Additives for animal feeding: The Institute of Animal Science on its 50 years

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This review is aimed at offering information on the main research studies developed during 50 years by the Institute of Animal Science of the Republic of Cuba on the subject of the use of additives in animal feeding. Aspects dealing with nutritional and animal additives used in monogastric and ruminant animals are also envisaged.

Key words: *monogastric, ruminants, nutritional additives, animal additives, animal production*

INTRODUCTION

For decades additives have been used in animal production due to the beneficial effects caused on physiological, productive and health indicators. In this way, costs can be reduced and the efficiency of the productive systems are increased. It is admitted by the scientific community that the most accepted definition of the term additives for animal feeding is that issued in the Regulations (EC) No. 1831/2003 of the European Parliament and the Council referring that they are substances, microorganisms and different preparations of the raw matters for feeds and premixes added intentionally to the feeds or to the water for realizing, predominantly, one or various functions. According to these functions, additives are classified as technological, organoleptic, nutritional, animal and coccidiostatic and histomonostatic.

The extraction, characterization and evaluation of additives in animal feeding are one the main fields of work of the Institute of Animal Science of the Republic of Cuba (ICA) since its foundation in 1965. The majority of these studies are related to nutritional and animal additives and their results are presented in this review.

MAIN TYPES OF ADDITIVES STUDIED

The first studies with additives developed by the Institute were related to the search and evaluation of substances influencing positively on the characteristics of the feeds or non-conventional feeds; fulfillment of the feeding requirements of the animals influencing positively on production, activity and welfare of the animals, especially acting on the gastrointestinal biota or the digestibility of the feeds. Some of the most relevant works are mentioned in table 1.

The use of diverse antibiotics and antimicrobial products as animal growth promoters turned into a common practice after its discovering in the forties. However, its continuous and indiscriminate use created serious problems of microbial resistance and intensified the appearance of residual effects in the foods for human consumption. For that reason, the World Health Organization (WHO) recommended in 2000 that the use of antibiotics must cease as animal growth promoters (AGP), aspects which were considered in the review of Castro (2005) on the occasion of the 40th anniversary of ICA. In view of this problematic and the prohibition in 2006 by the European Community of the use of AGP, the scientific community showed more interest in the study, evaluation and introduction of other nutritional

Table 1. Studies carried out with additives at ICA during the period 1967-2000

Sources	Additives	Referencies
Conventional feeds	Selenium, vitamin E, zeolite	Castro y Elías (1978 a, b)
	Formaldehyde and sodium sulfite	Castro *et al.* (1979) y Brito y Álvarez (1982)
Silage of pasture and forage and integral meal	Molasses, mineral salts and urea	Domínguez y Elías (1981)
	Organic acids	Michelena y Molina (1987 a,b)
	Urea, salts and zeolite	Molina *et al.* (1997 y 1999)
Saccharines	Mineral salts and urea	Elías *et al.* (1990) y Elías y Lezcano (1994)
Poultry litter	Zeolite	Lon-Wo y Rodríguez (1986)

and animal additives as alternatives to these AGP that show nutraceutic properties.

Among the most studied and used additives are the probiotics, prebiotic, fitobiotics, acidifiers, enzymes, minerals and microbial activators of ruminal fermentation. In table 2 are shown some the products studied at ICA. The use of these additives has great repercussion for the national and international livestock production development. Therefore, presently continues to be main objective of the scientific studies of the center.

