Specialized Goat Cheese: An Option to Improve Economic Footing in Highland Communities of Veracruz, Mexico

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Problem Articulation:

Communities in the Gavilanes River micro-watershed of Veracruz, Mexico's highlands face numerous challenges to make traditionally subsistence agricultural livelihoods more competitive in a dynamic market environment. Specialized goat cheese production in Veracruz' rural highland communities could provide an opportunity to increase household profits. Community members in Micoxtla, one community in the Gavilanes River micro-watershed, have identified the low price of cheese as a processing and marketing problem by stating, "We don't know how to prepare cheese well and don't have a place to sell it." (INIFAP baseline study, 2004) Assessment of the feasibility of value-added goat's milk production, processing, and marketing, will provide a case study for the potential benefits and potential pitfalls of this strategy. Currently, only one type of traditional fresh cheese is produced in the communities. Prices are low and profits are negligible. The current market price for milk and traditional milk products is approximately 3.4 to 4.0 pesos/liter. (Williams et al., 2006) Within rural communities, the traditional fresh cheese will still remain important as a form of diet diversification to contribute to food security in the communities. However, in order to compete in evolving regional markets, farmers must produce a differentiated product or a variety of different options that would have to be evaluated for consumer acceptance. Micoxtla farmers have expressed an interest in learning to produce new types of goat cheese with the objective of increasing profits from goat milk. This strategy will be considered here.

Household net margin from goat milk products have been minimal for many years. Although historic data is not available, it will be assumed that profits from goat milk products have been low throughout the history of goat raising in the region. By adapting cheese production to include new or specialized varieties of cheese, incomes from cheese production could increase. The chosen time horizon of 20 years (240 months) captures historically negligible income from goat cheese. The reference mode indicates the desired pattern of future behavior to increase profits from goat milk products (S-shaped growth) as new varieties of cheese are sold. Finally, potential oscillation could occur due to fluctuations in the size of the goat herd and goat production constraints. The time horizon might be sufficient to indicate a collapse in profits from goat milk products.

