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CURRENT STATUS OF FRUIT PRODUCTION IN ECUADOR

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Fruit area in the three regions of Ecuador covers about 163 000 ha (excluding bananas) and involves about 120 000 farmers. Fruit growing in the Coastal region is mainly for exportation (fresh and processed fruit), in the Highlands it is focused in the local market, while in the Amazon, with certain exceptions, are subsistence crops. The current problems for this agricultural sector is the low productivity due to poor management in the pre and post-harvest, limited technological generation, little use of fruit germplasm, lack of organization of producers and production chains, and productive loans (scarce and expensive). In response, the Fruit National Program of INIAP carry out research in different areas such as plant breeding, integrated pest management, crop management, pre and post-harvest management and fruit added value of tropical, Andean and Amazonian fruit. In tropical area, it works primarily with Mango (*Mangifera indica*), citrus, guava, soursop (*Annona muricata*), passion fruit (*Passiflora edulis*) and pineapple (*Ananas comosus*); in the Highlands with cherimoya (*Annona cherimola*) vasconcellas, tree tomato (*Solanum betaceum*), blackberry (*Rubus glaucus*), cape gooseberry (*Physalis peruviana*), avocado (*Persea americana*), peach (*Prunus persica*), and fruit adapted to inter-Andean valleys such as naranjilla (*Solanum quitoense*) and grape (*Vitis vinífera*); in the Amazon with arazá (*Eugenia stipitata*), copoazu (*Theobroma grandiflorum*), borojo (*Borojoa patinoi*), papaya (*Carica papaya*) and naranjilla. Among the research activities can be mentioned the use of Paclobutrazol for faster flowering (40 days) and increasing fruit yield by 50%; morphological and molecular characterization of soursop cultivars; evaluation of improved materials of passion fruit to increase yield (20 t ha-1) and fruit quality; conventional breeding of tree tomato searching for *Colletotrichum acutatum* resistance (disease causing up to 70% losses), use of *Trichoderma* sp. to enhance the development of the blackberry plants, morphological and molecular characterization of avocado cultivars, management of peach production by the use of defoliants (Zinc Sulfate 2%) and sprouting inducers (hydrogenated cyanamide 1%), manual pollination in cherimoya, and control of fruit borer (*Neolucinodes elegantalis*) in naranjilla (pest causing up to 70% losses). Generated technologies will allow designing strategies for integrated fruit production and increasing production by at least 10% of the current yield in the country.

Keywords: fruit, integrated production, pest, quality

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GENERATION OF AGRICULTURAL TECHNOLOGY WITH ADDED VALUE FOR THEIR IMPACT IN ECUADOR

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The Department of Nutrition and Quality of INIAP makes research to characterize the main physical, chemical and functional components on food in the agro-productive chain, increasing added value to fruit and developing technologies for food processing, guaranteeing quality and food safety. With funding from the COTESU (1995-1998), the diagnosis of the pre and postharvest problems on fruit began; maturity index for conservation of peach variety 'Conservero amarillo' was evaluated for 3 years in different growing areas. With funding from PROMSA (2001 -2004), agro-industrial technologies for Andean and tropical fruit for export was developed. ISNAR - IFPRI (2003-2004) innovated in mango processing by validating new technologies. FONTAGRO project (2005-2008) developed technology to improve the postharvest management of exotic fruit for exportation (passion fruit, tree tomato and gooseberry). SENACYT (2007-2008) supported research to determine the use of nutritional and functional potential of some fruits of the Ecuadorian Amazon (arazá , borojó and copoazú). Governmental funds (2007-2010) supported the development of innovative technologies for integrated crop management of naranjilla, improving productivity and fruit quality in the Tropical, Andean and Amazon regions of Ecuador. FONTAGRO (2007-2010) funded the project to competitive producers of naranjilla and blackberry through participatory selection of elite clones, integrated crop management and strengthening value chains. Governmental funds (2008-2013) supported the study to determine optimal conditions for producing arazá clarified juiced through enzymatic processes; the obtaining dehydrated fruit of naranjilla, borojó and copoazú by forced air thermal processes; and the relationship between color and antioxidant content of arazá , blackberry, Andean blueberry, naranjilla, tree tomato and goseberry. GESOREN-GIZ Ecuador (2010-2011) funded studies to improve the postharvest management and marketing of blackberry variety 'Castilla'. With funding from SENESCYT (2011-2013), studies to improve the pre and postharvest management were done in avocado variety 'Fuerte' and 'Hass' from two agro-ecological zones. SENESCYT (2012-2014) funded the study of nutritional characterization, functional assessment and safety of bioactive compounds in Ecuadorian fruit. SENPLADES (2014 to current date) finances the quantification of crop losses in avocado, blackberry and passion fruit.

