DETERMINATION OF THE CAPACITIES OF FARMERS TO ADOPT QUINOA GRAIN (*CHENOPODIUM QUINOA* WILLD.) AS POTENTIAL FEEDSTUFF

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Abstract

The quinoa (Chenopodium quinoa Willd.), is a pseudocereal that has been cultivated in the Andean region in South America and especially in Nariño, Colombia. The quinoa has a great potential in the improvement of food for humans and animals. Its importance could be due to the quality of its proteins, the content and balance of its amino acids. The objective was to determine the factors that affect quinoa adoption, by using the model innovation-decision process (Rogers 2003) which structured and evaluated following parameters: level of consumption, use in animal feed, quinoa related to profitability and expectations with the improvement of quinoa. The results of the survey indicated that high proportion of small farmers know the quinoa crop, but only a short time (16 years ago), this could be the main reason of the a low consumption and low quinoa production. Low proportion of farmers (20%) has used quinoa in animal feed so we could consider them as the Innovators and early Adopters according to Innovation Adoption Curve categories of Rogers (2003).
Due to knowledge of quinoa from previous state projects there is a good potential adoption to innovate food production. Quinoa has a good nutritional content, the availability of adequate agricultural conditions and broad varieties.

Key words: smallholders, feedstuff, innovation, adoption capacity, Nariño

INTRODUCTION

Traditionally Colombian's livestock farming is the country's' basic industry, one which does not guarantee a sustainable production, especially in the local population (Andean region). The reason for this is the dependency on imported cereals. Quinoa has great potential for production and food security (Bhargava et al.,2006; FAO, 2010; Koziol, 1993) in the Andean regions (Cardozo et al.,1979; Cerón, 2000). Its status as an indigenous crop, characterizes it as easy to produce in the Andean region for its adaptability to different agro-climatic environments, which is an agronomic advantage over any crop introduced (Del Castillo et al., 2007; Montoya and Roa, 1985). However, in Colombian foodstuff production of monogastrics, specifically poultry production systems, the feeding is exclusively on diets based on cereals and soybeans (Ly, 1993). This affects the production costs especially in the feeding (Rosero et al., 2008). Therefore, it is necessary for Colombia to develop economically feasible and sustainable production systems in order to upgrade tropical poultry. The study explores the low uptake of quinoa by-products for livestock feed among local farming communities in Colombia, utilizing core elements of the original innovation diffusion theory (Wonglimpiyarat and Yuberkb, 2005; Rogers, 2003; Sunding and Zilberman, 2000). The knowledge of having the quinoa by-products as a possibility is affected by its relative invisibility of quinoas' potential among people. To our knowledge, there have been no studies which examine perceptions of quinoa products by the farmers thus affecting the stated adoption of quinoa.

The local technological capability and indigenous knowledge can contribute significantly to the process of adaptive improvement (Uddin, 2006) and also the mechanism of conservation of local crop and the conservation of natural sources. Ways and methods to bring this knowledge, innovation and adoption (Rogers, 2003; Au and Enderwick, 2000) of a native crop can be brought through the knowledge of the quality of food products scientifically proven, establishing that within the production chain of quinoa cultivation there are not only economic benefits but also food security (Mendoza, 1993; MADR, 2010) from the availability of grain and indirectly from chicken meat production for family consumption. The present investigation was developed with the objective of determining the capacities of farmers to adopt quinoa grain as a potential feedstuff, through the determination of the factors that affected quinoa adoption, the state of farmer knowledge about the quinoa pro-

duction and the social and economic factors that impact the stated adoption

MATERIALS AND METHODS

Localization

The survey of quinoa crops come from the Municipalities of Cumbal, Iles, Carlosama, Aldana, Cordoba, Ipiales and Pasto; of the Nariño department in Colombia. The Nariño department is located at 4° 35' 56. 57'' latitude and 74° 4' 51. 30'' longitude West of Greenwich meridian, average altitude 2800 m above the sea level, a mean temperature of 10–15°C and an annual precipitation of 932 mm, in Andes Region (IGAC, 2009).

Survey: Adoption and perception of quinoa cultivation in Colombia

The model of survey was constructed according to constraints described for Feder et al. (1985). The body of survey had four sections: Section I: Level of consumption; Section II: Use in animal feed; Section III: Quinoa related to profitability; Section IV: Expectations with the improvement of quinoa.