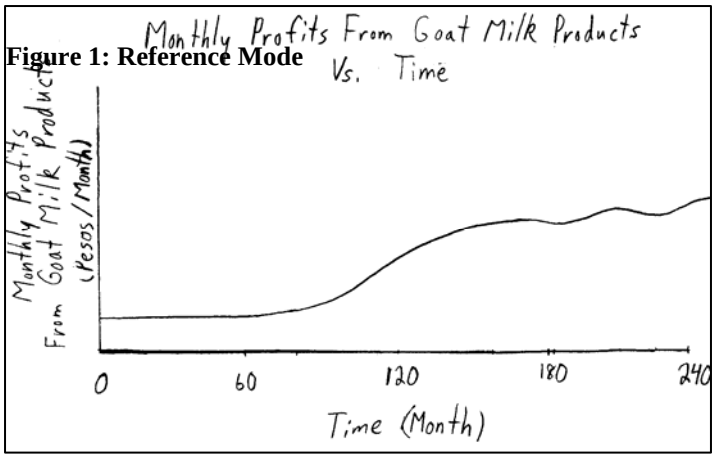
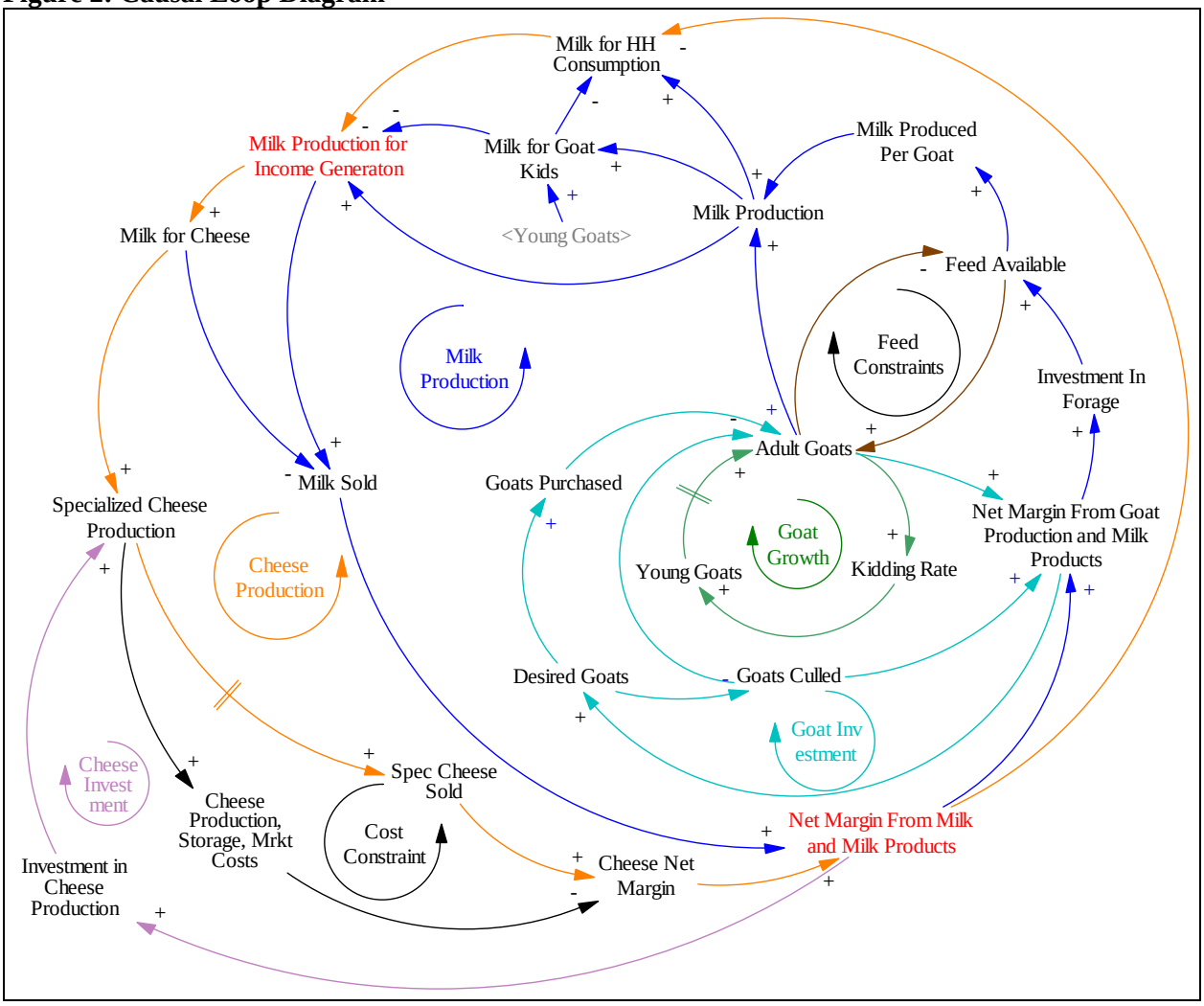


Figure 1: Reference Mode

Household profits from goat milk products might not be the best indicator of household well-being, however, it is the most convenient indicator of goat milk and goat cheese production's contribution to household well-being. Other reference modes such as total aggregate community goat producers' net-margin patterns (including the contribution goat sales or other income generation activities) and fulfillment of household health and nutritional needs could be considered.

Dynamic Hypothesis:

Figure 2: Causal Loop Diagram



The proposed causal loop diagram in Figure 2 shows important feedback loops in goat production, milk allocation and cheese production dimensions of the model under consideration. It relates to the hypothesized reference mode because goat production, forage constraints, allocation of goat milk to specialized cheese production, and decisions regarding reinvestment of profits from milk products and goat sales would constitute the principal feedback loops needed to reproduce the reference mode. Decisions will be made based on farmers' ability to increase (or decrease) profits from milk products (milk, traditional cheese, and specialized cheeses). Important feedback loops have been highlighted. Some feedback loops have different paths of causation. The most important balancing loops are cost constraints and feed constraints. The most important reinforcing loops are goat animal growth, milk production, and cheese production. However, milk and cheese production loops could be balancing loops depending on specification of the causal path.

The fundamental behavioral reference mode is hypothesized S-shaped growth followed by oscillation. Prior to S-shaped growth, milk production is hypothesized in dynamic equilibrium with minimal profits from milk and traditional cheese sales with no milk allocated to specialized

cheese making. This is hypothesized due to the low prices of milk and traditional cheese and the idea that currently all cheese income is obtained through sales of traditional cheese which is included in milk sales.

