Colegio de Postgraduados

Technical Assistance and Adoption of Technological Innovations: Analysis of GGAVATT Pig Producers in Guanajuato, Mexico

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ABSTRACT

Objective: To evaluate the level of adoption of technological innovations (TIs) and the effect of pig producers' participation in the GGAVATT model in the state of Guanajuato.

Design/methodology/approach: Monthly data from 5,162 records of 260 pig farmers who received technical assistance and training (TAT) through the GGAVATT model from 2014 to 2020 in Guanajuato were analyzed. The data included participation in meetings, training sessions, and technology transfer tours, as well as the implementation of 25 technical interventions (TIs). Five synthetic variables were constructed as adoption indices (AIs) of TIs: Technical Assistance and Training (TAT), Management (M), Nutrition (N), Reproduction and Genetics (RG), and Health and Biosecurity (SB). To evaluate the effect of technical assistance (TA) on the use of TIs, producers were classified into three levels according to their participation in GGAVATT: 1 year, 2-3 years, and 4-5 years. The five indices were calculated for each participation level.

Results: The estimated AI values by level of participation of pig farmers in the GGAVATT were 0.38, 0.40, and 0.46 for TAyC; 0.51, 0.55, and 0.62 for M; 0.58, 0.61, and 0.69 for N; 0.53, 0.61, and 0.66 for RyG; and 0.53, 0.58, and 0.63 for SyB.

Limitations on study/implications: While all the AIs changed positively, the transition from a semi-technified to a technified production system was not achieved. Therefore, future studies should analyze other factors that limit IT adoption.

Findings/conclusions: The TAT activities provided to pig farmers through the GGAVATT model positively influence the adoption of technological innovations, with the strongest effect observed in the area of nutrition.

Keywords: Livestock technology, Livestock groups, Pig farming.

Citation: Espinosa-García, J. A., Vélez-Izquierdo, A., & González-Orozco, T. A. (2026). Technical Assistance and Adoption of Technological Innovations: Analysis of GGAVATT Pig Producers in Guanajuato, Mexico. *Agro Productividad*. https://doi.org/10.32854/twhj8a58

Academic Editor: Jorge Cadena Iñiguez
Associate Editor: Dra. Lucero del Mar Ruiz Posadas
Guest Editor: Juan Francisco Aguirre Medina

Received: XXXX XX, 2025.
Accepted: March 12, 2026.
Published on-line: May XX, 2026.

Agro Productividad, 19(4). April. 2026. pp: 233-242.

INTRODUCTION

Livestock production focuses on generating animal protein to feed the population. In 2024, meat consumption in Mexico reached 10.8 million tons, of which 30.2% was pork, ranking second after poultry (COMECARNE, 2025). Meat production depends on the physiological development of sows and their offspring, which in turn is influenced by agroclimatic factors and the use of technology. In this context, technological innovations play a key role in ensuring the success of livestock production units (Montero *et al.*, 2015).

According to Quintero *et al.* (2021), technological innovation promotes changes in production processes through the adoption of technologies, procedures, new forms of organization and production management, which improve productivity and the efficient use of production factors. Although the concept of innovation has often been addressed from a business perspective, there is sufficient literature indicating its application to agricultural and livestock enterprises (Racewicz *et al.*, 2021; Sánchez *et al.*, 2022; Granada *et al.*, 2021).

Technological innovation materializes through adoption, which measures the outcome of producers' decisions to use or not a given innovation in the production process (Martínez *et al.*, 2018). In the case of agricultural and livestock innovation, this process is complex and is defined as a set of organizations with links and interactions among them, dedicated to: i) generation, ii) validation, iii) adaptation, iv) transfer, v) dissemination, and vi) adoption of technologies and knowledge for problem solving (Quintero *et al.*, 2021). For the first three stages, research institutions are primarily involved, although in some cases they also participate in technology transfer and dissemination. An example of this is the GGAVATT model (Grupos Ganaderos de Validación y Transferencia de Tecnología), which was developed by the National Institute of Forestry, Agricultural, and Livestock Research (INIFAP) in Veracruz. Its objectives are to validate and transfer livestock technology to organized groups of producers (Román *et al.*, 2021). One of the states where this model has been successfully applied is Guanajuato, where the state government has promoted the use of technological innovations under the GGAVATT model since 2002, supporting an average of 77 groups per year (Román *et al.*, 2021). One of the animal protein production systems that has benefited from this model is the pig production system.