Keywords: added value, agroindustrial, food, fruit, quality.

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CROP PROTECTION FOR GLOBAL MARKETS: NEW ZEALAND'S STRATEGIES

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New Zealand's horticultural sector exports are valued at more than US$2B per annum. The major apple and kiwifruit sectors export fruit to >65 countries simultaneously meeting many different quarantine, food safety and customer requirements. Strong sector organizations provide leadership and support for research and development that is focused on enhancing access to 'high-value' markets. Food safety, environmental responsibility and sustainability have been key platforms for New Zealand's horticultural export sector since the mid-1990's.

The apple sector adopted Integrated Fruit Production (IFP) in 1996 which maximized the use of biological control by eliminating broad spectrum pesticide use, especially organophosphates. It also introduced crop monitoring, pesticide use recording systems and residue testing combined with traceability of produce, from orchard to export carton. IFP was widely adopted by the apple sector and by 2006 it had reduced insecticide applications by 55% and organophosphate insecticide use by 97%. By 2005 European customer assurance programmes were demanding produce with even lower pesticide use, 50-70% less than the legal residue tolerances and not more than three residues in any one test. The sector responded with development and implementation of an 'ultra-low' residue programme in 2008 setting a goal of industry average residues of ≤10% the legal residue tolerances. Use of relatively persistent pesticides was confined to spring or early summer leaving just biological insecticides and/or non-insecticidal methods (e.g. mating disruption) for control in mid and late summer. This strategy was extremely successful as each year 65-70% of the New Zealand apple crop is exported without any detectable insecticide residues. This programme, known as 'Apple Futures' turned a market threat into an opportunity and added 8% per year to sector revenue. Organic fruit production accounts for about 4% of the export volume in each of the two major fruit crops grown in New Zealand, kiwifruit and apple. Interest in organic apple production developed in the late 1990's when price premiums for organic fruit exceeded 50%. Lepidopteran pest control in organic apple orchards is based on mating disruption whereas the biological insecticide *Bacillus thuringiensis* is primarily used for pest management in organic kiwifruit orchards. With the exception of leaf feeding beetles which can be very damaging in apples, biological control provides acceptable control of most other pests. Black spot is the major disease management that challenges organic production of apples. Lime sulphur and sulphur sprays provide effective control but are phytotoxic and can reduce fruit size and yield by as much as 50% in some varieties. Despite the higher prices margins for organic fruit, expansion of organic apple production in New Zealand is likely to be limited until new disease resistant varieties are developed.

