Bibliographic review on hydroponic forage cultivation for dairy cattle feeding in Ecuador

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Abstract

Hydroponic forage crops are an excellent alternative to supply the nutritional requirements in livestock feed to a certain extent, complementing livestock production in the shortest possible time and optimizing resources such as water and land. The objective of this bibliographic review study was to determine the nutritional composition, nutritional requirements, and the effect of the use of hydroponic forage crops on milk production in Ecuador, for which a total search of bibliography related to the subject was carried out in different scientific bases, such as Scopus, Springer, Scielo, Google Scholar, Researchgate, undergraduate, master's and doctoral thesis to later, using the Mendeley bibliographic manager, carry out a total analysis of the information. The nutritional content of the different forage hydroponic crops shows high values of protein, energy, and digestibility; the best results reported were 25.75%, 75% and 95%, respectively. Regarding nutritional requirements, hydroponic crops require 168-200 mg/L of nitrogen, 31-60 mg/L of phosphorus and 156-300 mg/L of potassium; to obtain forage with high-quality standards, on the other hand, the use of forage hydroponic crops can increase milk production by up to 14.7%, so its use in livestock feeding is recommended.

Keywords: *Hydroponic farming, nutritional requirements, milk production, forage farming.*

1. Introduction

Fodder crops grown in hydroponic systems are a soilless method of vegetable production. It involves giving the plant an aqueous solution containing all the nutrients required for growth and production. Hydroponic farming, from a chemical perspective, strives to provide plants with the same vital components they would find in soil delivered in a technologically advanced way [1].

Hydroponic forage production is a method of growing plant biomass that begins with the germination and early development of seedlings from viable seeds. This technique can grow healthy and nutritious plants in a short time (only 9 to 15 days), regardless of season or location. These crops create their organic food and absorb the nutrients given to them, maintaining a high nutritional content of 18% to 22% of proteins, minerals and vitamins that are digested by animals [2].

Processed hydroponic feeds have many benefits, including lower costs, no need for land expansion, can take advantage of dry and cold weather to grow anywhere in the world, faster germination, higher yields, higher nutrient content, palatability and attractiveness to animals, increased milk and meat production, and are also free of parasites [3].

There are many dry and semi-arid regions in the world, and many of them are at risk of desertification due to soil degradation and water scarcity. Despite these challenges, agriculture often plays a crucial role in the national economy in these areas. Therefore, hydroponics, as an alternative method of crop production, can promote environmental conservation and sustainability [4].

Therefore, the objective of this literature review study was to determine the nutritional composition, requirements and effect of hydroponic forage crops on Ecuador's dairy production. For this purpose, a complete search of the literature related to the subject was carried out, followed by a total analysis of the information.

2. Methodology

2.1 Type of research

This literature review presents a non-experimental documentary approach, adjusting to the collection of information through the analytical reading of documents and bibliographic materials related to hydroponic fodder crops for dairy cattle feeding in Ecuador, a systematic procedure was used to establish, collect and examine the information contained in the various scientific documents.

2.2 Research method

The research is qualitative with a descriptive scope since it details the parameters required in the hydroponic crop's market. The method used is exploratory of a secondary order since a thorough search of bibliographic information of documents obtained in scientific databases such as Scopus, Springer, Scielo, Google Scholar, Researchgate, undergraduate, master's and doctoral theses were carried out. To comply with a critical reading of the main selected bibliographic documents was carried out, which were subsequently classified and separated according to the information supporting the work.

2.3 Inclusion criteria for documents collected

To write the results of the current study, research published in the last 10 years was considered. Likewise, each document's information must be consistent with the object of this research. On the other hand, the studies must contain accurate information to make an appropriate citation.

2.4 Variables considered

Hydroponic forage crop, bromatological analysis and effect of hydroponic forage crops on milk production.

2.5 Exclusion criteria for collected documents

Studies older than 10 years, documents not related to the present research and scientific articles that have not been published in indexed journals were not taken into account.

2.6 Information management

The research studies were evaluated, and greater attention was given to those documents whose results were related to the present work. After the discrimination of the studies, a critical and detailed analysis was applied to discuss the most important results.

3. Results and discussion

3.1 Nutritional value of hydroponic forage crops

Different researches show the nutritional value of different hydroponic crops for feeding dairy cattle; the results reported by different authors are shown below (Table 1).