In Mexico, pig production is highly important as it provides meat, generates employment, and adds value. It is based on three production systems: a) technified, b) semi-technified, and c) backyard or artisanal (Alonso and Rodríguez, 2024). The system that predominates in the state of Guanajuato is the semi-technified system, which is characterized by traditional facilities, medium productivity, and poor animal health.

In 2023, 140,169 tons of pork were produced, with 16,412 production units housing 1,746,492 pigs, with an average carcass weight of 80 kg (Alonso and Rodríguez, 2024). Pork production is one of the most dynamic livestock activities (SIAP, 2022); for this reason, GGAVATT groups of pig producers have been established in Guanajuato, receiving technical assistance and training from livestock technicians. Through this model, a technological package consisting of 25 technical assistance, training, management, and technological innovation activities is promoted, although the effect of this model on the adoption of these practices remains unknown. The objective of this study was to evaluate the level of adoption and the effect of participation in GGAVATT among pig producers in the state of Guanajuato, Mexico.

MATERIALS AND METHODS

Variables and Information Sources

The study was conducted in the state of Guanajuato using information from pig farmers organized in informal groups within the pork production system, who receive technical

assistance and training from livestock technicians (Román *et al.*, 2021). The methodological strategy applied with these producers is based on the GGAVATT model, which includes the establishment of technical, economic, and technology-use records (Román *et al.*, 2021). Therefore, monthly information on the application of a technological package is available.

For this research, monthly data from 5,162 records of 260 pig producers who received technical assistance through the GGAVATT model between 2014 and 2020 were compiled and analyzed. The study covered five municipalities: León, Moroleón, Pénjamo, Tarimoro, and Yuriria in Guanajuato (Figure 1).

The information was obtained from monthly monitoring forms in which each advisor recorded the participation of producers in GGAVATT monthly meetings, the training sessions provided, and the scheduled technology tours. Additionally, participation in management activities, practices, and technological innovations implemented by each producer during the month of record was documented, assigning a value of 1 if performed and 0 if not (Table 1). The data were compiled into a database using Excel®.

Figure 1. Location of GGAVATT pig producer groups in the state of Guanajuato.

Table 1. Synthetic variables used.

Synthetic variables	Activity, practice, and technological innovations
Technical assistance and training	1) Monthly meeting, 2) Training course or workshop, 3) Training in the use of artificial insemination, and 4) Technological tours.
Management	1) Permanent numerical identification, 2) Individual female record, 3) Recording of piglet birth date and weight, 4) Recording of piglet weaning date and weight, 5) Record of initial age and weight for fattening, 6) Record of age and weight at the end of fattening, and 7) Record of monthly income and expenses.
Nutrition	1) Use of concentrates/premixes and 2) Management of balanced diets by production stage.
Reproduction and Genetics	1) Use of farrowing crates, 2) Breeding stock selection, 3) Use of artificial insemination, 4) Raising of replacement gilts, and 5) Use of maternal lines.
Health and Biosecurity	1) Internal and external deworming, 2) Vaccination against viral diseases, 3) Washing and disinfection of facilities, 4) Biosecurity measures, 5) Ammonia control, 6) Rodent control, and 7) Temperature control.

Source: Author's elaboration, based on data available from the Bajío Experimental Station, INIFAP.

