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Development and use of Vitafert in the agricultural sector

Desarrollo y utilización del Vitafert en el sector agropecuario

Elaine C. Valiño Cabrera[1]*, Yaneisy García Hernández[1], Daymara Bustamante García[1], A. Beruvides Rodríguez[2]

[1]*Instituto de Ciencia Animal, C. Central, km 47 ½, San José de las Lajas, Mayabeque, Cuba*
[2]*Universidad de Matanzas Camilo Cienfuegos, Vía Blanca, km 3 ½, Matanzas, Cuba*

**Email: elainevalino@gmail.com*

At Instituto de Ciencia Animal (Cuba), an additive called Vitafert was obtained, with probiotic activity, for animal production. This review mainly deals with the aspects related to the process for the development of this zootechnical additive, which includes microbial inoculants, percentages of raw matters used, the production process, technological variants and its use in the agricultural sector. Information about the progress made with this zootechnical additive is also collected, with positive effects on physiological, immunological, health and production indicators of different species of economic interest. Due to its importance, it is proposed to continue the researchers carried out with Vitafert, with the aim of improving its production and optimization process, as well as the mechanisms of action that generate beneficial responses in animals, based on advanced technologies in health and nutrition.

Key words: *animals (Source CAB), fermentation, microbial additive*

En el Instituto de Ciencia Animal (Cuba) se obtuvo un aditivo denominado Vitafert, con actividad probiótica, destinado a la producción animal. Esta reseña aborda, fundamentalmente, los aspectos relacionados con el proceso para el desarrollo de este aditivo zootécnico, que incluye inóculos microbianos, porcentajes de las materias primas utilizadas, proceso de obtención, variantes tecnológicas y su utilización en el sector agropecuario. Se recopila, además, información acerca de los avances alcanzados con este aditivo zootécnico, con efectos positivos en indicadores fisiológicos, inmunológicos, sanitarios y productivos de diferentes especies de interés económico. Por su importancia, se propone continuar las investigaciones realizadas con Vitafert, con el propósito de mejorar su proceso de obtención y optimización, así como los mecanismos de acción que generan las respuestas benéficas en los animales, basadas en las tecnologías de avanzada en la salud y la nutrición.

Palabras clave: *aditivo microbiano, animales (Fuente CAB), fermentación*

Introduction

The International Organization for Epizootics, the World Organization of the United Nations for Feeding and Agriculture and the World Health Organization are working to introduce new products and technologies into animal production systems to obtain healthy foods, which will allow for high productions with adequate economic sustainability and biological guarantee, in order to protect animals and humans. Among these products, in the category of zootechnical additives, microbial additives highlighted, which represent a potentially significant and safe alternative (Barba-Vidal *et al.* 2019 and Pandey *et al.* 2019).

Microbial additives are products that do not cause problems of microbial resistance or the residual effects produced by antimicrobials when they are used as animal growth promoters, indiscriminately and for a long time. These additives are mainly made from lactic bacteria, *Bacillus*, fungi and yeasts, which contribute to maintaining a favorable ecological balance in the gastrointestinal tract and the proper functioning of the immune system (Quach *et al.* 2021, Konieczka *et al.* 2023 and Rasaei *et al.* 2023).

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Also, they can exert specific activity or multifunctional effects, which through different mechanisms manage to improve the productive and health indicators of animals (Al-Shawi *et al.* 2020, Lambo *et al.* 2021, Sun *et al*. 2021 and Crespo-Piazuelo *et al.* 2022).

In Cuba, at the end of the 1990s, the Instituto de Ciencia Animal (ICA) developed a microbial preparation called Vitafert, composed of lactic acid bacteria, yeasts, organic acids and other metabolites. A large number of researchers describe its use as a zootechnical additive and show its ability to control the development of enterobacteria, reduce the incidence of diarrhea, increase live weight gain and increase energy and nitrogen retention in different species of productive animals (García *et al.* 2008, Bustamante *et al*. 2016, Savón *et al.* 2020 and Beruvides *et al.* 2021). In addition, technological variants were used which were differed in the form of presentation, the inoculum and raw materials used in their preparation (Bustamante *et al.* 2016 and Beruvides *et al*. 2021). This review mainly deals with the aspects related to the process for the development of this additive, which includes microbial inoculants, percentages of raw matters used, the production process, technological variants and its use in the agricultural sector.