Population survey

The survey was conducted among 430 randomly selected farmers in Nariño department. The farmers are peasants and are part of the native population that belong to "Pueblo de Pastos". The survey of semi-structured interviews were performed, from which study participants were asked the following core questions regarding quinoa production and the understanding of supplementation of animal feed processes. The questions were formulated to generate descriptive narrations while lowering the possibility of enumerator input or bias. The survey was developed in the period of 10 December 2009 to January 10, 2010.

Application of model of the innovation-decision process

The conceptual model for this study is a modification of the innovation-decision process which comprises of six stages: problem definition, research (basic and applied), development, commercialization, adoption and diffusion, and consequences (Rogers, 2003; Stoneman, 2002), because were complementary part of general process, which consisted with a traditional adoption study were developed 10 year ago for Colombian government (Corredor 2005). Since a farmer could receive satisfaction from the perceived nutritional, economic and environmental benefits of quinoa, this model was based on utility maximization.

The responses of 4 categories (Level of consumption, use of quinoa in animal feed, quinoa related to profitability, expected with the improvement of quinoa) were regrouped into quinoa attributes, farm attributes and outside influences.

Level of consumption: In this category were the following: the time knowledge, profitability and quinoa quality effect. Farmers were asked to rank their opinions about four statements of quinoa characteristics on which, how many (kg), and why. The statements were: for time (long-time, medium time, short time and nothing); production, consume, sold and feedstuff for animal (high, means, low, nothing,).

Time knowledge: This means whether the farmer perceives the practice as time knowledge of quinoa or not. Time knowledge is related to relative advantage since "capacity adoption", but it may also be associated with the traditional of the practice. Responses that view quinoa as time consuming are expected to be negatively correlated with quinoa adoption.

Quinoa quality effect: This measures the farmer's perception that quinoa improves feed quality, as taste or nutritive benefits of quinoa related to the relative advantage nutritious compound (Gonzalez et al., 1989; Ogungbenle, 2003). Farmers who think that quinoa improves feed quality are expected to be positively correlated with quinoa adoption.

Use of quinoa in animal feed: *Species*: identifies the types of species the farm produces. This variable captures the compatibility of quinoa with the farm. It is expected that non-ruminant species, such as swine, broilers and other non-ruminants, are positively correlated with quinoa use. Ruminants are expected to be negatively correlated with quinoa use. Non-ruminants are expected to be negatively correlated with farmers who do not know if quinoa is used since quinoa is applicable to non-ruminants only.

Outside influences: These variables measure the influence of outsiders on the agricultural production decisions of the farm. The aspects evaluated in this variable were: Institutional cooperation and natural conservation sources. Responses on quinoa varieties (the NRC actions), institutions cooperation's and consumers gave variable response.

Natural resource conservation: This measures how much influence the natural resource conservation has on the farm. It is expected that farms with more influence from the NRC are going to be more likely quinoa users because they are considered to have more important genetic

resources for conservation biodiversity of the native crops produced in Andeans region in South America (Mujica et al. 2001; Corredor, 2003; Christensen et al., 2007).

Statistical analysis

The categories were rated on a five-point Likert scale (5 = strongly agree, 4 = agree, 3 = indifferent, 2 = disagree, 1 = strongly disagree) with a no non-response variable (Likert, 1974; Hosseini et al., 2009; Ryan and Garland, 1999). Schnettler et al. (2009) mentioned that to Kinnear et al. who used a Likert scale with five levels (5 = very useful, 4 = useful, 3 = indifferent, 2 = not very useful, 1 = not useful at all) for subjects to indicate the assigned utility to eight different types of information. For this reason it was used in each variable and the statements were: for time (Very long, long-time, medium- short time and nothing); production, consumption, price, sold and feedstuff for animal (very high, high, means, low, nothing) and area of crop (nothing, small, medium and large very large) and the capacities of adoption were established using the Innovation Adoption Curve categories (Rogers, 2003): innovators (2.5%), early Adopters (13.5%), early Majority (34%), late Majority (34%) and laggards (16%).

The statistical analysis of the results was analyzed with descriptive statistics as means and standard deviation, frequency histogram, and statistical analyse were used the test of Kruskall-Wallis and correlations using Minitab 15 (Minitab, Inc., in the United States) Statistical software.