Estimation of Technological Innovation Adoption Indices

Based on the previously mentioned database, five synthetic variables were constructed as technological indices by livestock area (Table 1). To estimate the technological level per production unit, the methodology of technological indices proposed by De Freitas and Pinheiro (2013) was applied, based on the use of the 25 technological activities, practices, or components, which are distributed across five areas (or synthetic variables). Within each area, the variables take a value of 1 or 0, indicating whether they were applied or not. To estimate the synthetic variables, the methodology proposed by Espinosa *et al.* (2018) was adapted. The formula is described below:

$$I_{ij} = \sum_{ij}^{n} \frac{\delta_{in}}{\delta_{i \cdots n}}$$

Where: I_{ij} is the adoption index for livestock area i for producer j, δ_{in} is the actual sum obtained by the producer according to the number of activities, practices, or technological innovations implemented, and $\delta_{i \cdots n}$ is the maximum sum of the n practices or technologies that a producer j can implement in livestock area i. The calculated index values range within the interval $0 > I_{ij} < 1$.

Effect of the GGAVATT Model on Innovation Adoption

To measure the effect of the GGAVATT model on innovation adoption, producers were classified into three levels according to their duration in the group receiving technical assistance: 1 year, 2-3 years, and 4-5 years. The five adoption indices were calculated for each level. Additionally, Pearson partial correlations between the estimated indices were calculated using the statistical software JMP® 17.

RESULTS AND DISCUSSION

GGAVATT for Pig Producers in Guanajuato

The GGAVATT model consists of an organized group for livestock production, in which all enthusiastic farmers receptive to technological changes can participate. Groups are formed with 10 to 20 "friendly" producers whose ranches or farms have similar characteristics and production purposes, such as milk and meat (Galindo, 2001). In Guanajuato, GGAVATT groups have been established for producers in the following production systems: beef cattle, dairy cattle, beekeeping, goats, sheep, and pigs. These producers receive technical assistance and training from livestock technicians to improve productivity, income, family self-employment, and the sustainability of their production units (Román *et al.*, 2021).

This model has been operating in the state since 2002, and in 2024 it served 1,100 farmers organized into 55 groups, who received technical assistance from 55 professionals, mainly veterinarians and livestock agronomists, as well as technical support from a researcher at the National Institute of Forestry, Agricultural, and Livestock Research (INIFAP), affiliated with the Bajío Experimental Station.

In the state of Guanajuato, an average of six GGAVATT pig producer groups were established per year during the 2014-2020 period, serving an average of 138 pig producers. This indicates that each GGAVATT consisted of 23 members, exceeding the number of producers suggested by the model designers, which was a maximum of 20 producers (INIFAP, 2005; Román *et al.*, 2021). The number of GGAVATT pig producer groups during 2014-2020 did not show major variations; however, the number of producers did. As shown in Figure 2, this is because the average number of producers per group increased from 16 in 2014 and 2015 to 30 in the following three years, and then decreased again in 2019 and 2020.

The distribution by year, municipality, gender, and years of participation in the GGAVATT model for the 5,162 records analyzed is presented in Table 2. It can be observed that most records correspond to men, from the municipalities of León, Pénjamo, and Yuriria, and to producers with four or more years in the model.

Adoption of Technological Innovations

The adoption indices of technological innovations by livestock area are presented in Figure 3. It can be observed that all values increased among pig producers who were more consistent in their participation in the GGAVATT.