Obtaining and characterization of Vitafert and its technological variants

In the available scientific literature, different formulations are described for obtaining the additive, adapted to the availability of raw matters and existing conditions in each region or locality of Cuba or in other countries where it was applied (López 2010, 2012 and Ruiz 2014). The production process is simple and does not require specialized infrastructure to produce small volumes, which offers economic advantages and facilitates its preparation under rustic and sustainable production conditions in its two forms of presentation, liquid and solid (Bustamante *et al.* 2016 and Beruvides *et al.* 2021).

In general, it is obtained through a discontinuous fermentation process, for 48 hours and at room temperature (28 ±2 ºC), of a mixture of easily fermented carbohydrates (sugar cane molasses, sugar cane juice, whey and raw sugar), energy meals (corn meal and wheat meal), a source of vegetable protein (soybean cake meal), a source of non-protein nitrogen, such as urea and mineral salts. This additive involves the addition of an inoculum of fresh excrement, ruminal content or lactic bacteria from yogurt.

Qualitative and quantitative composition

Vitafert liquid additive: It is made up of raw matters (inert ingredients) corn meal (4 %), soybean meal (4 %), urea (0.5 %), magnesium sulfate (0.25 %), mineral premixture (0.5 %). The composition of the premix per kg of product is described as follows: vit. A 10 000 IU, vit. D3 2 000 IU, vit. E 10 mg, vit. K 2 mg, thiamine 1 mg, riboflavin 5 mg, pyridoxine 2 mg, vit. B12 15.4 µg, nicotinic acid 125 mg, calcium pantothenate 10 mg, folic acid 0.25 mg, biotin 0.02 mg, selenium 0.1 mg, iron 40 mg, copper 12 mg, zinc 120 mg, magnesium 100 mg, iodine 2.5 mg, cobalt 0.75 mg) and final sugar cane molasses (10 %) or raw sugar (15 %). Microbial and lactic acid bacteria (LAB) sources are inoculated at 1 % (active ingredients). They are stable for 90 days or more.

The fermentation process lasts 48 hours at room temperature (26 ± 2ºC). Under production conditions, it can be extended up to 96 hours. The liquid presentation is acidic (pH, 3.5-4.0), reddish brown in color and has a pleasant smell.

Dry Fermented Vitafert Additive: The dry fermented Vitafert additive is made from the mentioned product (it contains the active and inert ingredients). Corn meal (new inert ingredient) is added to liquid VITAFERT in a 1:1 (w/v) ratio. This starchy source used as an absorbent support has the following chemical composition: dry matter (DM) 88.28 % and crude protein (CP) 8.4 %. Drying is carried out by direct exposure to the sun for 72 h. The average maximum temperature and relative humidity values are 27.3 °C and 76.0 %, respectively. Dry Vitafert has a particle size of 1 mm. The presentation of the solid Vitafert additive is golden meal, sweet smell, according to the formulation used in the production of the liquid VITAFER additive, as part of the mixture with corn meal.

The safe and harmless effect of this product was proven in monogastric animals, ruminants and small ruminants.

Use of Vitafert in the agricultural sector

The first publication about Vitafert was made by Díaz *et al.* (1996) based on scientific reports from Instituto de Ciencia Animal, which stated that it is a solid product, made from aerobic fermentation in an open-air dish of a mixture of ground sugar cane and fresh chicken manure, with the addition of urea and a premixture of minerals in a process similar to the obtaining of Saccharina (Elías *et al.* 1990). In addition, at the laboratory level, it was reported that the results with this product showed the presence of a high content of antibodies, vitamins and other nutrients of importance for the pre-fattening category of pigs. The protein content of the product makes it comparable in composition to corn meal, although its level of crude fiber is much higher, as well as that of ash and non-protein nitrogen. The work highlighted that during the fermentation process colibacilli disappear and lactobacilli, streptococci and yeasts predominate. This product, as a substitute for cereals in the diet of pre-fattening pigs, starting at 10 kg of live weight, had no effect on daily gain, final weight and total conversion. However, its inclusion at 10 and 20 % improved the conversion of traditional products with a favorable economic impact.