RESULTS

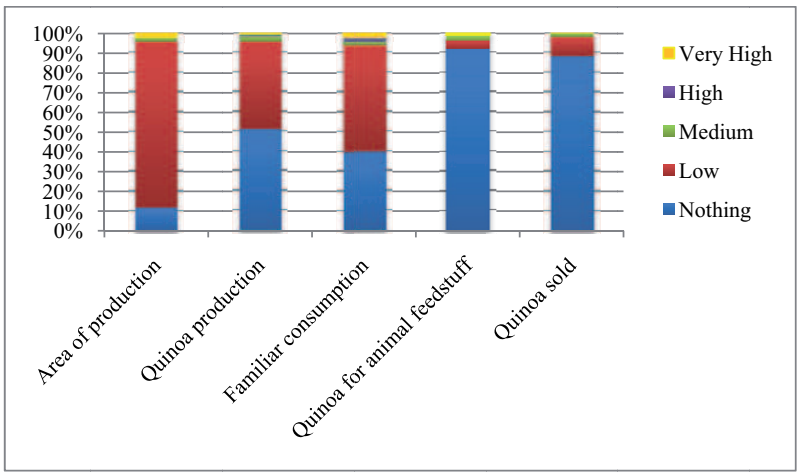
According to the five-level Likert scale (Table 1) the different themes of information on level of consumption presented values higher proportion of farmers, who had low acceptation (2) more 50% of producers than in the total sample, however corresponds to levels of high utility for consumption. And quinoa related to profitability low level of utility was given to region (40 farmers). The level of consumption and quinoa related to profitability the results indicated that 98% of small farmers know the quinoa crop, 70% of this 98% farmers knew of quinoa for a short time (16 years ago), the recent knowledge of quinoa was the main reason for 53.5% of the farmers to have a low consumption (2). In the profitability, the major production range was between 525 to 700 kg, however this was only represented in 0.5% of farmers, the major percentage of farmers 44.2 % that did produce had a low quinoa production (1-175 kg) and that production was not sold (37% of farmers) because it was used as self supply. This factor showed significant differences ($P < 0.05$) using the test of Kruscall-Wallis. According to Rogers (2003), the results indicated that a high proportion of farmers were own adoption curve categories innovators (2.5%) and early adopters (13.5%).

In the five-level Likert scale the different themes of information on level of consumption presented the lowest utility were for use in animal feed. The use of quinoa in animal feed, only 20% of farmers have used quinoa in animal feed indicating the low level of adoption, 78% of farmers did not use it. The species fed with quinoa were chickens and guinea pigs, 9% of farmers have used quinoa to feed chickens and 2% of them to feed guinea pigs, sheep and cow. The proportion of quinoa supplied in the animals diet had a low level (1 to 2.5 kg) for 4.5% of farmers, followed by 2.3% of farmers who used from 2.5 to 5 kg of quinoa and a high level (7.5 to 10 kg) was used in 1.4% of farmers (Figure 1).

Tab. 1: Likert-scale applied to 7 statements that pertained to the characteristics of production, use and profitability as regards the acceptance of the quinoa crop.

Perception statement	1	2	3	4	5
1. Level of consumption					
since when you have quinoa crops or know (years)	10	300	40	40	40
planting area (acres/meters square)	50	360	10	0	10
quinoa crop production (kg)	220	190	12	6	2
That amount of quinoa is reserved for family consumption (kg)	170	230	10	10	10
2. Use in animal feed					
Amounts of quinoa has been used as fed (kg)	392	20	10	2	6
3. Quinoa related to profitability					
Quantity of quinoa to sold (kg)	379	40	10	0	1
Price per kg $	290	10	60	10	60

Figure 1: Quinoa production with relation to use



The expected with the improvement of quinoa, the results found showed that in the region of Nariño there is an outside influence especially from governmental institutions. However a high proportion of farmers (80%) ignore the existence of institutions that incentive the promotion of quinoa crop. Natural resource conservation, which is very important in Andean populations, 48% of the population know varieties of quinoa.

DISCUSSION

The level of consumption and the farmer's response to the knowledge of quinoa was because they cultivated or consumed it. However this knowledge only corresponds to a short period of time, between 1–16 years, and this result indicated that despite of being a native crop, over the past 60 years it has been forgotten. According to the five-level Likert scale the different themes of information on level of consumption presented values of a higher proportion of farmers who had low adoption (2) more than 50% of producers than in the total sample. But this shows a large potential for growth in quinoa production in the future. Among the themes with the lowest utility were those for use in animal feed and quinoa related to profitability. A low level of utility was given to region (40 farmers).