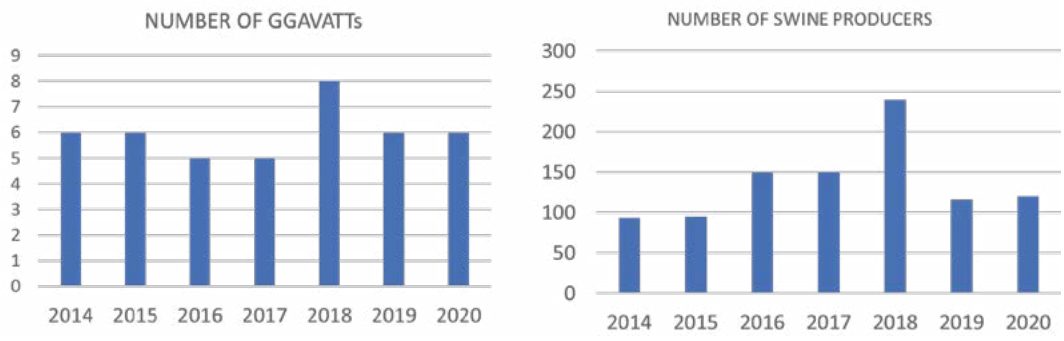

Figure 2. Trends in GGAVATT and the number of pork producers in the state of Guanajuato. Source: Author's elaboration, based on data available from the Bajío Experimental Station, INIFAP.

Table 2. Distribution of pig producers by municipality, level, year, and gender.

Municipality	Frequency	%	Gender	Frequency	%
León	1,261	24.4	Hombre	4,324	83.8
Moroleón	630	12.2	Mujer	838	16.2
Pénjamo	1,279	24.8	**Year**	**Frequency**	**%**
Tarimoro	720	13.9	2014	245	4.7
Yuriria	1,272	24.6	2015	362	7.0
			2016	846	16.4
Level	**Frequency**	**%**	2017	1,110	21.5
Un año	723	14.0	2018	1,110	21.5
2 ó 3 años	2,193	42.5	2019	859	16.6
4 ó 5 años	2,246	43.5	2020	630	12.2

Source: Author's elaboration, based on data available from the Bajío Experimental Station, INIFAP.

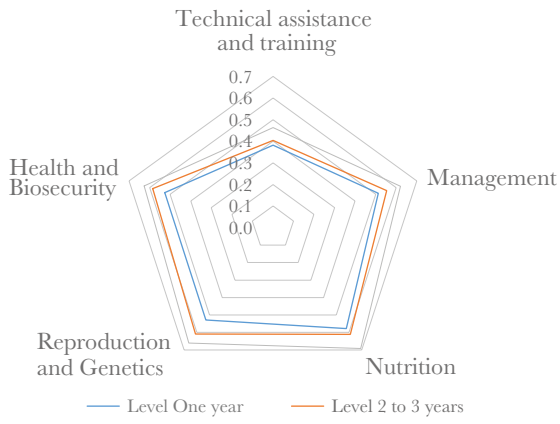

Figure 3. Adoption of health and biosecurity innovations in GGAVATT pig producer groups in Guanajuato, Mexico. Source: Author's elaboration, based on data available from the Bajío Experimental Station, INIFAP.

The index that reached the highest value, almost 0.7, was Nutrition, followed by the indices for Reproduction and Genetics (RG) and Health and Biosecurity (HB), each about three percentage points lower. This indicates that nearly 70% of pig producers incorporated technological innovations in these areas. This value is consistent with the study by Martínez *et al.* (2018) on beekeepers in Campeche, which reported adoption values of good production practices in the categories of artificial feeding and apicultural health of 0.90 and 0.68, respectively. It also aligns with the study by Espinosa *et al.* (2018) on livestock producers in the Mexican tropics, which reported adoption indices for innovations in the areas of nutrition and health of 0.70 and 0.71, respectively. Furthermore, these results show that technical assistance has a positive effect on the adoption of innovations.

By analyzing the change in adoption index values between pig producers with one year of participation in the GGAVATT and those with up to five years, it can be observed that the area with the greatest effect is Reproduction and Genetics, followed by Nutrition and Health and Biosecurity, with increases of 13%, 11%, and 10%, respectively. The positive effect of technical assistance and training in these three areas aligns with a study reported by Forero *et al.* (2013) for dual-purpose cattle producers in rural high-Andean areas of Colombia.