Table 1. Nutritional value of different hydroponic fodder crops

Hydroponic cultivation	Protein (%)	Energy (%)	Digestibility (%)	Reference
Wheat	16,50 28,80 25,75	74,60 72,20 73,12	87,70 85,32 84,41	[5] [6] [7]
Oats	19,00 17,13 18,32	69,50 66,97 68,49	93,30 95,39 93,88	[8] [9] [7]
Corn	14,80 19,40 14,80	75,00 75,00 73,64	90,00 90,00 92,15	[10] [11] [12]
Barley	25,00 23,60 25,35	72,84 57,00 64,92	81,60 81,60 83,00	[13] [14] [15]
Rice	7,92 9,00 9,93	70,22 68,87 69,36	84,34 85,67 83,54	[16] [17] [18]

The results on the nutritional composition of hydroponic forage crops show high protein, energy and digestibility contents; according to [19], the nutritional composition of hydroponic crops depends mainly on the fertilization applied, which directly influences forage quality by increasing protein and energy levels, on the other hand [2], mention that the correct supply of nutrients in hydroponic crops has an important impact on protein contents. The better the nutrient solution applied, the better the protein quality, and [20] indicate that high concentrations of nitrogen in nutrient solutions improve the energy content and digestibility of forage, [21] mention that heat, radiation from the medium, and planting density are factors

that influence the properties of hydroponic forages, and [22] reveal that the nutritional composition of hydroponic forages varies according to the availability of nutrients in the fertilization.

3.2 Nutrient requirements of hydroponic crops

The different researches reveal the nutritional requirements that hydroponic crops need for their correct development. The results reported by several authors are presented below (Table 2).

Table 2. Nutritional requirements of different hydroponic crops.

N	P	K	Ca	Mg	S	Faith	Cu	Zn	Mn	Reference
mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
168	41	156	160	36	48	28	0,064	0,065	0,54	[23]
200	60	300	170	50	68	12	0,1	0,1	2	[24]
168	31	273	180	48	336	4	0,02	0,11	0,62	[25]

The table above shows the general nutritional requirements for hydroponic crops to develop better. According to [26], adequate doses of nutrients such as N, P and K help to achieve forages rich in protein and energy, which will benefit the milk yield of livestock. On the other hand, [27] indicates that hydroponic crops for animal feed can increase milk production as long as the nutritional requirements have been supplied. In this way, the levels of energy, digestibility and protein will increase, favoring the animals that consume them, mainly those destined for dairy production. Likewise, [28] specify that meeting the nutritional requirements of hydroponic forages increases the protein content, organic matter and energy, which are very important requirements for the animals. The best hydroponic forages are obtained only if adequate amounts of macro and micronutrients, such as N, P, K, Ca, Mg, S and Fe, are included through nutrient fertilization [29].

3.3 Effect of hydroponic feeding on milk yield

Table 3. Milk yield according to the different hydroponic cultures.

Type of FVH	Kg/day	Increase in milk (%)	Reference
Wheat	12-18	From 10.00 to 24.70	[30]
Oats	15-20	From 8.00 a.m. to 2.43 p.m.	[4]
Corn	13-19	From 12.25 to 25.63	[1]
Barley	12-20	From 7.48 to 15.66	[31]

Research (Table III) shows that the inclusion of hydroponic fodder in the daily feeding of animals significantly increases milk production, as reported by [20], when he says that feeding based on hydroponic fodder increases the milk production of animals.

On the other hand, [32] mentions that due to the high levels of protein and energy that hydroponic forages have, they significantly increase milk production levels. Likewise, [33] affirms that daily doses of 13-29 kg of hydroponic forage considerably improve milk yield by up to 15%. In this sense, [34] mentions that hydroponic forages such as barley and wheat have high protein concentrations, and therefore, if daily doses of between 15-20 kg of green forage are supplied, milk production increases significantly. [34] alludes that hydroponic forages such as barley and wheat have high protein concentrations and therefore, if daily doses of between 15-20 kg of green forage are supplied, milk production can be increased by up to 22%. On the other hand, hydroponic forages are an excellent economic alternative to improve production yields in dairy cattle, and hydroponic technology is more environmentally friendly [35].

4. Conclusions

Hydroponic forage crops have high protein, energy and digestibility contents; in the case of protein, maximum values of 25.75% have been reported, in energy 75% and digestibility 95%. On the other hand, research showed that the quality of hydroponic forages depends on the nutrient solutions supplied to them. In this sense, the nutritional content of hydroponic forage crops will improve, for it requires 168-200 mg/L of nitrogen, 31-60 mg/L of phosphorus and 156-300 mg/L of potassium. Finally, it has been verified that the use of hydroponic forages increases up to 14.70% the milk yield in animals, which is recommended for feeding dairy cattle.