González and Enríquez (1997) reported the effect of a new food, called liquid Vitafert (Elías 1995, unpublished) on the nutritional value of a ration for ruminants, based on star grass hay (*Cynodon nlemfuensis*). This new food was obtained by liquid fermentation from the final sugar cane molasses. Valdivié *et al.* (1997) compiled researchers on new variants of Saccharinas, from combinations of sugar cane with other substrates. Among these variants, "Sacchasoyamaíz" inoculated was presented, a product made from a primary substrate of ground corn (30 %), ground soybean cake (5 %), ground cane (63 %), urea (1.5 %) and mineral salts (0.5 %), to which after mixing 10 % of Vitafert MN was added (primary name due to the addition of a mixture of minerals) as an inoculants, components that were dried and fermented, according to the rustic technology of Saccharina. Also, Elías *et al.* (2001 and 2009), Valdivié and Elías (2006) and Díaz (2010) referred to Vitafert MN as an inoculum to generate other variants of Saccharina.

After the year 2000, a large number of researchers were carried out with Vitafert and its variants, all with the principle or line to produce and apply efficient biologically activated microorganisms (MEBA) (Elías and Herrera 2015).

García *et al.* (2008) carried out the first studies on the dynamics of fermentation of excreta from broilers and laying hens, the main microbial inoculants for obtaining Vitafert, the first variant used. These researchers mainly focused on the proposal to improve the quality of the additive and the benefit of the products derived from mixed fermentation, such as lactic acid and other organic acids. These fermentation processes potentially eliminated pathogenic microorganisms. Regardless of the obtained results, poultry manure was no longer used in Cuba as inoculum for reasons of biological safety.

In their research, Díaz *et al.* (2014) isolated and characterized strains of lactic acid bacteria from native microbial preparations, made from agro-industrial wastes (whey, bovine manure and ruminal content), designed as biological inoculants for post-harvest organic waste silage processes. These authors proposed that other crop wastes could be studied with these inoculants.

Table 1 summarizes the most significant elements of different studies on Vitafert, in which chicken manure, bovine excrement, whey, rumen content were used as inoculum and final molasses as an energy source. Their effects on biological activity are also described.

The introduction of natural yogurt to obtain Vitafert gave the zootechnical additive a high concentration of metabolites during fermentation, due to its content of lactic acid bacteria. This formulation was obtained as a safer alternative to previous biological inoculants. Table 2 shows the different researchers carried out with Vitafert, made with yogurt as inoculum, in ruminant and monogastric animals, obtained not only under laboratory conditions but also under production conditions.

The production of Vitafert using sugar cane molasses as an energy source in the fermentation process showed difficulties due to its limited availability and the quantities needed to be used under production conditions. Hence, its replacement in the formulation with raw sugar not suitable for human consumption was evaluated. The new variant was produced under production conditions and its effect as an additive was proven to make it accessible to medium and small pig producers in Cuba, mainly (table 3).

Table 1. Researchers carried out with Vitafert made with final sugar cane molasses and different microbial inoculants

Microbial inoculum	Purpose of the research	Results	References
Fresh poultry manure	Evaluation of the inoculum applied by spraying on coffee husk beds and poultry manure. Supplementation of grazing Pelibuey sheep with beds inoculated with Vitafert.	• Reduction of enteropathogenic organisms in beds and poultry excrement. • Increase of the productive indicators in the cycle of laying hens and their replacements. • Improvement of the productive indicators of growing and fattening sheep, by applying 20 g of inoculated bed/kg of live weight of the animal supplemented with final sugar cane molasses to guarantee energy requirements.	Calderón *et al.* (2005)
Bovine manure, fresh whey or ruminal content	Obtaining microbial consortia with lactic acid activity for silages.	• Fresh whey was the best inoculum for microbial preparations. • A low-cost, high biological value silage product was obtained, with the capacity to stimulate production and improve the quality of milk in cows.	Díaz *et al*. (2014)
Ruminal content	Supplementation of broilers with a dry Vitafert.	• It improved the health and histological indicators of the animals that intake it at 3 %.	Savón *et al*. (2020)