Keywords: integrated fruit production, organic, biological, residues

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STRATEGIES OF BIOLOGICAL CONTROL FOR SUSTAINABLE AGRICULTURE

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Biological control is an integral part of pest management for sustainable agriculture which aims to produce safe, high quality, agricultural products in a way that protects and improves the natural environment. Pests and diseases have their own natural enemies which will limit their number and impact on our crops. Microbes are one component of this complex and entomopathogens and microbial antagonists can be used against pests and diseases. By production and formulation the beneficial microbes can be used to produce biopesticides or bioinoculants for the control of pests and diseases, but their successful use will depend on selection of stable, effective strains of microbes and development of efficient production systems and application strategies based on the characteristics of the pest and the host/pathogen interaction. For pests invading a new environment, inoculation can be sufficient to start an epizootic of disease that will spread naturally through the pest population. In all cases, microbial controls must be economical for the user and amenable to large scale production to provide viable alternatives to chemical pesticides. Production of high density cell cultures is the first step in the product development process, and cells must be robust enough for further processing. After production, cells are formulated for survival in storage and format for application. Liquid concentrates, wettable powders, granules and baits can all be used in biological control. Application methods must take account of the characteristics of the applied agent. Non- spore forming microbes are often susceptible to ultra-violet light or desiccation and have to be applied in a protected formulation or directly to the soil. Farmer/applicator understanding of the characteristics of the microbial agent and its activity will be essential for long-term success. Microbial products are often more susceptible to stresses during handling and application than their chemical counterparts and may not have the same speed of activity. In Ecuador, smallholder farmers growing fruits are confronted by a wide range of pests and diseases and a consumer demand for safe, pesticide free produce. Microbial controls are an option for the growers ranging from fungal colonisers of the soil for control of root pests and diseases to bacterial biopesticides for control of leaf feeding insects. The successful use of microbial agents in biological control will require a strong and effective partnership between researchers, microbial producers and the farmer users. Once biological control systems are established they will underpin maintenance of safe environments and a sustainable agriculture for the future.

Keywords: pest, disease, microbial, formulation, biopesticide, bioinoculant.

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CODEX ALIMENTARIUS: OBJECTIVES, STRUCTURE AND ITS BINDING IN ECUADOR

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The National Committee on Food Code (CNCA) in Ecuador is constituted by the Ministry of Public Health, Ministry of Agriculture, Livestock and Fisheries (MAGAP), Ministry of Industry and Productivity (MIPRO), Ministry of Environment, Ministry of Foreign Trade, SENESCYT and INEN. It was created on September 29, 2004, and became effective as Official Act on October 7, 2004. On October 15, 2013 the Regulations of the CNCA is issued. This Committee is ruled by Codex Alimentarius (CA), which is a committee or multilateral organization founded by the FAO/OMS, responsible for generating standards, guidelines, recommendations and codes of practice relating to food. All participants of the FAO and OMS can be members of the Codex. Regional economic integration organizations may also can be members. The Codex Alimentarius Commission (CAC) is comprised of 186 Member States and 1 organization (European Union), 234 Observer Members, including 54 intergovernmental organizations, 264 NGOs and 16 agencies of United Nations. The objectives are to protect the health of consumers and ensuring fair practices in food trade, promote coordination of food standards and initiating and guiding normative projects. It has a base of scientific advisers (FAO/WHO Expert Committee on Food Additives). Topic which are analyzed are pesticide residues and microbiological risk assessment. The structure of the CA is conform by the CAC, which has an Executive Committee, the Secretary and Contributory Parties, the latter is divided into the Regional Coordinating Committees (dealing with relevant activities of the regions) and Technical Codex Committees, which are divided into horizontal committees, which deal with general issues, and vertical committees dealing on specific products. The point of contact in each country is the link with the Codex Secretary, coordinates the activities of Codex in the country, receives and circulates Codex documentation, send comments on them or proposals to the Commission. The Contributory Parties work with the National Codex Committee and act as link with all sectors, maintains the Codex library, and promotes the activities of Codex in the country.

Keywords: committee, code, food, health.

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INTERNATIONAL STANDARDS OF FOOD: TREE TOMATO AND UVILLA CODEX SUBCOMMITTEE ON FRESH FRUITS AND VEGETABLES ECUADOR

