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Social network of producers of dehydrated products with thermosolar technology in Zacatecas, Mexico

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ABSTRACT

Objective: To analyze the social networks and the trust there is among the producers of dehydrated products with thermosolar technology in the agricultural strip of Zacatecas, in order to determine the organizational potential through prevailing levels of trust between producers.

Design/methodology/approach: A survey was applied to 30 producers of dehydrated products who have received training and information about the use of the thermosolar plant, all belonging to the state of Zacatecas. Indicators were used for the social networks analysis.

Results: The results confirmed the importance of direct and indirect links; of all the producers, eighteen had no relationship with any other producer, although the rest showed at least one interaction with another producer. The producers have notable characteristics and acceptable trust relationships.

Limitations on study/implications: The results apply to the selected sample; thermosolar food dehydration technology is still unknown among the producers.

Findings/conclusions: Trust relationships must be strengthened and strategies should be created to disseminate knowledge in a timely and efficient manner with key stakeholders and thus boost their pre-existing interactions.

Keywords: technology, solar energy, food.

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INTRODUCTION

One of the greatest problems that humanity faces currently is the balance between food production and consumption (Murthy, 2009). A way of reducing the loss and waste of foods is through conservation techniques, among which moisture removal from fresh products without processing stands out, minimally processed by drying (using environmental conditions) or by dehydration (using artificial heat) (De Michelis and Ohaco, 2022). Both techniques are used to eliminate water from the enzymes and

microorganisms responsible for the deterioration of products. Dehydration allows conserving and maintaining the quality of the foods for a longer time, favoring the addition of value and their availability (Menchaca and Recio, 2017). Solar dehydration is one of the simplest and most inexpensive techniques, given the availability of electromagnetic radiation from the sun (Guzmán *et al.*, 2020).

The state of Zacatecas has an important tradition using the techniques of drying and dehydrating of horticultural products such as chili peppers, garlic, fruits and vegetables. In 2017, in Morelos, Zacatecas, a thermosolar plant was established to dehydrate horticultural products and, thus, take advantage of the privileged total annual solar irradiance (520 W/m^2) in benefit of the agroindustrial sector of the state (UNAM, 2017). In 2021, the activities of this plant were taken up again to promote their use among farmers with equipment and modernization of this biospace, which provides training and technical assistance to producers in the process of dehydration and value aggregation to various agricultural and livestock products.

The response from farmers has been positive in the elaboration of dehydrated byproducts based on guajillo chili pepper, garlic, peach, apple, nopal, tomato, celery, cilantro and beef. In addition, individually, producers have sought different means of commercialization of their products in stores, fairs, government offices and schools. However, there is the urgent need for strategies that allow the appropriate organization to become integrated as micro-businesses in the generation of agricultural products with added value (Poot *et al.*, 2021). Nevertheless, there is a need to identify the most recommendable legal and organizational figure for these producers, based on the existing trust between them (Luna and Velasco, 2005; Figueroa-Rodríguez *et al.*, 2012). For Cevallos *et al.* (2020) trust constitutes a key component of social capital to favor cooperation and to solve collective action problems, which, at the same time, allow better levels of development. Therefore, the analysis of trust between producers of dehydrated products is fundamental to reinforce the cooperation between them and to strengthen the participation of these in exchange networks for information, knowledge and technology.

This information can be obtained through Social Networks Analysis (SNA). SNA is a quantitative method that studies the social structure from regularities in the pattern of relationships established between social entities (for example, people, groups or organizations) (Kuz *et al.*, 2016). In turn, Aguirre (2011) defines a social structure as a social network composed by a finite group of actors and configured around a series of relationships between them, which can be represented in the form of one or several graphs. The graphs are made up of nodes that are related with other nodes through connections named edges that allow studying the existing relationships between them (Clark, 2006).