Table 2. Results of researchers carried out with Vitafert, made with yogurt as inoculum in ruminant and monogastric animals

Purpose of the research	Results	References
• Evaluation of Vitafert on intake, feeding behaviour, ruminal fermentation and *in situ* degradation of DM and NDF in goats fed with *Brachiaria brizantha* hay. • Evaluation of the best dose in a stable system under production conditions, its effect on DM intake, feed efficiency, production and chemical composition of milk.	• With the addition of 6 mL/kg of live weight (best dose), an increase was achieved in the voluntary intake of DM and total NDF and in its positive relation with live and metabolic weight under controlled and production conditions. • Increase of ingestion and rumination. • Increased fermentation capacity of the goat rumen. • Reduction of the colonization time of the neutral detergent fiber and increase of the degradation rate and effective degradability of the DM and NDF • Productive and economic advantages in relation to gross profitability per goat and increase of milk quality.	Gutiérrez *et al.* (2012)
Inclusion of the microbial additive Vitafert in the *in vitro* ruminal fermentation of a diet for goats.	• The inclusion of Vitafert did not affect gas production or the kinetic parameters of diet fermentation. • The degradability of DM and neutral detergent fiber was increased with 4.5 mL of the additive/kg of animal live weight. • Microbial biomass production and synthesis efficiency was improved with 8.5 mL/kg of live weight.	Rodríguez *et al.* (2013)
Evaluation of the MUSS-LACTIBIOL supplement (Vitafert variant) in beef production.	• Average daily gain increased (higher than 1000 g in bull fattening). • Vitafert variant dose of 1.37 kg/d per animal.	Castellón *et al.* (2014)
Evaluation of the inclusion of Vitafert as a microbial additive in the behavior and health of growing pigs	• Live weight, average daily gain, feed conversion and viability of animals supplemented with Vitafert (10 mL/kg of live weight) were increased. • Morbidity, mortality and lethality due to diarrheal episodes were reduced • Lower risk of death in pigs that intake it, which represents lower economic loss due to death.	Lazo-Pérez *et al.* (2017)
Effect of beneficial microorganisms activated in the finishing of bulls in silvopastoral system with leucaena, supplemented with sugar cane.	• The use of the biological product Vitafert® (vtf) generated a contrasting productive effect on average daily gain, weight increase and yield per hectare. The intake of sugar cane was also encouraged.	Iraola *et al.* (2017)
Biological response in broiler that intake 2 % of Vitafert + corn meal (1:1), sun-dried and a diet with *Moringa oleifera* foliage meal, Supergenius variety (10 %)	• The apparent ileal digestibility of amino acids was increased and the productive performance and meat yield of chickens were improved.	Bustamante *et al.* (2021)

In the previous researchers has shown that Vitafert positively influences on the physiology and productive performance of animals. Effects that were attributed, mainly, to the presence of beneficial microorganisms with probiotic activity, proven in birds, pigs, calves and to its content of organic acids with antimicrobial action and modulation of the immune system. Likewise, other studies showed that Vitafert stimulated the fermentation process and increased the nutritional value of grasses, foliages, forages, fruits, legumes and protein plants, crop residues or mixtures of these sources, as a starter culture (table 4).

Final considerations

In most of the researchers, where Vitafert was applied in its different formulations and technological variants, improvements were obtained in the indicators evaluated in the animals that intake it or in the quality of the plant materials where it was applied. The microorganisms present in Vitafert and its metabolites are considered to have been able to promote the absorption of nutrients, strengthen the barrier function of the intestinal mucosa, improve the balance of the intestinal microbiota, promote the growth of beneficial microorganisms, inhibit the growth of pathogens and modulate immunity. However, the effectiveness of the zootechnical additive depended on its chemical and microbiological composition, the dose, mode and frequency of application, as well as the species or category of animal that intake it.