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According to the Central Bank of Ecuador, exports of tree tomato in thousands of USD (FOB) were 65.8, 80.2, 102.5, 207.2, 299.7 and gooseberry 334.4, 224.6, 374.8, 429.7, 87.2, during the years 2010, 2011, 2012 , 2013 and 2014, respectively. The standards for tree tomatoes (*Solanum betaceum* Cav.) (CODEX STAN 303-2011) and gooseberry (*Physalis peruviana* L.) (CODEX STAN 226-2001), amendment 2005, 2011; apply to commercial varieties, to be supplied fresh to the consumer, after preparation and packaging. Those for industrial processing are excluded. There are the categories Extra, I, II; presenting rules concerning presentation, uniformity, packaging, contaminants and hygiene. The minimum requirements subject to the special rules and the tolerances allowed are as follows: tree tomato should be whole, healthy and free of rottenness or deterioration, clean and free of any visible foreign residue, pest and damage caused by them, affecting the general appearance of the product; free of abnormal external moisture, excluding condensation following removal from cold storage, as well as rare smell and/or taste; firm consistency and fresh appearance. With stem to the first node; reached an appropriate degree of development and ripeness, taking into account the characteristics of the variety and the area they are produced. The development and condition should enable them to withstand transport and handling. Sizing is given by the diameter, weight and number of fruit per container. Gooseberry must be whole, with or without calyx; healthy, no rottenness or deterioration; clean and free of any visible foreign residues. Free of pests affecting the general appearance of the product and damage; as well as abnormal external moisture, excluding condensation following removal from cold storage; rare smell and/or taste is not allowed. It must be firm consistency, fresh appearance, smooth and glowing skin. If the calyx is present, the stalk must not exceed 25 mm in length. Reached an appropriate degree of development and ripeness, taking into account the characteristics of the variety and the area they are produced. Ripeness can be visually assessed from its external coloring, from green to orange; it can be determined by the total content of soluble solids least 14.0 ° Brix. Sizing is given by the diameter.

Keywords: category, classification, requirement, caliber.

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BREEDING PROGRAMS AND BIOTECHNOLOGY FOR BREEDING NEW VARIETIES FRUIT CROPS

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INIA´s Breeding Program is aimed at improving the quality and yield of vegetables and fruit mainly based on the extent of genetic resources as a source of genes and interdisciplinary work with departments and programs within and between institutions and an active participation of industry. Regarding fruit, it has started breeding on apples, peaches, cherries and grapes. Chilean table grapes accounts for 20% of the national production of fruit and becomes the first exporter in the world. Unfortunately, the Chilean industry is based almost entirely on imported cultivars of short duration for long trips, constraints related to Intellectual Property and restricted licensing of new varieties, which has resulted in the need to initiate own breeding programs (18 years ago). In grapes, breeding aims to improve fruit quality looking for features such as seedless berries, > 20 mm in diameter, firm, good flavor and aroma, different harvest times, loose clusters, low labor requirement, low or no use of growth regulators, tolerant to powdery mildew, storage > 45 days and more. To get this target, it has incorporated molecular tools to the process of selection of the best phenotypes and functional genomics + proteomics + metabolomics studies have initiated to identify genes of interest (QTLs) through genetic mapping and use of molecular markers. Additionally, developing genetic transformation studies have been carried out to study the function of genes and incorporate characters in elite varieties. During the stages of the grape breeding program, after the crosses and planting of segregating plants, a primary selection of the best progenies between 5 and 6 years of planting is carried out, subsequently, materials are cloned and grow, and after 10 years (cumulative time), an intermediate selection of the best clones is done, and after being evaluated during the years 11 and 12 an advanced selection of clones is carried out, they are assessed until year 14 or 15 to make the final selection of a new variety. Based on the above, INIA currently has four registered varieties like 'INIA grape-one', coming from crossbreeding of 'Flame' x 'Black Seedless' which meets quality parameters and high yield.

Keywords: genetics, genomics, selection, molecular.