Nevertheless since this last decade there has been a reactivation of the cultivation of quinoa as a result of the project "Quinoa as a multipurpose crop for agro-industrial uses in Andean countries". This project began in August 2002, with the objective to help create additional revenue opportunities for small-scale Andean farmers, small businesses and national industry. This also took advantage of the great diversity of the quinoa germplasm (Corredor, 2003). The process was initiated in some departments such as Cundinamarca, Boyacá, Cauca and Narino, which had an agro-alimentary chain using priority crops (DPN, 2007). This means that it can help the recovery and promotion of native or local crops as a part of a strategy of community welfare and food security (Moreno, 1993; FAO, 1995) and as a new foodstuffs, which helps to improve the diet and is conducive to a healthier state of the population (Jancurová et al., 2009). Around half of the farmers consumed quinoa as food for their family, although is low. This pseudocereal is important in the Andean regions due to its similar conditions in Boyacá, Cundinamarca y Nariño, because they are promising crops for organic farming production (DNP, 2007). With this research it was established that consumer populations are guided by the nutritional precedent which is vital for widespread adoption of farming and increased production rather than considering the potential and history of the Andean largest producing countries like Ecuador, Bolivia (Del Castillo et al., 2008) and Peru (Mujica et al., 2003). Although quinoa has been grown as an alternative crop with environmental conditions, traditional economy and nutritional factors, especially in the areas with indigenous populations where quinoa was their ancestral crop, where the women play a key role in this process because it is them who know the different materials and their culinary and nutritional benefits (Reyes and Corredor, 1999).

When quinoa was related to profitability it showed that commercial production was the principal objective the economic advantages. However, even the small farmers were unable to establish the cultivation of quinoa as a primary crop, hence their production is low. The low

production is due to the fact that it has been associated with other crops which are generally used for self-consumption. Thus a largest proportion of farmers do not sell the quinoa because it is the subsistence crop and the tendency of the use of grain for family consumption reflects the lack of information concerning market prices of quinoa. The low quantities sold are distributed for the local population and a very small amount is exported from Colombia to Ecuador and Peru, but they are not registered. According to the latter situation the area of cultivation has been increased in Nariño Department (Corredor, 2005) and its goals were improve nutritional conditions of producers (Mendoza, 1993; MADR, 2010). DPN (2007) determined some characteristics as advantages: suitable land, different thermal levels and when more than 50% of population lives in rural zone having as their main economic activity the agriculture. However, it is necessary that quinoa production has a commercial purpose. There are two issues that are essential for a correct understanding of its identity: (1) the business model of producer organisations in developing countries, (2) the development of approaches to help small producers strengthen their position in domestic markets (Ton and Bijman, 2006; FAO, 2010). Therefore advances in research and a gradual market acceptance permit a selection to be made of those Andean crops that have an immediate chance of being saved for food use regionally and worldwide (FAO, 1995).

The leaves or stems of quinoa used in animal feed (the quantities formerly given in kg) were not precisely recorded by the farmer and therefore these are approximations. To analyse its use in animal feed, with the purpose of understanding the potential of using its by-products in animal feeds, specific questions were made over the use of quinoa grain and/or plant parts. Cardozo and Tapia (1979) mentioned that although the main objective in the cultivation of quinoa is the production of grain for human consumption, it has been considered a second-class grain from the by-products of a crop that can be used in feeding poultry, pigs and cattle in special conditions. In Nariño some companies (Molinos San Fernando) that process manufactured quinoa products, generate by-products (hulls, small grains or pieces) which are destroyed, because their potential uses are ignored.

Sweet and bitter quinoa were when feeding chickens. The quinoa base (30%) had no reported negative effects on performance in weight. However, higher levels of bitter quinoa (with saponin) have been reported to cause a deficiency of vitamin A (Ward, 2000). Other experimental studies have been conducted on the use of quinoa in feed for chickens (Jacobsen et al., 1997; Improta and Kellems, 2001; Munoz, 1980); pigs (Cardozo and Tapia, 1979; van der Peet-schwering et al., 2006), yielding excellent results. However, at farms not used, the first reason is the lack of knowledge of quinoa use. The second reason is that at the level of household consumption, the grain produces digestive disorders and some fear that animals would suffer from similar effects. Some studies in infant quinoa food found modestly lower iron absorption (Cook et al., 1997) which can be due to antinutrients (Chauhan et al., 1992)

There are important facilitators such as institutional and production organisations, experienced with Bolivian quinoa production. They were established by exploiting economies of scale and reducing transaction costs, thus allowing the production organisations to improve the efficiency and efficacy of agri-food supply chains (Ton and Bijman, 2006). However it is a long process. Even countries like Bolivia, which is the largest producer, have flaws in its production. Soto et al. (2006) affirmed that Bolivia's agricultural sector is characterized by insufficient use of advanced knowledge and technology in production and processing, despite the continuous efforts of public and semi-public research and extension of agencies and development co-operations.