In order to achieve S-shaped growth in monthly household net margin from cheese production, milk must be at least partially allocated to specialized cheese making. Therefore, milk production and its allocation are considered an important decision point in the proposed causal structure. To achieve S-shaped growth, at least one balancing loop and one reinforcing loop are required. The initial phase of exponential growth requires dominant reinforcement that concludes at the point of inflection after which a balancing loop or loops dominate to produce goal seeking behavior. The structure in Figure 2 features reinforcing loops in goat production, milk and cheese production, sales, and cheese investment. These loops are a function of the effects of forage availability on goat production and costs. Reinforcing loops also could be influential if net margin decreases from the production of dairy products. This outcome also depends on household decisions; therefore, net margin from milk and dairy products is another important decision point. Several potential investment decisions are indicated in the causal diagram. For example, increased net income could be used to invest in improving forage resources. In contrast, decreased net income from dairy activities could result less investments in specialized cheese making or decreases in goat flock size.

The proposed structure considers several delays. A cheese maturation delay occurs between cheese processing and its sales. Another delay accounts for growth of young goats into adults. There are also delays in the culling rate (average time in flock), deaths (average lifetime), and a goat purchase delay. Finally, investment and allocation decisions are influenced by goat producers' expectations about profitability. These expectations and corresponding decisions are influenced by information delays about monthly profitability.

Simulation Model:

The simulation model is comprised of four components: community goat herd and forage resources, milk allocation, specialized cheese making, and cash resources. The model initializes in dynamic equilibrium except for cheese production, which initializes in static equilibrium with no milk allocated to cheese. However, if an initial proportion of milk were allocated to specialized cheese manufacture, the cheese component of the model would also initialize in dynamic equilibrium.

The goat aging chain is connected to forage resources through the forage available per goat variable. Available forage per goat and reference forage per goat are used to define the fraction of forage needs met. Fraction of forage needs met influences the birth rate via a reference multiplicative effect. It also influences the Adult Goat death rate and desired forage production through additional reference multiplicative effects. This forage resources formulation does not account for forage quality. The maturation delay between the Young Goat and Adult Goat stocks is a higher order delay of the kidding rate (minus young goat deaths and sales). Young Goat Sales is initially not active but can be activated through a pulse input to sell goats or by changing the base fractional sales rate. The Culling Rate affects the number of Adult Goats through the average time in flock variable, which is a function of the desired number of adult goats to actual number of adult goats ratio (through a lookup function). Goats can be purchased and the Culling Rate decreased when the desired number of Adult Goats is greater than the actual number of Adult Goats. Desired Adult Goats is a function of adult goats and the expected profitability of goat production and all milk products. Goats can be purchased when the Cash Available stock (minus food expenses) is greater than the price of a goat and the desired number of adult goats is greater than the actual number of adult goats. Goat forage

production costs are not yet included in the model. Income from the slaughter of culled animals and sales of young goats affects the Goat Production Monthly Net Margin.

The milk allocation component of the model attempts to represent the different avenues available for milk allocation. This is tied to the goat production portion of the model through the Adult Goats and Young Goat stocks. Milk for household consumption can decrease when profitability from milk and cheese production increases over the reference level. Milk for goat kid consumption varies as the number of young goats varies. Daily Milk Yield per Nanny also varies based on forage availability. The model begins with all milk available for income generation activities being sold as milk or traditional cheese. In order for milk to be allocated to specialized cheese production, a hypothesized initial investment of 5000 Pesos in cheese making infrastructure may be necessary. After making the initial investment, specialized cheese production can begin. It is difficult to obtain the necessary cash to make the initial investment in specialized cheese production endogenously so a remittance or gift (could also be a loan) of at least 6000 Pesos (to cover that month's food expenses as well) must take place to begin specialized cheese production. Another option is to increase the base young goat sales rate but this does not allow the Cash Available to initialize in dynamic equilibrium. An error in the current formulation is that the initial investment can only be made at a specified time during the simulation. After the initial investment in specialized cheese production, if the monthly net margin from milk products becomes greater than the reference monthly net margin from milk, more milk will be allocated to specialized cheese production.