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AGRONOMIC PRACTICES TO IMPROVE CROP MANAGEMENT AND INCREASE YIELD OF CHERIMOYA

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Cherimoya (*Annona cherimola* Mill.) belongs to the Annonaceae family. This fruit is native to the eastern slopes of the Ecuadorian-Peruvian Andes, which makes it a promising fruit for Ecuador because of its exquisite fruit quality, which is fully consumed in the domestic market. It is grown from 1200 to 2400 MASL, does not tolerate frost, temperatures below 13°C produce spots on the fruit and leaves. It grows in light and deep soils, rich in organic matter with a pH of 6.5 to 7.5 The total area sown of this species reach 13 500 ha worldwide, with an estimated yield 81 000 t per year. Spain is the largest producer of cherimoya (28%), Peru and Chile are the countries that follow in production. In Ecuador, the approximate total area of this fruit is 384 ha, cultivated in monoculture and associated with other crops, and distributed mainly in the provinces of Pichincha, Imbabura, Azuay and Loja; obtaining yields of 2.8 t ha^{-1} as average yield due to the low natural pollination percentage (2%). Hand pollination of flowers must be carried out to ensure production, pollinating 50 fruits $plant^{-1}$, being recommended to pollinate 50% more flowers (75 in total), and achieving yields up to 30 t ha^{-1}. Distances for high density planting of 4 m between rows and 2 m between plants are recommended, with a planting density of 1250 plants ha^{-1}. For crop management is recommended to perform the following tasks: irrigation between 300-350 l $plant^{-1}$; fertilization (ha) using 200 kg of N, 80 kg of P2O5, 200 kg of K2O, and 30 kg of Ca, Mg and B from the sixth year; pruning and leaving four to six buds; weed control (manual and chemical); and control of major pests such as leaf spot, anthracnose, leaf rust, fruit fly, seed drill and silver cherimoya. To control fruit fly is recommended to sheathe the small fruit (5 cm) using kraft paper bags. Harvesting is done when fruit change color from bright green to opaque green.

Keywords: pollination, pruning, nutrition, yield.

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BIOFORMULATIONS OF BENEFICIAL MICROORGANISMS IN ECUADOR

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Bioformulations are derived from animals, plants, bacteria and minerals. According to the ingredient they can be microbial (bacteria, fungi, viruses or protozoa), biochemical (sex pheromones, attractants, repellents) and PIP (Plant-Incorporated-Protectans) which are substances produced by plants from incorporated genetic material. Among the functions that plays a bioformulate in relation to the incorporated microorganism are suspending in the appropriate carriers that allow more stability, survival in storage time and optimize its application, protecting it against adverse environmental conditions such as excessive solar radiation. There are different types of formulations, such as powders, wettable powders, granules, dispersible granules, covered granules, concentrated suspensions, among others. The formulating process of a microorganism involves several steps, starting from a very thorough selection process with use of bioassays under controlled conditions, standardized production processes with a system of quality control in each step and finally incorporating the target microorganism to different carriers to provide stability and protection. Among the main processes carried out for the bioformulation are: 1) production of the microorganism on various substrates, 2) washing spores, 3) formation of the mother broth, 4) mixing the microorganism with various ingredients, 5) pelletizing (dispersible granules), 6) drying 7) packaging and 8) quality control (concentration of spores and CFU/gram or milliliter should be between 1×10^8 and 1×10^9, viability and purity greater than 90% and specific water activity value for each microorganism). In Ecuador, through the INIAP, they have been developed several prototypes for bioformulation such as dispersible granules and covered granules for application of entomopathogenic fungi and bacteria, besides, gels for application of nematodes in field have been developed. In a study about quality analysis of several bioformulations currently sold in the country, it was concluded that the microorganisms *Trichoderma* sp. and *Beauveria* sp. are very stable in carriers when the water activity (aw) is less than 0.600. In the case of wettable powders formulated with these same organisms, they show stability with a aw value not more than 0.300. Finally, the antagonist fungus *Trichoderma* sp. shows greater stability in the liquid formulations than *Beauveria* sp.

Keywords: concentration, entomopathogenic, granule, pest, survival.

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MANAGEMENT OF FORCED PRODUCTION IN CHERIMOYA (*Annona cherimola* Mill.)