Reference

Mejía, D., & Alejandra, R. (2020). Exploración para la producción de forraje verde hidropónico de maíz y sorgo para la alimentación de ganado lechero: Revisión de Literatura [Escuela Agrícola Panamericana, Zamorano Honduras]. https://bdigital.zamorano.edu/items/6e1849d8-3896-4ead-853a-9700d1db0428

Juárez-López, P., Morales-Rodríguez, H. J., Sandoval-Villa, M., Danés, A. A. G., Cruz-Crespo, E., Juárez-Rosete, C. R., Aguirre-Ortega, J., Alejo-Santiago, G., & Ortiz-Catón,

M. (2018). Producción de forraje verde hidropónico. Revista Fuente Nueva Época Año, 4(13).

Romero, R. (2017). Rendimiento productivo de Cavia porcellus “CUY” en la etapa de crecimiento – engorde, alimentados con diferentes niveles de forraje verde hidropónico de Hordeum vulgare “Cebada” Y Pisum sativum l. “ARVEJA [Universidad Nacional de Trujillo]. https://dspace.unitru.edu.pe/handle/UNITRU/9662

Camacho, F., & Jácame, P. (2018). Repositorio Digital: Propuesta de otra alternativa de alimento para el ganado lechero del cantón Mejía a base de forraje verde hidropónico [Universidad Central del Ecuador]. http://www.dspace.uce.edu.ec/handle/25000/16929

Contreras, J., Tunque, M., & Cordero, A. (2016). Rendimiento Hidropónico de la Arveja con Cebada y Trigo en la Producción de Germinados. Revista de Investigaciones Veterinarias Del Perú, 26(1), 9–19. https://doi.org/10.15381/RIVEP.V26I1.10910

Sánchez, F., Castillo, D., Del, E., Moreno Pérez, C., Contreras Magaña, E., & Morales Gómez, J. (2013). Producción de forraje hidropónico de trigo y cebada y su efecto en la ganancia de peso en borregos.

Hydroponic wheat and barley fodder yields and their effect on weight gain in sheep. Revista Chapingo Serie Horticultura, 19(4), 35–43. https://doi.org/10.5154/r.rchsh.2012.02.020

Romero Valdez, M. E., Duarte, G. C., Odalmira, E., & Gallardo, H. (2014). Producción de Forraje Verde Hidropónico y su Aceptación en Ganado Lechero. Acta Universitaria, 19(2), 11–19. https://doi.org/10.15174/AU.2009.93

Fuentes, F., Poblete, C., Huerta, M., & Palape, I. (2013). Evaluación de la producción y calidad nutritiva de avena como forraje verde hidropónico en condiciones de desierto.

Idesia (Arica), 29(3), 75–81. https://doi.org/10.4067/S0718-34292011000300011

PACCO, J. (2018). Producción de forraje verde hidropónico de cebada y avena con adición de fitohormonas [Universidad Nacional del Altiplano]. http://tesis.unap.edu.pe/handle/UNAP/10373

Marcelino, Z.-T., Sergio, M.-G., Socorro, S.-M., Francisco, E.-V., Bladimir, P.-P., & Fernando, C.-D. (2016). Hydroponics maize green forage production with watering every 24 hours Producción de forraje verde hidropónico de maíz con riego de agua cada 24 horas. Revistas Abanico, 6(1), 6.

González M., E., Ceballos M., J., & Benavides B., O. (2015). Producción de forraje verde hidropónico de maiz Zea mays L. en invernadero con diferentes niveles de silicio.

Revista de Ciencias Agrícolas, 32(1), 75–83. https://doi.org/10.22267/RCIA.153201.26

Trevizan Rispoli, J. F., Challapa Moscoso, G. A., Trevizan Rispoli, J. F., & Challapa Moscoso, G. A. (2020). Comparación del rendimiento de forraje verde hidropónico con maíz lluteño y maíz comercial, utilizando cuatro calidades de agua. Arica, Chile. Idesia (Arica), 38(3), 113–122. https://doi.org/10.4067/S0718-34292020000300113

Candia, L. (2015). Evaluación de la Calidad Nutritiva de Forraje Verde de Cebada Hordeum vulgare Hidropónico, fertilizado con soluciones de guano de Cuy Cavia porcellus a dos concentraciones. Salud y Tecnología Veterinaria, 2(1), 55–62. https://doi.org/10.20453/STV.V2I1.2202