Table 2. Examples of experiments carried out with additives at ICA in the period 2000-2014

Additives	Type	References
Probiotics	*Lactobacillus rhamnosus* *Bacillus subtilis* *Wickerhamomyces anomalus*	Bocourt *et al.* (2004 a,b) Ayala *et al.* (2012) García-Hernández *et al.* (2012 y 2014)
Prebiotics	Inulin Fructanes of *Agave fourcroydes*	García-Curbelo *et al.* (2007b) García-Curbelo *et al.* (2009)
Phytobiotics	Oregano	Ayala *et al.* (2006 y 2011)
Acidifiers	Vinasse	Hidalgo *et al.* (2009)
Enzymes	β-manase Cellulass y xylanase Phytase	Lon-Wo *et al.* (2000) Lon-Wo *et al.* (2002) Acosta *et al.* (2006, 2007a y 2008)
Minerals	Zeolite Bentonite	Reyes *et al.* (2003) Gutiérrez *et al.* (2004)
Additives activators of the ruminal fermentation	Polyethylenglicol Sulfonic bromoethane acid *Saccharomyces cerevisiae* Vitafert	La O *et al.* (2001) González *et al*. (2006) Marrero *et al.* (2010) Elías (2014)

RESULTS IN MONOGASTRIC ANIMALS

The additives before mentioned were mainly evaluated in poultry and pigs as monogastric species of greater economic interest. Zeolite due to its properties is one of the products most evaluated as additive or concentrate replacer. These investigations were developed by Castro and other authors during the 50 years of scientific work of ICA. Main results of the evaluation of this mineral are related to its hydration-dehydration, adsorption and cationic interchange capacity (Castro 2005). Therefore, its use makes feasible the improvement of the efficiency utilization of nutrients of conventional and non-conventional feeds and consequently, the increase of the animal growth rate, as well as the control of enteric problems and undesirable smells in the productive facilities and reduction of the environmental contaminants (Lon-Wo and Rodríguez 1986, Castro and Lon-Wo 1991 and Castro 2005).

The beneficial effects of the use of enzymes in the diets of monogastric animals with appreciable contents of non-amylaceous polysaccharides are widely recognized. Studies of Lon-Wo *et al.* (2000 and 2002), Acosta *et al.* (2006, 2007a and 2008) and Martínez *et al.* (2009) confirmed that the utilization of enzymatic products (β-mannases, cellulases, xylanases and phytases) in conventional and alternative diets for poultry and pigs improve the efficiency of utilization of the feed nutrients, reduce anti-nutritional factors, do not provoke disorders in the productive performance, reduce phosphorus and nitrogen excretion by their retention increase and, thus, contribute to the reduction of environmental pollution, as well as produce economic advantages.

Probiotics are other of the most evaluated additives by ICA's researchers, mainly, in the last 10 years. Results corroborated that the biological response of the animals (poultry and pigs), when these additives are included in the diet, depends on factors such as the strain, species and genus of the microorganism or microorganisms employed, category or animal species, age and physiological state of the animals and experimental conditions. In a general way, the effects found in the works of Bocourt *et al.* (2004 a,b), Acosta *et al.* (2007b), García-Curbelo *et al.* (2007a), Ayala *et al.* (2008 and 2012) and García-Hernández *et al.* (2014) showed morphophysiological changes, immunomodulatory response, health improvement and productive performance of broilers, pigs and other animals.

Studies with prebiotics, phytobiotics and acidifiers have received less attention. There is experience on the use of inulin as energy source by probiotic microorganisms, though its combined use would increase the intestinal survival of the beneficial bacteria with

positive effects on the animals (García-Curbelo *et al.* 2007b). Also different sources of obtaining fructanes were investigated. The stems of *Agave fourcroydes* (henequen) were the most promissory for its use as prebiotic additive in animal feeding (Garcìa-Curbelo *et al.* 2009).

Regarding the phytobiotics, the oregano was evaluated in broilers and rabbits. Ayala *et al.* (2006) included the additive in diets for broilers and obtained biological and economical benefits. In another study, Ayala *et al.* (2011) supplied vulgar oregano (*Origanum vulgare*) dried at two temperatures (25 and 60 ºC) in diets for rabbits of the White New Zealand breed and found increases in feed consumption and live weight gain, as well as improvements in feed conversion in favor of the oregano dried at 60 ºC.

Hidalgo *et al*. (2009) studied the inclusion of distillery's concentrated vinasse in broilers. These authors observed that the additive can optimize the use of nutrients in the diet guaranteeing better productive performance, which was reflected on live weight increase of the animals and improvements in feed conversion and higher meat yields.