Once milk is allocated for cheese making, it enters the cheese component of the model. Cheese production is determined by cheese yield. A fixed delay of cheese production in cheese maturation allows accumulation to occur in the Aging Cheese in Storage stock. After maturation, cheese moves to the Aged Cheese stock. It exits the Aged Cheese stock through the sales rate which is a first order delay. Variables for specialized cheese production costs, storage costs, and marketing costs are determined by the quantity of cheese being produced, stored, and sold, respectively. Specialized cheese sales and specialized cheese price are used to determine cheese revenues. The difference between cheese revenues and cheese costs is expressed as the monthly net margin from cheese production and also affects the Cumulative Specialized Cheese Net Margin stock and the Smooth Monthly Net Margin Specialized Cheese variable.

The Smooth Monthly Net Margin variables were added to the model to represent goat producers' expectations about the profitability of goat production, specialized cheese production, and milk products. These variables are used to determine producer decisions about milk allocation, desired number of adult goats, and investment of profits.

The initial model includes numerous constants that are estimated with great uncertainty. These parameter values are based primarily on my limited knowledge of goat production in Micoxtla and basic knowledge from a small goat herd on my family's ranch. Therefore, most parameters need to be investigated for the tropical highlands or additional information should be obtained from INIFAP's research team. Some parameters such as production costs might be better represented as an endogenous part of the model structure because costs would be likely to increase as production increases.

A way to represent investment in cheese production capacity or reinvestment in specialized cheese production when it is profitable should be added to the model. In addition, seasonality should be added for milk production; nannies can still be milked year round and forage production is not influenced by seasonality. Additional limits in demand for goats, specialized cheese, and milk are not currently represented in the model.

Table 1: Model Boundary Diagram

Endogenous	Exogenous	Excluded
Revenue from Specialized Cheese	Avg. Number Goats per Household	Specialized Cheese Demand
Total S Cheese Production, Storage and Marketing Costs	Number Households	Milk Demand
Net Margin from S Cheese	Average Number of Goats/HH	
Specialized Cheese in Storage	Milk Price	
Specialized Cheese Production Rate	Specialized Cheese Yield	
Net Margin from Milk Sold	Specialized Cheese Price	
Net Margin from Milk Products	Average Lifetime	
Specialized Cheese Sales	Average Time in Herd	
Milk Production	Maturation Delay	
Household Milk Consumption	Cheese Maturation Delay	
Milk for Goat Kid Consumption	Fractional Kidding Rate	
Milk Produced Per Nanny	Fractional Young Goat Death Rate	
Milk Available For Income Generation	Feed Per Land	
Milk Sold	Land Area	
Forage Resources	Forage Consumption Per Goat	
Forage Production	Milk Production Costs	
Forage Consumption	Traditional Cheese Production Costs	
Adult Goats		
Birth Rate		
Death Rate		
Goat Purchases		
Goat Culling Rate		
Young Goats		
Maturation Rate		
Young Goat Mortality Rate		

Table 2: Parameter Summary Table

STOCKS	Description
Adult Goats	The community goat population. It can increase through maturation of young goats or goats purchased, and decrease from deaths or culls.
Young Goats	This stock represents young goat kids. The residence time in this stock is a function of the goat maturation delay.
Forage Resources	Total forage mass available at any given time. This is oversimplified.
Available Cash	This is the cumulative amount of cash available from specialized cheese production and milk production. It increases due to milk and specialized cheese sales.
Cumulative NM from Milk Products	This represents the accumulation of profits (or decreases if losses are incurred) for milk product production.
Aging Cheese	This is the amount of cheese that is aging in storage.