Natural resource conservation for the survival of Andean crops has been due, until now, to the existence of numerous natives and peasant communities which still inhabit the area and which by preserving their traditions and their ancestral knowledge of handling quinoa, as well as cultivating and using these species have managed to prevent them from being lost. Nevertheless there is the existence of several phenotypic characteristics, suggesting the existence of considerable genetic diversity. According to McElhinny et al. (2007) and Delgado et al. (2009), found that the farmers' field selection criteria for quinoa in the field were mostly based on yield, earliness and plant colour. As well as breeders' measurements of yield and panicle height significantly correlated to farmer selection scores. The study allows the co-operation of natives and local communities and has sought the conservation of natural resources (FAO, 1995). This was achieved by the natural conservation resources of the Nariño regions using mechanisms of conservation, the use of quinoa as genetic resources, and its an essential native crop for the sustainability of future production of natives communities. Through collecting expeditions (IBPGR, INIAP, UNAL) in Colombia, Ecuador, Peru and Bolivia samples have been obtained showing the variability of Andean crops and have ensured the conservation of a high percentage of genetic material (Corredor, 2005). Of equal importance has been the compilation of descriptions of the main Andean species, done with the help of FAO's Seed and Plant Genetic Resources (FAO, 1995).

CONCLUSION

The advancement of sustainable agriculture in developing countries depends largely on the application of scientific information. The producer requires specific solutions. There is a good potential of quinoa adoption that will enable farmers to innovate food and feed production, due to its knowledge, addition of quinoa by-products in animal diet and broad varieties of quinoa.

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REFERENCES

AU A.K., ENDERWICK P. (2000): A cognitive model on attitude towards technology adoption. Journal of Managerial Psychology,15 (4): 266.

BHARGAVA A., SHUKLA S., OHRI D. (2006): Chenopodium quinoa – an Indian perspective. Industrial Crops and Products, 23: 73–87.

CARDOZO A., TAPIA M. (1979): Valor nutritivo. In: Tapia M., Gandarillas H., Alandia S., Cardozo A., Mujica A.: Quinua y Kañiwa, Cultivos Andinos. Bogota CIID, Oficina Regional para la America Latina, pp. 149–192; ISBN: 0-88936-200-9.

CARLSSON R., HANCZAKOWSK, P., KAPTU T. (1984): The quality of the green fraction of leaf protein concentrate from *Chenopodium quinoa* Willd. grown at different levels of fertilizer nitrogen. Animal Feed Science and Technology, 11 (4): 239–245.

CERÓN E. (2000): Cultivo de quinoa. Universidad de Nariño –Ministerio de Agricultura, San Juan de Pasto. Boletin No. 1., 15 p.

CHRISTENSEN S.A., PRATT D.B., PRATT C., NELSON P.T., STEVENS M.R., JELLEN E.N., COLEMAN C.E., FAIRBANKS D.J., BONIFACIO A., MAUGHAN P.J. (2007): Assessment of genetic diversity in the USDA and CIP-FAO international nursery collections of quinoa (*Chenopodium quinoa* Willd.) using microsatellite markers. Plant Genetic Resources: Characterisation and Utilisation, 5 (2): 82–95.

COOK J., REDDY M., BURRI J., JUILLERAT M., HURRELL R. (1997): The influence of different cereal grains on iron absorption from infant cereal foods. The Americal Journal of Clinical Nutrition, 65: 964–969.

CORREDOR G. (2003): Proyecto quinua: memorias del curso producción de Quinua cultivo multipropósito. In: Corredor G., Romero A., Ochoa M.T. Universidad Nacional de Colombia Bogotá.

CORREDOR G. (2005): Alianza "CADENA AGROALIMENTARIA DE LA QUINUA". Universidad Nacional de Colombia, Facultad de Ingeniería y Ministerio de Agricultura y Desarrollo Rural- Proyecto Apoyo a Alianzas Productivas.