RESULTS IN RUMINANT ANIMALS

García-López *et al.* (1988 and 2001) and Reyes *et al.* (2003) assessed the zeolite as mineral additive in the concentrate of Holstein cows. These experiments showed that a good nutriment balance in the ration and the inclusion of this additive has a beneficial effect on milk quality, health status and reproductive performance of the animals.

In 2005, Galindo and Marrero made a full compilation of the main investigations carried out at ICA since its creation, related to the topic manipulation of ruminal fermentation through the use of additives in the diet. These authors highlight the use of Nitrogenous Activators Supplements (NAS) (Muñoz *et al.* 1987); chemical substances (carbonates, bicarbonates and sodium, potassium, calcium and magnesium phosphates) used as pH buffers for attaining an effective microbial activity (Marrero *et al.* 1987 and Galindo *et al.* 1990); mineral as zeolite and sodic bentonite (Galindo 1988); ionosphere antibiotics as the monnensin (Galindo *et al.* 2004); organic acids as the malic acid and the fumaric; secondary metabolites of plants with defauning effects: polyphenols, condensed tannins and saponins (Galindo *et al.* 2001 and Galindo *et al.* 2004).

Vitafert and the Jordan Granulated are other of the products evaluated as activators of ruminal fermentation (Jordán 2001 and Elías 2014). Gutiérrez *et al.* (2012) included the Vitafert as additive in goats fed poor quality hay of *Brachiaria brizantha* finding and increase of the fermentative capacity of the rumen in correspondence with the increase of the SCFA concentrations and production of bacterial biomass. Jordán *et al.* (2005) applied the granulate to yearlings of the Zebu breed attaining high live weight gains for the stocking rates used during the pasture abundance period, due to an improvement of the ruminal efficiency when fibrous diets are employed.

In the last decades great acceptance has been given to the extraction and use of viable microorganisms for improving the health and productivity of ruminants. The yeast and fungi of *Saccharomyces cerevisiae* and *Aspergillus oryzae* species, respectively, have been defined as the most promissory for these ends. Studies carried out by Marrero *et al.* (2006) demonstrated that the addition of a strain of *S. cerevisiae* favors the development of total viable and cellulolytic bacteria and increase the concentration of short chain fatty acids. Also, Sosa *et al.* (2010) found stimulation of ruminal fermentation of *Pennisetum purpureum* cv. Cuba CT-115 on adding an Aspegillus oryzae strain.

Ruminal methanogenesis is a subject of interest in scientific investigations, since methane emission is an ecological problem and also represents great loss of the feed energy and decreases animal productivity (Anderson *et al.* 2003). Thus, different scientific studies at the Institute of Animal Science were aimed at searching for the influence of the use of additives on ruminal methanogenesis. González *et al.* (2006) found inhibition of methane production when bromoethasulfonic acid (BES) was employed, but did not find alteration in the methanogenic populations, or in those participating in fiber degradation. BES effect seems to be more related to the mechanisms and metabolic processes carried out by the microorganisms intervening in methane formation. Galindo *et al.* (2010) assessed the effect of different yeasts and demonstrated that *Saccharomyces cerevisiae* and LEVICA-25 reduce the methanogens and ruminal methanogenesis. This offers the possibility of using them for improving the efficiency of utilization of ruminant energy that could contribute to mitigate the impact of these gases to the environment.

FINAL CONSIDERATIONS

From the scientific work of the Institute of Animal Science during its 50 years of experience it is evidenced that the subject of extraction and evaluation of additives in animal production is widely tackled. This line of work has been in correspondence with national regulations and their subsequent modifications, as well as the guidelines and objectives of the country. The above mentioned demonstrates the importance and validity of the investigations developed for attaining, mainly, improvements in animal health and productive increases. Even though results show progress, it is necessary to prepare future research strategies for increasing knowledge on this subject.

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