Quispe Cusi, A., Paquiyauri, Z., Ramos, Y. V., Contreras, J. L., & Véliz, M. A. (2016). Influencia de niveles de azufre en la producción, composición química bromatológica y digestibilidad del forraje verde hidropónico de cebada (Hordeum vulgare L.). Revista de Investigaciones Veterinarias Del Perú, 27(1), 31–38. https://doi.org/10.15381/RIVEP.V27I1.11457

Montalvan, H., & Cardenas, I. (2022). Estudio de Factibilidad del cultivo de pasto hidropónico como alimentación continua durante todo el año para ganado caprino lechero [Universidad Privada Antenor Orrego]. http://repositorio.upao.edu.pe/handle/20.500.12759/8697

Eslava, A. (2017). Evaluación del forraje verde hidropónico de arroz (oryza sativa) como alternativa para alimentación animal [Universidad Francisco De Paula Santander]. https://repositorio.ufps.edu.co/handle/ufps/4374

Espinosa, W. (2019). Evaluación de densidades de siembra en maíz, arroz y frijol vigna en la producción de forraje verde

hidropónico. Revista Investigaciones Agropecuarias. Revista Investigaciones Agropecuarias, 1(2), 13.

http://200.46.139.234/index.php/investigaciones_agropecuarias/article/view/493

Condori, K., & Jefry, F. (2019). Efecto del nitrógeno en el crecimiento y rendimiento en forraje verde hidropónico de maíz (Zea mays L.), cebada (Hordeum vulgare L), arroz (Oryza sativa L.) y sorgo (Sorghum vulgare L.). [Universidad Nacional de Tumbes]. http://repositorio.untumbes.edu.pe/handle/20.500.12874/767

Salas, L. (2015). Maíz (Zea mays) producido en invernadero bajo fertilización orgán - Search. Interciencia, 37(3), 7.

https://www.bing.com/search?q=ROPÓNICO+DE+MAÍZ+(Zea+mays)+PRODUCIDO+EN+INVERNADERO+BAJO+FERTILIZACIÓN+ORGÁN&cvid=f21a442eb0a54dd0b8ae01a2b90a7858&aqs=edge..69i57j69i11004.1380j0j1&pglt=41&FORM=AN NAB1&PC=HCTS

Yhony, V.-L., Fernando, A.-V., Francisco, O.-I., Luis, A.-C. J., Julio, G.-O., Del, D., Resumen, A., & De, D. (2018). Producción de tres variedades de Forraje verde hidropónico con diferentes dosis de fertilizante nitrogenado Production of three varieties of hydroponic green forage with different doses of nitrogen fertilizer. Journal of the Selva Andina Research Society. Bolivia. All Rights Reserved., 9(2), 7. www.sanvicente.

Mokhtar, A. R. R. A. S. . (2022). Development Of Saponin Based Wettable Powder Formulation from Phaleria macrocarpa To Control Pomacea maculate. Journal Of Advanced Zoology, 43(1), 17–31. Retrieved from http://jazindia.com/index.php/jaz/article/view/111

Beltrano, J., & Gimenez, D. O. (2013). Cultivo en hidroponía, Facultad de ciencias agrarias y forestales. http://sedici.unlp.edu.ar/bitstream/handle/10915/46752/Documento_completo.pdf?seq uence=1#:~:text=La disponibilidad de agua y,en el rendimiento del cultivo.

Patricia, P., Acosta, L., Cano Montes, A., Sonia, G., De, R., Rocha, L. A., Flores, N. T., Margarita, S., Rodríguez, R., & Ricardo, Y. (2015). Densidad de población en cultivo hidropónico para la producción de tubérculo-semilla de papa (Solanum tuberosum L.). Scielo.Org.Mx, V(2), 12. http://www.scielo.org.mx/scielo.php?pid=S1027-152X2009000500005&script=sci_abstract&tlng=pt

Osorio, C. (2017). Repositorio Institucional de la Universidad de Guanajuato: Diseño de un sistema mezclador de soluciones nutritivas usadas en cultivos hidropónicos [Universidad de Guanajuato]. http://repositorio.ugto.mx/handle/20.500.12059/5271

Núñez-Torres, O. P., & Guerrero-López, J. R. (2021). Forrajes hidropónicos: una alternativa para la alimentación de animales domésticos. Journal of the Selva Andina Animal Science, 8(1), 44–52. https://doi.org/10.36610/J.JSAAS.2021.080100044

Arias, R. O., Muro, M. G., Marino, B., Trigo, M. S., Boyezuk, D., & Cordiviola, C. Á. (2019). Aporte nutricional del Forraje Verde Hidropónico en la alimentación de cabras cruza criollas x Nubian. Revista de La Facultad de Agronomía, 118(1), 137–144. https://doi.org/10.24215/16699513E013

Soto-Bravo, F., Rodríguez-Ocampo, G. A., Soto-Bravo, F., & Rodríguez-Ocampo, G.