CHAUHAN G.S., ESKIN N.A.M., TKACHUT R. (1992): Nutrients and antinutrients in Quinoa seed. Cereal Chemistry, 69 (1): 85–88.

DEL CASTILLO C., MAHY G., WINKEL T. (2008): La quinoa en Bolivia: une culture ancestrale devenue culture de rente " bio-équitable ". Biotechnology, Agronomy, Society and Environment, 12 (4): 421–435.

DEL CASTILLO C., WINKEL T., MAHY G., BIZOUX J-P. (2007): Genetic structure of quinoa (*Chenopodium quinoa* Willd.) from the Bolivian altiplano 4 as revealed by RAPD marker. Genetic Resources and Crop Evolution, 54 (4): 897–905.

DELGADO A.I, PALACIOS J.P., BETANCOURT C. (2009): Evaluation of 16 genotypes of sweet quinoa (Chenopodium quinoa) in the municipality of Iles, Nariño (Colombia). Agronomia Colombiana, 27 (2): 159–167.

DPN (2007). Departamento Nacional de Planeación. Agenda Interna para la Productividad y la Competitividad: Cluster agroalimentario – cadena de la quinua. Documento regional, Boyacá, Bogotá.

FAO (2010). Investing in food security. The agriculture and consumer protection department.

FAO (2008). Plant Production and Protection Series. In: Hernández J.E, León J.: Neglected crops 1492 from a different perspective. No.26; ISBN 92-5-103217-3. Available at http://www.fao.org/docrep/T0646E/T0646E00.htm (accessed January 2009).

FEDER G., JUST R.E., ZILBERMAN D. (1985): Adoption of Agricultural Innovations in Developing Countries: A Survey. Economic Development and Cultural Change, 33 (2): 255–298.

GONZALEZ J.A., ROLDAN A., GALLARDO M., ESCUDERO T., PRADO F.E. (1989): Quantitative determinations of chemical compounds with nutritional value from Inca crops: *Chenopodium quinoa* ("quinoa"). Plant Foods for Human Nutrition, 39 (4): 331–337.

IGAC-Instituto Geográfico Agustín Codazzi. Mapa Base de Colombia. January 2010 Available at http://mapascolombia.igac.gov.co/wps/portal/mapasdecolombia/ (accessed 1 March 2010).

IMPROTA F., KELLEMS R.O. (2001): Comparison of raw washed and polished quinoa (*Chenopodium quinoa* Willd.) to wheat, sorghum or maize based diets on

growth and survival of broiler chicks. Livestock Research for Rural Development, 13 (1): 10.

JACOBSEN E.E., SKADHAUGE B., JACOBSEN S.E. (1997): Effect of dietary inclusion of quinoa on broiler growth performance. Animal Feed Science and Technology, 65: 5–14.

JANCUROVÁ M., MINAROVIČOVÁ L., DANDÁR A. (2009): Quinoa – a Review. Czech Journal of Food Sciences, 27: 71–79.

KOZIOL M.J. (1993): Quinoa: A potential new oil crop. In: Janick J., Simon J.E. (eds.): New crops. Wiley, New York, pp. 328–336.

Likert, R. The method of constructing an attitude scales. In Maranell, G.M. Scaling: a sourcebook for behavioural scientists. Library of Congress, New Jersey, USA, 1974. 429p. ISBN: 978-0-202-36175-8.

LY J. (1993): The role of monogastric animal species in the sustainable use of tropical feed resources. In: Proc. VII World Conf. Anim. Prod., Edmonton, 1: 95–117.

MC-ELHINNY E., PERALTA E., MAZÓN N., DANIAL D.L., THIELE G., LINDHOUT P. (2007): Aspects of participatory plant breeding for quinoa in marginal areas of Ecuador. Euphytica, (153): 373–384.

MENDOZA G. (1993): Alternativas de producción y consumo de quinua en Colombia. Instituto Colombiano de Bienestar Familiar – ICBF.

Ministerio de Agricultura y Desarrollo Rural – MADR (2010). Programa oportunidades rurales. MADR. Bogota, Colombia.

MONTOYA A., MARTÍNEZ VIANCHÁ L., PERALTA BALLESTEROS J. (2005): Análisis de variables estratégicas para la conformación de una cadena productiva de quinua en Colombia. INNOVAR, 15 (25): 103–119; ISSN: 0121-5051.

