicines: From the past to the future. *Journal of Research in Pharmacy*, 27(4): 1313-1328 https://doi.org/10.29228/jrp.419

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