SNA has been used to determine the importance in the type of relationship, the levels of trust, and the organization between agricultural producers (Figueroa-Rodríguez *et al.*, 2012) to define the process of information and knowledge exchange for agricultural innovation (Monge and Hartwich, 2008; Aguilar-Gallegos *et al.*, 2016; Villarroel-Molina *et al.*, 2019), and to analyze the commercial relationships between

different links in the value chains (Callejas *et al.*, 2020). However, although this tool contributes to a starting point to develop a better understanding of the direct and indirect interactions between farmers and other stakeholders, something true is that there are no studies about the relationships of trust there are between producers already linked to the market of dehydrated products in the state. Therefore, this study sought to decrease the gap present in the literature. The objective of this study was to analyze social networks and the trust there is between producers of dehydrated products with thermosolar technology in the agricultural strip of Zacatecas, with the aim of defining the potential for organization through the prevalent levels of trust between producers. The hypothesis suggested was that producers of dehydrated products have established networks, although this does not imply that they are stakeholders that have high levels of trust.

MATERIALS AND METHODS

A survey was applied to 30 producers who participated in the use of the thermosolar plant in Zacatecas. Based on what was presented by Figueroa-Rodríguez *et al.* (2012), the instrument applied was designed to capture information referring to the following points: 1) general information of the producers; and 2) record of the names of other producers that dehydrate agricultural products in Zacatecas. They were asked about the importance according to the type of relationship for family members, friends, neighbors and business acquaintances and the level of trust of each, expressed in an ordinal scale of 1 to 5 (where 1 is not having any trust, 2 has almost no trust, 3 has regular trust, 4 has plenty trust, and 5 has absolute trust); they were also asked if they would lend money, if they would ask to borrow money, and if they would make a society, and the responses to these questions were expressed in a nominal scale of yes or no and considered as a measurement for the level of trust between stakeholders. The surveys were applied during the months of September and October 2022.

Information analysis

For the social networks analysis, the information was codified and registered in databases to construct a mode-one network, in which each node can be related to any other network (Aguilar-Gallegos *et al.*, 2016). SNA indicators were estimated in the symmetrical matrix made up by the producers surveyed, which were the size of the network, the density, and the index of centralization (entry and exit).

The size of the network corresponded to the number of producers who have a relationship with other producers. The stakeholders are linked one to the other through social, technical, management or commercial links; these "links" are represented with lines. Thus, a link is established between two stakeholders when they are related in some sphere (Rendón *et al.*, 2007).

The density of the network is the percentage of existing relationships between the ones possible to carry out (Equation 1) (Rendón *et al.*, 2007); the density (D) was calculated according to the next formula:

$$D = \frac{1l}{n(n-1)} * 100 \quad (1)$$

Where l was the number of existing relationships divided by the number of possible relationships $n(n-1)$. If the value of D was 100%, then the interpretation is that the network is completely articulated and there is an optimal information flow between stakeholders.

The centralization index measures the degree at which a stakeholder is dominant in the network (Aguilar *et al.*, 2017). The values will range between 0 and 1, with 1 being the value for the most centralized graph and there are no links between the other stakeholders and zero when there is no dominating stakeholder and all stakeholders are linked between one another (Cuevas-Reyes *et al.*, 2016; Aguilar *et al.*, 2017). The degree of centralization of entry was estimated to identify the nodes that serve as an important source of information and the degree of centralization of exit to identify the stakeholder who obtains information from different stakeholders.

The Kruskal-Wallis non-parametric test with a significance level of 5% was used to identify the differences between the groups by type of relationship, the importance that they gave to it, and the level of trust. The hypothesis considered was: H_0: the level of trust is equal for family members, friends, neighbors and business acquaintances. The Wilcoxon test with a significance level of 5% was used to establish the differences between the qualitative variables of importance of the relationship and the level of trust. The null hypothesis established for this test was: H_0: the importance given to the relationship is equal to the level of trust in the producers.