A. (2021). Crecimiento, evapotranspiración y uso de nutrientes en cultivo hidropónico de Eryngium foetidum, en dos diferentes ambientes y niveles de nutrición. Agronomía Costarricense, 45(1), 19–40. https://doi.org/10.15517/RAC.V45I1.45674

Soriano, A., Castell, V., & Lidón, A. (2016). Acta de horticultura Comunicaciones Técnicas Sociedad Española de Ciencias Hortícolas. VII jornadas del grupo de fertilización Una fertilización más eficiente es posible Editores: Josep Llinares Inmaculada Bautista Cristina Lull Nùria Pascual. VII Jornadas Fertilización SECH. Acta de Horticultura 82, 7(3), 7.

Vekhnik , V. A. . (2022). Postembryonic Development of The Edible Dormouse (Glis Glis Linnaeus, 1766). Journal Of Advanced Zoology, 43(1), 32–42. Retrieved from http://jazindia.com/index.php/jaz/article/view/112

Lopez, R., Wilfredo, M., & Ruiz, P. (2019). Evaluación de la dosis de caldo de humus de lombriz bajo sustrato sólido hidropónico en el cultivo de la Paprika (Capsicum annuum L.) en condiciones de ambiente protegido en la ciudad de El Alto. Revista de La Carr.deIngeniería Agronómica, 5(3), 9.

http://apthapi.agro.umsa.bo/index.php/ATP/article/view/38/35

Serrano, J., Aquino, R., Macedo, R., Alvarez, O., & Mayoral, M. (2021). Sistema automatizado de monitorización y control para cultivos hidropónicos. Revista de Difusión Científica Ingenierías y Tecnologías., 15(3), 6.

http://difu100cia.uaz.edu.mx/index.php/difuciencia/article/view/212/152

Mirabá, C. (2015). Repositorio Universidad Estatal Península de Santa Elena: Cinética de degradación y digestibilidad del forraje verde hidropónico de maíz (Zea maíz) en cabras criollas en Santa Elena, Ecuador [Universidad Estatal Península de Santa Elena]. https://repositorio.upse.edu.ec/handle/46000/2214

Coveña, N. (2021). Repositorio Universidad de Guayaquil: Desarrollo de forraje verde de cebada (Hordeum vulgare) en condiciones hidropónicas [Universidad de Guayaquil]. http://repositorio.ug.edu.ec/handle/redug/56260

Alaa M. Alrudainy. (2022). Utilization The Fungus of Mycorrhriza to Control Bean Root Rot Caused by Pathogenic Fungi Rhizoctonia Solani. Journal Of Advanced Zoology, 43(1), 96–103. Retrieved from http://jazindia.com/index.php/jaz/article/view/140

Ramos F., E., Contreras P, J. L., Cordero F., A. G., Curasma C., J., Ordoñez M., B. J., Paytan, M. E., Rojas D.L.C., Y. C., Castrejon V., M., Ramos F., E., Contreras P, J. L., Cordero F., A. G., Curasma C., J., Ordoñez M., B. J., Paytan, M. E., Rojas D.L.C., Y. C., & Castrejon V., M. (2021). Rendimiento hidropónico del asociado de vicia con avena, cebada y trigo en la producción de germinados. Revista de Investigaciones Veterinarias Del Perú, 32(6), 21678. https://doi.org/10.15381/RIVEP.V32I6.21678

Cunuhuay, O. (2013). Repositorio Digital Universidad Técnica de Cotopaxi: Niveles de forraje verde hidropónico de maíz en la dieta alimenticia en engorde de cerdos mestizos en el cantón la Maná [Universidad Técnica de Cotopaxi]. http://repositorio.utc.edu.ec/handle/27000/1634

Calani, R. (2021). Aplicación de promotores naturales de crecimiento en el cultivo de cebada (Hordeum vulgare L.) como forraje verde hidropónico [Universidad Mayor San Andrés]. https://repositorio.umsa.bo/handle/123456789/25611

Ballén, A. (2017). Lumieres - Repositorio institucional Universidad de América: Estudio de factibilidad para la elaboración de un plan de negocio relacionado a la producción de forraje verde hidropónico como suplemento alimenticio de ganado lechero [Universidad de América]. http://repository.uamerica.edu.co/handle/20.500.11839/6526