The behavior of the variables that make up each of the indices presented above is described below. Regarding technical assistance and training activities (Aguilar *et al.*, 2003), these are carried out monthly by the technicians with the pig producers. Participation in these activities is shown in Figure 4, where it can be observed that participation is highest in the monthly meetings, which follow a work program designed at the beginning of each year. About 70% of pig producers who join a GGAVATT attend the meetings, increasing their participation to 80% after five years in the program. Participation in training sessions is lower, although it increases among producers who remain in the GGAVATT, reflecting a positive change in their attitude toward training, as noted by González (2021). Finally, participation in technology tours is low, which is justified by biosecurity reasons that recommend restrictions when visiting or being visited by pig production farms (Montero *et al.*, 2015; Racewicz *et al.*, 2021).

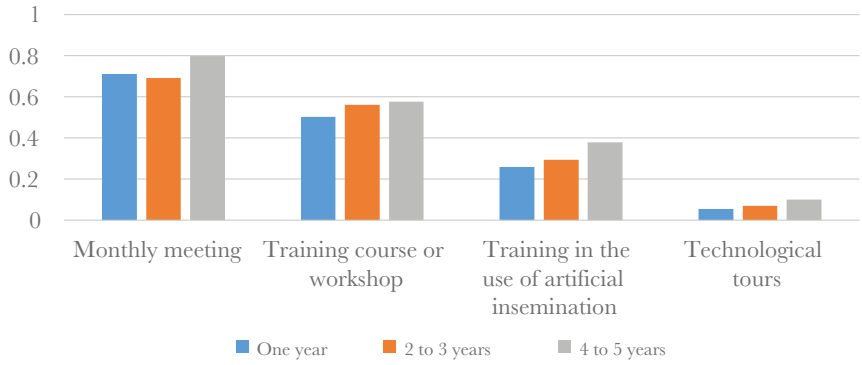

Figure 4. Participation of pig producers in Guanajuato in technical assistance and training activities of the GGAVATT. Source: Author's elaboration, based on data available from the Bajío Experimental Station, INIFAP.

Participation of pig producers in management activities is presented in Figure 5. Across the seven variables considered, a positive change is observed as producers spend more time in a GGAVATT. Recording the identification, dates, and weights of piglets and weaners showed the highest values, although progress in the use of economic records is also important, as it generates information for conducting technical and economic evaluations (Benítez, 2015).

Figures 6, 7, and 8 present the behavior of technological innovations in the Nutrition, Reproduction and Genetics, and Health and Biosecurity indices, respectively. The adoption of these innovations increased positively with longer participation in the GGAVATT, so that more than 50% of pig producers with five years of technical assistance applied most of the recommended innovations. The highest adoption values were observed for the administration of balanced diets by production stage, deworming, use of farrowing crates, use of maternal lines, and rearing of replacement animals.

The use of these innovations does not exceed 80% adoption in any case, which indicates that the technological level of pig farms participating in the GGAVATT in Guanajuato

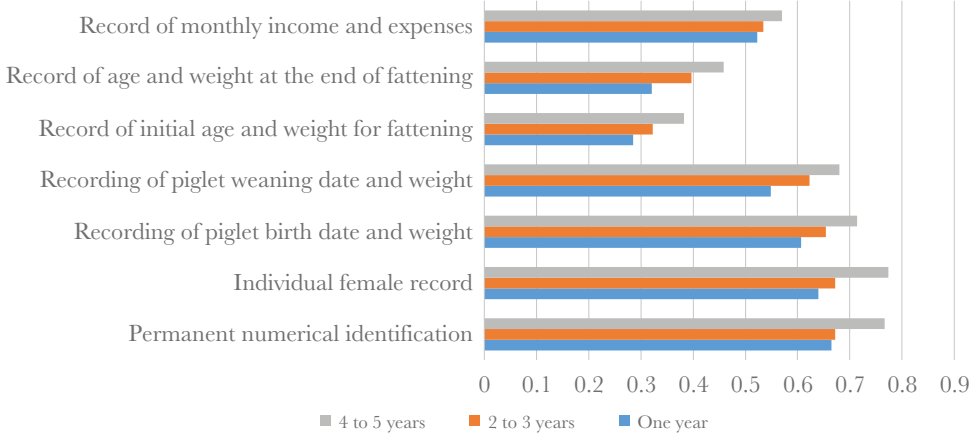

Figure 5. Adoption of management activities in GGAVATT pig producer groups in Guanajuato. Source: Author's elaboration, based on data available from the Bajío Experimental Station, INIFAP.