MORENO R. (1993): Valor nutritivo y usos en alimentacion humana de algunos cultivos autoctonos subexplotados de Mesoamerica. In: Cultivos Andinos FAO. Oficina regional de la FAO para America Latina y El Caribe, 1993. Santiago, Chile. January 2010. Available at http://www.rlc.fao.org/es/agricultura/produ/cdrom/contenido/libro11/reconoc.htm (accessed March 2010).

MUJICA A., MARCA S., JACOBSEN S.-E. (2003): Current production and potential of quinoa (*Chenopodium quinoa* Willd.) in Peru. Food Reviews International, 19 (1–2): 149–154.

MUJICA A., IZQUIERDO J., MARATHEE J-P. (2001): Quinua y la kañiwa : cultivos andinos. Capitulo I. Origen y Descripcion de la Quinua. CIID. Oficina Regional para América Latina y el Caribe. FAO, Santiago de Chile. [CDROM Version 1].

MUÑOZ V. (1980): Effect of 5 levels of Chenopodium quinoa (Quinoa) as a partial substitute of soybean cake in the broilers chickens feeding. Thesis Zootechnician Degree, Universidad de Nariño, Pasto, Colombia.

OGUNGBENLE H.N. (2003): Nutritional evaluation and functional properties of quinoa (*Chenopodium quinoa*) flour. International Journal of Food Sciences and Nutrition, 54 (2): 153–158.

REYES L.M., CORREDOR G. (2008): Uso y potencial de la quinua en Colombia. Primer Taller Internacional en quinua: Recursos genéticos y sistemas de producción, 10-14 de mayo de 1999. In: Cultivos Andinos FAO-versión 1.0. January 2008. Available at http://www.rlc.fao.org/es/agricultura/produ/cdrom/contenido/libro14/cap4.7.htm (accessed March 2010).

ROGERS E.M. (2003): Diffusion of Innovations. 5th ed. Free Press, New York; ISBN: 0743222091.

ROSERO O., MAROUNEK M., BŘEŇOVÁ N., LUKEŠOVÁ D. (2009): The Use of the Quinoa Seeds (*Chenopodium quinoa* Willd) as food for Poultry and Pigs in Colombia. Agricultura Tropica Et Subtropica, 42 (1): 53.

ROSERO O., LUKEŠOVÁ D. (2008): Food and Perspectives on Pig Production System in Colombia. Agricultura Tropica et Subtropica, 41 (3): 122–127.

RYAN C., GARLAND R. (1999): The use of a specific non-response option on Likert-type scales. Tourism Management, 20: 107–113.

SOTO J.L., HARTWICH F., MONGE M., AMPUERO L. (2006): Innovación en el Cultivo de Quinua en Bolivia: Efectos de la Interacción Social y de las Capacidades de Absorción de los Pequeños Productores. International Service for National Agricultural Research Division (ISNAR), Division Discussion Paper 11.

STONEMAN P. (2002): The Economics of Technological Diffusion. Blackwell Publishers Ltd, Oxford; ISBN: 0-631-21977-3.

SUNDING D., ZILBERMAN D. (2000): The Agricultural Innovation Process: Research and Technology Adoption in a Changing Agricultural Sector. For the Handbook of Agricultural Economics.

TON G., BIJMAN J. (2006): The role of producer organisations in the process of developing an integrated supply chain; experiences from Quinoa chain development in Bolivia. Paper presented at the 7th International Conference on Management in AgriFood Chains and Networks, Ede, The Netherlands, 31 May–2 June.

UDDI M.K. (2006): The role of diffusion of innovations for incremental development in small enterprises. Technovation, 26: 274–284.

VAN DER PEET-SCHWERING C.M.C. VAN KRIMPEN M.M., KEMME P., BINNENDIJK G.P., VAN DIEPEN J.T.M., JONGBLOED A.W., HENNIPHOF-SCHLICK G., BUBENHEIM D.L. (1993): Quinoa: An Emerging "New" crop with potential for CELSS. NASA Technical Paper 3422.

WARD S.M. (2000): Response to selection for reduced grain saponin content in quinoa (*Chenopodium quinoa* Willd.). Field Crops Research, 68 (2): 157–163.

WONGLIMPIYARAT J., YUBERKB N. (2005): In support of innovation management and Roger's Innovation Diffusion theory. Government Information Quarterly, 22: 411–422.

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