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Cherimoya is a deciduous tree that under the subtropical conditions of Tumbaco-Ecuador (17°C, 800 mm rainfall, altitude 2348 masl) shows partial defoliation and uneven budding causing the disorganization of its phenology. The phenological stage from sprouting to harvest lasts about nine months and the dormant phase last three months. Through various physiological studies related to the use of chemicals to standardize and stimulate defoliation and sprouting, bud study to determine the time of the formation of new flowers for the timely application of products, irrigation management, nutrition and phytosanitary controls, have allowed to obtain a better organization of the tree phenology, reducing the period of dormancy and off-season production. Thus, it has been determined that after 5 months, the buds of new shoots begin the formation of the flowers, which is important to bring forward the defoliation at least one month after harvest, and reduce in 60 days the period of dormancy. The application of defoliants (copper chelate 1%), when 70% of buds and leaves have matured, produces defoliation percentages above 80% at 15 days after application of the product (DDAP) and over 70% of bud sprouting at 30 DDAP, thus plant organizes its phenology in contrast to plants without application. The complementary use of a promoting of sprouting (Cianamida hydrogenate) at 0.5 to 1.0%, applied after defoliation and a irrigation increases and accelerates the rate of sprouting. Reducing irrigation during the harvest, and proper management, without excess of nitrogen fertilizer favor ripening, lignification of the tissues, the reserve of nutrients, and facilitate defoliation to accelerate the process; to slow it will have to keep irrigation, increasing the nitrogen fertilization, doing phytosanitary controls to prevent the fall of leaves. Forced production has succeeded in changing harvest season from March to May and avoids low prices of the fruit that start from June, where fruit is scarce and even is import, therefore, achieving high prices for producers.

Keywords: deciduous, defoliant, inductor, sprouting.

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DEVELOPMENT OF NUTRITIOUS DRINK TO SCHOOL AGE CHILDREN

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Indigenous children comprise 10% of the total population, but 20% of them suffer from chronic malnutrition and 28% of severe chronic malnutrition. In Ecuador, almost 371 000 children under five age suffer from chronic malnutrition. Fruit are the main source of vitamin C, especially citrus. Despite their many properties, the consumption of vegetables and fruits in our country reaches on average 166 g per day, a very low amount compared to the 400 g proposed by the World Health Organization. The objective of this study was to evaluate the use of local raw materials in developing a nutritious and acceptable sensory drink, aimed at improving the health balance and nutrition of school-age children. The following raw materials were selected, based on their nutritional content, cost and volume of production at the national level: yellow carrot (*Daucus carota* L.), guava (*Psidium guajava* L.) passion fruit (*Passiflora edulis* Sims); pineapple (*Anana comosus*); blackberry (*Rubus glaucus* bent), bean variety 'INIAP 429' (*Phaseolus vulgaris*); lupine variety 'Andean 450' (*Lupinus mutabilis* Sweet), Quinoa variety 'Tunkahuan' (*Chenopodium quinoa* Willd) soybean variety 'INIAP 307'

(*Glycine max*). A nutritional drink based on a vegetable, a cereal or legume and a fruit was developed. It was determined that fruit of higher acidity, soluble solids, such as blackberry and guava, transferred these characteristics to the final beverage, attenuated by 25% or 50% depending on the proportion of dilution applied. The results of sensory analysis and considerations about cost and availability of raw materials, as well as nutrient balance, lead to select the most appropriate and feasible formulation to be implemented at industrial level. The combination of yellow carrot (25%) + blackberry (25%) + bean (50%) was accepted, characterized by a medium acidity of 0.55%, pH of 3.96 and sweet taste expressed in the content of soluble solids (10.3 °Brix). Regarding to the nutritional profile, it was determined that the beverage is rich in protein, microelements (Fe, Zn, Cu and Mn), vitamin (C, B1, B2) and folic acid. These nutrients broadly cover the recommended daily allowances of children ages from 4 to 10 years. The protein content was 11.13% (27 g 250 ml^{-1}), representing a contribution of 112.5% to the daily requirement of children aged form 4 to 6 years, and 96.43% for children aged from 7 to 10 years. Finally, it was determined that life- term of the pasteurized drink packed in polyethylene bottle and stored at 18°C and 65% of relative humidity was 90 days.

Keywords: cereal, fruit, legume, nutrition, vegetable.

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