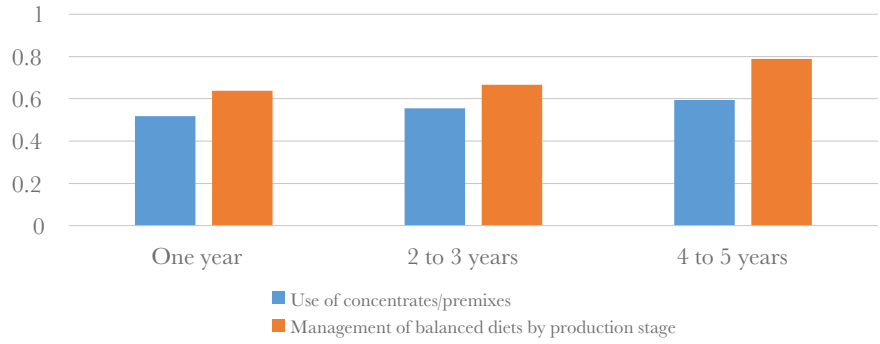

Figure 6. Adoption of animal nutrition innovations in GGAVATT pig producer groups in Guanajuato. Source: Author's elaboration, based on data available from the Bajío Experimental Station, INIFAP.

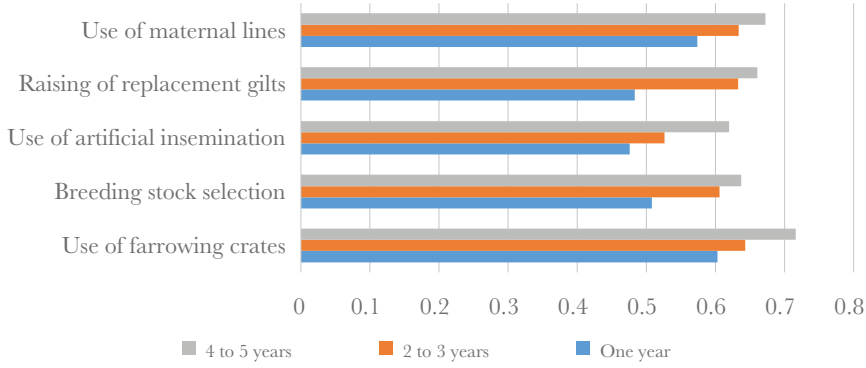

Figure 7. Adoption of reproduction and genetics innovations in GGAVATT pig producer groups in Guanajuato. Source: Author's elaboration, based on data available from the Bajío Experimental Station, INIFAP.