With the questions about whether they would lend or ask to borrow money and if they would form a society, 2×2 contingency tables were made, which were used to calculate the coefficient *Phi* (r_{φ}) that determined the correlation between two variables in nominal scale. Finally, three logistic regression models were estimated to calculate the probability of loaning money, borrowing money and making a society (Figueroa-Rodríguez *et al.*, 2012); the Wald entry method was used for the selection of the variables to be included in the model. The empirical model estimated was:

$$P(Y / X) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 x)}} + \varepsilon \quad (2)$$

Where β_0 and β_1 were the coefficients of the regression model and the term ε represents the residual error.

The social networks analysis was carried out with the UCINET 6 software for Windows and NetDraw 2.141; while the statistical analysis of the ordinal variables (means and standard deviation), correlation tests and logistic regression models were conducted with the SPSS 27.0 software for Windows (IBM, 2022).

RESULTS AND DISCUSSION

Characteristics of the survey respondents

The producers surveyed were mainly men (93%) and only 7% women, with an average age of 48 years, which ranged between 25 and 75 years, and have on average 20 years of experience with the process of dehydration. Of the survey respondents, 6.7% have primary school studies, 26.7% secondary school, 13.3% high school, 40% undergraduate studies, and 13.3% graduate studies. These results reaffirm what was found by Minjarez *et al.* (2019) in the characterization and classification of producers from the western highlands in San Luis Potosí and what was mentioned by the OECD (2007); the organization stated that the sociocultural and economic traits present in producers from a certain region could also be found throughout the Mexican territory. However, the condition of the farmers surveyed (young and trained adults) will allow generating efficient strategies for training in technological innovations and new management plans, and to improve the commercialization channels.

From the survey respondents, 83.3% had agriculture as the main activity and 16.7% have established a business of their own. However, 58.6% of the total involved mentioned that their income comes from dehydrated products that they trade; 50% have a legally established business where they commercialize their dehydrated products, while the other 50% do not have a legally constituted business and trade informally. The businesses constituted have been functioning for 2 to 50 years, with an average of 14±13 years; annually, they generate 13±21 permanent jobs and 34±35 occasional jobs. In this sense, Acevedo (2017) stated that in most of the world there is an individualistic mentality that makes associations difficult. For their part, González and González (2017) mentioned that the sense of organizing formally has decreased from past experiences that have not had favorable results, in addition to the uses, customs, culture and ideology of the collaborating agent (Tamayo *et al.*, 2019).

Of the producers, 58.8% dehydrate chili pepper and this trend is derived from the productive tradition of the state, since at the national level, Zacatecas has been characterized as being the main producer of dry chili pepper. This agrifood chain is socially and economically strategic for the state and for the generation of jobs in production and commercialization of the product (Aguilar and Esparza, 2010). Other products that are dehydrated in the state are nopal, apple, strawberry, fig, pineapple, celery, parsley, tomato, onion, garlic and dry meat. The diversification of products is something key in Zacatecas, and thus 13.3% of the survey respondents dehydrate more than one product. Although 50% of the survey respondents grow their own raw materials, the remaining 40% acquire it through another producer.

Social networks of producers of dehydrated products

An asymmetrical matrix was constructed with the information gathered, which derives into a total of 85 names mentioned, of which 9 were producers interviewed and 55 were not registered. Figure 1 shows the existence of names referenced most frequently, which means that they have a larger number of networks. However, as mentioned by Figueroa-Rodríguez *et al.* (2012), the fact that a producer has many networks does not imply that he is a stakeholder that has high levels of trust.