Due to its importance, it is proposed to continue the researchers carried out with the Vitafert additive to improve the process of obtaining and optimizing it, in addition to its mechanism of action that generates beneficial responses in animals, based on advanced technologies in health and nutrition.

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Table 3. Researchers carried out with Vitafert, made with raw sugar and yogurt, in breeding sows, pre-fattening and piglets

Purpose of the reseacher	Results	References
Evaluation of different levels of Vitafert in growing and fattening pigs.	• With the use of Vitafert in the feeding of growing-fattening pigs, with inclusion levels of 5, 10, 15 mL/kg of live weight, improvements in productive performance and health were obtained.	Vitaluña (2014)
Evaluation of the zootechnical additive Vitafert in the productive performance and health of pre-fattening piglets.	• The weaning-estrus interval was shortened and the weight loss of the breeder during lactation was reduced	Beruvides *et al*. (2018)
Effect of the zootechnical additive Vitafert on the biological response of piglets.	• Improvements in the digestive physiology of breeding and pre-fattening pig categories were achieved under production conditions	Beruvides *et al.* (2020)
Evaluation of productive and health response in pigs using the Vitafert additive. Chemical and microbiological characterization.	• A positive effect on the performance of microbiological, hematological, immunological, and productive and health indicators was obtained, under intensive production conditions.	Beruvides *et al.* (2021)
Productive and health performance in suckling piglets, supplemented with sugar, fermented with yogurt	• Growth rate, feed efficiency and reduction of intestinal infections were favored	Beruvides *et al.* (2023)

Table 4. Researchers carried out with Vitafert as an inoculum in fermentation processes of agricultural products and wastes

Purpose of the research	Results	References
Obtaining a food, fermented in a solid state from the returned bagasse, polished rice and inoculants.	• The inclusion of rice polishing + Vitafert at 5 % increased the TP to 11.1 %. • The NDF decreased to 57.4 % and pH values ranged from 3.85 to 4.67. • Lactic acid production was high and VFA performance ranged from 2.8 to 6 % and 9.6 to 33 mg 100g of DM^{-1}. • The results suggest that returned bagasse can be used as a nutritious food for cattle.	Cárdenas *et al.* (2008)
Inclusion of Vitafert as an inoculum in the solid fermentation of breadfruit meal for diets of pre-fattening pigs.	• The chemical composition of the fermented food was improved with the inclusion of 5 % Vitafert.	Brea *et al*. (2014)
Evaluation of the chemical composition and ruminal degradability of DM from silage mixtures of *Tithonia diversifolia*: *Pennisetum purpureum* cv. Cuba CT-169, inoculated with Vitafert.	• Crude protein and ash content were increased and NDF was reduced in all inoculated silages. • The best results were obtained with the inclusion of 4.5 and 6.0 % of Vitafert. • The 20:80 combination of *Tithonia:Pennisetum* with 4.5 % of the additive achieved the highest degradability in the shortest time, highest degradation rate and effective degradability.	Gutiérrez *et al.* (2014)
Inclusion of Vitafert in the nutritional value of *Tithonia diversifolia* and *Pennisetum purpureum* silages.	• The chemical composition of silages was improved with 4.5 and 6.0 % of Vitafert. • The best indicators of *in vitro* fermentation of mixed silages were obtained with 60 % *T. diversifolia* and 8.0 % Vitafert.	Morales *et al*. (2016)
Obtaining an inoculant that enhances solid fermentation from postharvest wastes of *Solanum tuberosum*	• The microbial preparation with lactic acid bacteria favored the fermentation process of potato harvest wastes.	Borrás *et al.* (2017, 2020 a, b; 2021)
Evaluation of the nutritional value of mixed silages of *Cenchrus purpureus* cv. Cuba CT-169 and *Moringa oleifera* with the inclusion of 1 % Vitafert and *Ipomoea* batata (0, 5, 10 and 15 %)	• Both additives improved the fermentation characteristics of silages by reducing butyric acid levels and increasing propionic acid levels.	Rodríguez *et al*. (2019)

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