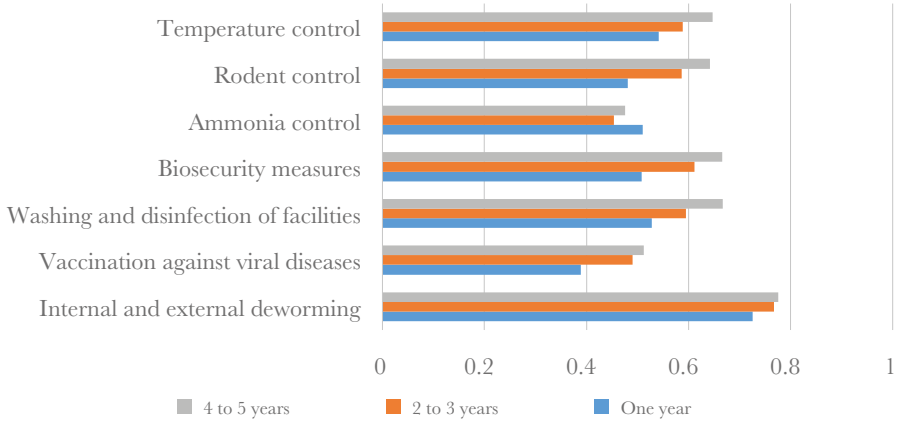

Figure 8. Adoption of health and biosecurity innovations in GGAVATT pig producer groups in Guanajuato, Mexico. Source: Author's elaboration, based on data available from the Bajío Experimental Station, INIFAP.

is consistent with the semi-technified production system (Alonso and Rodríguez, 2024). This also shows a margin for improvement, which may not be achieved through technical assistance alone.

The correlation analysis showed positive and significant values between technical assistance and training and the indices associated with the adoption of technological

innovations. This confirms the positive effect that the technical assistance provided by the technicians implementing the GGAVATT model has on the adoption of technological innovations, as reported by Tejeda *et al.* (2019).

Table 3. Partial correlations.

Item	Technical assistance and training	Management	Nutrition	Reproduction and Genetics	Health and Biosecurity
Technical assistance and training	—	0.080***	0.045**	0.187***	0.165***
Management	0.080***	—	0.409***	0.585***	0.650***
Nutrition	0.045**	0.409***	—	0.447***	0.467***
Reproduction and Genetics	0.187***	0.585***	0.447***	—	0.709***
Health and Biosecurity	0.165***	0.650***	0.467***	0.709***	—

Note. * p<.05, ** p<.01, *** p<.001. Source: Author's elaboration, based on data available from the Bajío Experimental Station, INIFAP.

CONCLUSIONS

The technical assistance and training activities promoted among pig producers participating in the GGAVATT model in the state of Guanajuato have increased the adoption of technological innovations, with the greatest effect observed in the areas of Nutrition and Reproduction and Genetics. The adoption index values reached by pig producers with five years of technical assistance range between 0.46 and 0.69, with the lowest value corresponding to technical assistance and training and the highest to nutrition. This indicates that the level of technological innovation is consistent with a semi-technified production system.

REFERENCES

COMECARNE, Consejo Mexicano de la Carne (2025). Compendio Estadístico 2025. En: https://compendio2025.comecarne.org/.

Montero L., E.M.; Martínez G., R.G.; Herradora L., M.A.; Ramírez H., G.; Espinosa H., S.; Sánchez H., M. y Martínez R., R. (2015). Alternativas para la producción porcina a pequeña escala. UNAM, 1ª Edición. Coyoacán, Ciudad de México. 208 p.

Quintero, S., Ruiz C., W.L., Cubillos J., S.; Marín S., B.M.; Giraldo, D.P. y Vélez A., L.M. (2021). Medición de las capacidades tecnológicas para la innovación en los sistemas de conocimiento e innovación agrícola. *Ciencia y Tecnología Agropecuaria, [online] 22*(1). https://doi.org/10.21930/rcta.vol22_num1_art:1896.

Racewicz, P.; Ludwiczak, A.; Skrzypczak, E.; Składanowska-Baryza, J.; Biesiada, H.; Nowak, T.; Nowaczewski, S.; Zaborowicz, M.; Stanisz, M. and Slósarz, P. (2021). Welfare Health and Productivity in Commercial Pig Herds. *Animals*, 11, 1176. https://doi.org/10.3390/ani11041176.

Sánchez S., R.; Gómez F., E.; Córdova I., A.; De la Cruz V., P. y Martín L., M. (2022). Evolución de los sistemas productivos en ganado porcino. *Rev. Fac. Nac. Agron. Medellín, 75*(Suplemento):34-38.