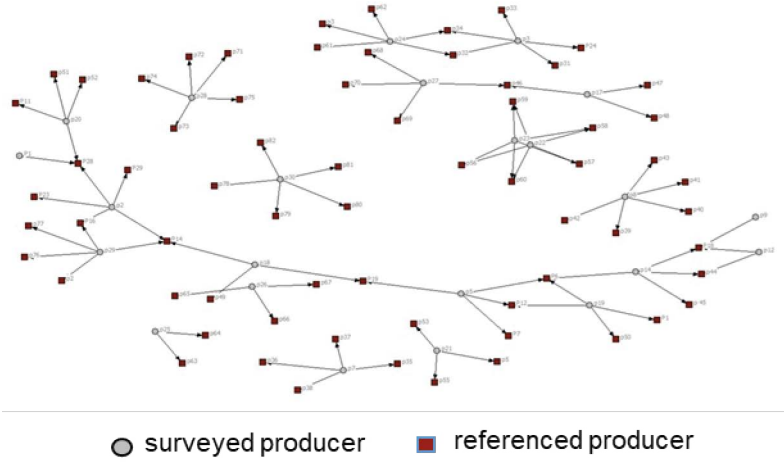

Figure 1. Reference network of the producers of dehydrated products.

The social network of producers of dehydrated products is presented in Figure 2. There were 18 producers who did not have any relationship with any other producer; however, the rest showed having at least one interaction with another producer. The network of dehydrating producers was formed by a total of 12 nodes and 15 relationships (Figure 2). The density of the network was 3.4%, that is, from every 100 relationships, only three materialized. The network was more centralized in degrees of exit (14.27%) than of entry (10.70%); that is, in the network there is one or more modes that are dominant in the establishment of exit links, for this case it was seen that producers 2, 19, 5 and 18 referred between 5 and 3 producers with whom they maintained links. Regarding the stakeholders with more degree of entry, they were producers 5, 18, 14 and 6 with 4 to 3 producers who were their source of information (Cuevas-Reyes *et al.*, 2016; Aguilar *et al.*, 2017).

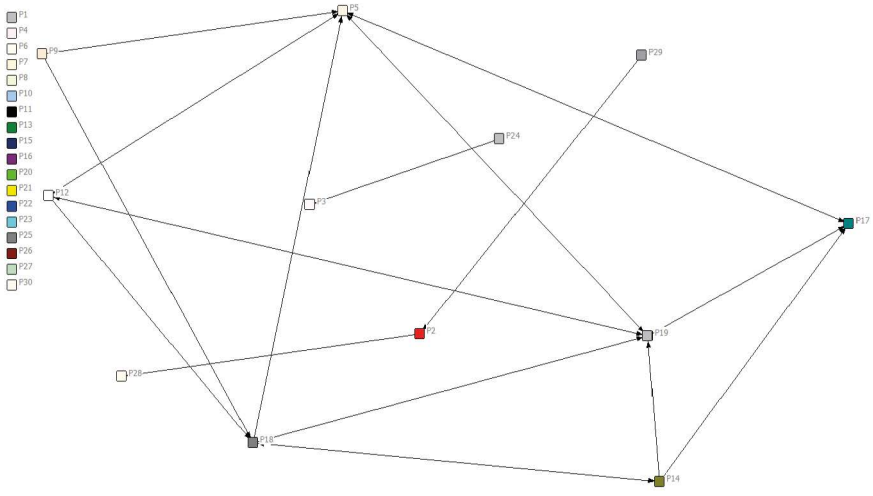

Figure 2. Social network of producers of dehydrated products.

Trust between producers

The trust demonstrated by producers in relation to family members was 75% of absolute trust and 25% of plenty trust. Regarding the relationship with friends, 28% had regular trust, 30% plenty trust, and 42% absolute trust. Of the survey respondents, 44% refer that they maintained a level of plenty trust with their business acquaintances and for 49% of the survey respondents this relationship was of absolute trust. Finally, the producers mentioned having between regular trust (33%), plenty trust (17%) and absolute trust (50%) with their neighbors. These results indicated that there is an important degree of trust; however, as Cevallos *et al.* (2020) points out, trust is integrated by the associative experience, participation and reciprocity to have strengthened social cooperation; this situation must be developed among the producers to be able to become organized. This is how trust plays an important role when committing the members to a deal between peers with responsibility, which allows at the same time generating social relationships and of long-term exchange (Tepox and González, 2021).