Granda R., D.; Herrera G., F.; Romero B., W. y Mora S., N., (2021). Implementación de modelo de gestión para granjas porcinas en la provincia de El Oro. *593 Digital Publisher CEIT, 6*(6):222-233. https://doi.org/10.33386/593dp.2021.6.737.

Martínez G., E.G.; Arroyo P., H.; Aguilar G., N.; García Á., J.M.; Santoyo C., V.H. y Aguilar Á., J. (2018). Dinámica de adopción de buenas prácticas de producción de miel en la península de Yucatán, México. *Rev Mex Ciec Pec. 9*(1):48-67. http://dx.doi.org/ 10.22319/rmcp.v9i1.4366.

Román P., H.; Rodríguez Ch., M.A.; Espinosa G., J.A.; González O., A.T.; Vélez I., A.; Zárate A., J.P.; Valdovinos T., M.E.; Aguilera S., R.C.; Guarneros A., R.; Santos E., R.; Bueno D., H.M. y Aguilar B., U. (2021). Historia y perspectivas del modelo GGAVATT. *Rev Mex Ciec Pec. 12*(supl 3):286-307. http://dx.doi.org/ 10.22319/rmcp.v12s3.5846

Alonso P., F.A. y Rodríguez de J., E. (2024). El Sector Porcino en México. *Los Porcicultores y su Entorno*, 158:76-84.

SIAP, Servicio de Información Agroalimentaria y Pesquera. (2022). Guanajuato, Infografía Agroalimentaria 2022. SIAP. Miguel Hidalgo, Ciudad de México. 55p.

De Freitas B., W. y Pinheiro DeS., E. (2013). Nível tecnológico e seus determinantes na apicultura Cearense. *Revista de Política Agrícola, XXII*(3):32-47.

Espinosa G., J.A.; Vélez I., A.; Góngora G., S.F.; Cuevas R., V.; Vázquez G., R.; y Rivera M, J.A. (2018). Evaluación del impacto en la productividad y rentabilidad de la tecnología transferida al sistema de bovinos de doble propósito del trópico mexicano. *Tropical and Subtropical Agroecosystems, 21*(2): 261–272. http://dx.doi.org/10.56369/tsaes.2411.

Galindo, G. G. (2001). Uso de innovaciones en el Grupo de Ganaderos para la Validación y Transferencia de Tecnología Joachin, Veracruz, México. *Terra Latinoamericana*. 19:385-392.

INIFAP, Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias. (2005). Contribuciones del Modelo GGAVATT al desarrollo de la ganadería: Testimonios. INIFAP. Publicación especial No. 1. 185 p.

Forero C., C.A.; Rojas C., G.H. y Argüelles C., J.H. (2013). Capital social y capital financiero en la adopción de tecnologías ganaderas en zonas rurales altoandinas de Colombia. *Corpoica Cienc. Tecnol. Agropecu. 14*(2):149-163.

Aguilar B., U.; Amaro G., R.; Bueno D., H. M.; Chagoya F., J. L.; Koppel R., E. T.; Ortiz O., G. A.; Pérez S., J. M.; Rodríguez Ch., M. A.; Romero F., M. Z. y Vázquez G., R. (2003). Manual para la formación de capacitadores Modelo GGAVATT. Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y alimentación (SAGARPA). Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias (INIFAP). Centro de Investigación Regional del Centro (CIRCE). Campo Experimental Zacatepec. 186 p.

González B., H.A. 2021. Capacidades: (otra vez) un análisis conceptual y metodológico. *Intersticios sociales*, 21:9-43.

Benítez M., A.; Gómez G., A.; Hernández B., J.; Navarrete M., R. y Moreno F., L. (2015). Evaluación de parámetros productivos y económicos en la alimentación de porcinos en engorda. *Abanico veterinario, 5*(3):36-41.

Tejada E., G.C.; Cruz M., J.M.; Uribe H., Y.C. y Ríos H., J. J. (2019). Innovación tecnológica: Reflexiones teóricas. *Revista Venezolana de Gerencia, 24*(85):1-10.