From the Kruskal-Wallis test, it was determined that the importance of the relationship that producers maintain between groups ($H(4)=2.106$) was not significant ($p=0.551$), and therefore the null hypothesis is not rejected and there is inference that producers give the same importance to the relationship they maintain with other producers. Statistically, it was shown that the level of trust was equal for family members, friends, neighbors and business acquaintances, since the test statistic was $H(4)=3.408$, with $p=0.333$.

On average, the level of trust was higher (4.27 ± 0.82) than the importance that producers give to the type of relationship between them (4.03 ± 0.76). This was corroborated with the results obtained in the Wilcoxon test $Z=-3.833$ and $p<0.000$, whose contrast was conducted considering 5% of significance. The decision to trust entails a risk, so there is no certainty that the person to whom that trust is given responds in the same way (Acedo and Gomila, 2013). However, trust can be achieved by determining viable behaviors that allow interactions of mutual help to reach the organizational objectives in the best way (Cansino, 2020).

The correlation between independent variables was higher between borrowing money and making a society ($r_{\varphi}=0.5000$, $p\leq0.001$), followed by lending and borrowing money ($r_{\varphi}=0.455$, $p\leq0.001$), and lending money and making a society ($r_{\varphi}=0.417$, $p\leq0.001$). The results obtained indicated that there is a positive and moderate association between variables (Muria and Saura, 1998). Derived from the previous data, it was pertinent to carry out the logistic regression of each dichotomous variable and level of trust.

The results obtained from the estimation of the models are presented in Table 1. Model 1 defined that trust explains loaning money in 72.3% of accuracy in the prediction. The relationship of trust and that of forming a society (model 3) obtained an accuracy of 67.3%, and both explain the relationship between variables in more than 60%; however, trust explains better that a producer is willing to lend money.

In the case of the relationship between trust and asking to borrow money, the estimated model explained 48.5% and the relationship between both variables was not significant. The result obtained was similar to that reported by Figueroa-Rodríguez *et al.* (2012), where they indicated that the scarce relationship between both variables is because the action of

Table 1. Results of the logistic regression model.

Model	Variable	B	E.T.	Wald	gl	Sig.	Exp(B)
Lend money[a]	Trust	1.074	0.304	12.464	1	0.000	2.927
	Constant	−2.410	0.952	6.409	1	0.011	0.090
Ask for money[b]	Trust	0.145	0.252	0.333	1	0.564	1.156
	Constant	−0.295	0.844	0.122	1	0.727	0.745
Form a company[c]	Trust	0.701	0.269	6.803	1	0.009	2.016
	Constant	−1.801	0.886	4.126	1	0.042	0.165

[a] Variable introduced in step 1: Trust. R^2 de Negelkerke=0.188; X^2=14.073, p=0.000.
[b] Variable introduced in step 1: Trust. R^2 de Negelkerke=0.004; X^2=0.564, p=0.564.
[c] Variable introduced in step 1: Trust. R^2 de Negelkerke=0.093; X^2=7.202, p=0.007.

a producer of asking to borrow money from another is attributed not to trust, but rather to the reputation that the producer has within the group.

CONCLUSIONS

Producers of dehydrated products from the state of Zacatecas have characteristics of note and acceptable relationships of trust, which also have important implications to reach a higher number of farmers and to consolidate the existing links. Therefore, it is important to create strategies to disseminate the knowledge about solar dehydration in a timely and efficient manner with key stakeholders, in addition to strengthening actively the pre-existing interactions in producers' networks. It is priority to create awareness of the importance of networks and teamwork. This, as a strategy to promote the cooperation between them and to strengthen the participation in exchange networks for information, knowledge, technology, and commercialization.

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