Aged Cheese in Storage	This is the amount of aged cheese in storage where it accumulates before being sold.
Cumulative Spec Cheese NM	This stock accumulates the net margin from specialized cheese throughout the simulation time. It is used to find the final cumulative net margin at the end of the simulation.
FLOWS	**Description**
Kidding Rate	The kidding rate is a function of Adult goats, proportion nannies, and the fractional kidding rate. It is an inflow to the Young Goats stock.
YG Death Rate	The young goat mortality rate is the fractional kidding rate multiplied by the number of young goats.
Maturation Rate	A higher order delay with a delay time of 3 months is used to formulate the maturation rate equation. First order control is used to avoid negative values.
Goats Purchased	Initially, no goats are being purchased. This could be a decision point for farmers. When enough cash is available to invest in more goats and desired adult goats > actual adult goats, goats can be purchased.
Adult Goat Deaths	Deaths are calculated through the average lifetime of a goat which is affected by forage availability. Adult Goats/Average Lifetime
Culling Rate	This is the adult goat population divided by the average time in the herd. It is initially set to the base average time in herd (48 months) but can vary as the ratio of desired goats to adult goats changes.
Forage Production	Forage resources increase through this inflow which is the feed per land multiplied by land area. It can increase or decrease as the desired forage production changes.
Forage Consumption	Monthly Forage consumption is given by the adult goats stock multiplied by reference consumption per goat times the output of the lookup function.
Change in Available Cash	This is a net flow to the cash available stock. It fluctuates (can be positive or negative) depending on the profitability of goat production, specialized cheese production, and milk production.
Initial Investment in Cheese Production	This formulation works for now the initial investment to begin specialized cheese production can only be made at one time. Ideally, this would happen the first time enough cash is available to make the investment. Perhaps this should be assumed rather than modeled explicitly.
Gift or Remittance	This inflow to the Available Cash Stock represents a remittance or gift to goat production (possibly to get specialized cheese production started).
Food Expenses	This is the expenditure rate for food expenses.
Invest in Goats	When conditions are met in the goat production part of the model, goats will be purchased. This outflow from the Available Cash stock represents the investment in additional goats.
S Cheese Production	This is the conversion of milk for specialized cheese production to cheese through the cheese yield conversion.
Cheese Maturation	The Cheese Maturation Rate is a fixed delay of Cheese Production. This delay allows production and storage costs to be incurred prior to selling cheese when additional milk is allocated for cheese production.
S Cheese Sales	Cheese sales is given by an 2 week first order delay of the Aged Cheese stock.
ABBREVIATED LIST OF ADDITIONAL IMPORTANT PARAMETERS	
Desired Adult Goats	The desired number of animals can change as the goat herd net margin changes. This occurs via a reference multiplicative effect formulation.

Average Time in Herd	The base average time in herd is affected by the lookup function. As a result, when desired adult goats > adult goats, the average time in herd will increase.
Goat Purchases	Goat purchases are determined by cash availability to buy goats and the desired purchase rate, the minimum of which is returned. It is controlled to avoid negative goat purchases.
Increase Forage Production	Increase forage production is the minimum of available cash to invest in forage and desired increases in forage.
Fraction Forage Needs Met	Fraction of Goat Forage/Nutritional needs met. This fraction affects the kidding rate, adult goat death rate, and daily milk yield from goats.
Monthly NM Goat Production	This is the monthly net margin from goat production. It is used in the net flow to the Available Cash stock. It is also used as the input in the Smooth Monthly NM Goat Production variable to estimate producer expectations about goat production profitability.
Smooth Monthly NM Goat Production	The output from this variable represents community goat producers' expectations about the monthly net margin from goat production (sales of culled goats and young goats minus non-feed goat costs). It is calculated through third order smooth function.
Milk For Specialized Cheese Prod	This is the monthly milk allocated for specialized cheese production. This can be activated through Cheese Allocation Switch when an initial investment is made to begin cheese production. It can also increase if the producers expectations about the monthly profitability from milk products is higher than the reference level.
Monthly NM from Milk	This is the monthly net margin from milk production. It is used to increase cash in the Available Cash stock. It is also used to calculate producer expectations about milk profitability in the Smooth Monthly NM Milk variable.
Smooth Monthly NM Milk	The output from this variable represents community goat producers' expectations about the monthly net margin from milk and traditional cheese sales. It is calculated through third order smooth function.
Milk Production	This is the daily Milk Production from all Nannies in the goat herd. At some point in the future, this should be revised to reflect seasonality in milk production which is currently not represented in the model.
Monthly NM Specialized Cheese	This is the monthly net margin from specialized cheese production. It is used to increase cash in the Available Cash stock. It is also used to calculate producer expectations about specialized cheese profitability in the Smooth Monthly NM S Cheese variable.
Smooth Monthly NM Specialized Cheese	The output from this variable represents community goat producers' expectations about the monthly net margin from specialized cheese. It is calculated through third order smooth function.

The formulation of several equations is important to the model's current performance (or lack thereof).

The milk for specialized cheese production variable is determined by the following equation: milk for specialized cheese production=MIN(MIN((Milk Production for IncomeGeneration* "Days/Month")*(initial proportion of milk to be allocated for specialized cheese production+additional proportion*Cheese Allocation Switch)*Effect of Expected Profits From Milk Products on Milk for Specialized Cheese Production(Expected Profitability of Milk

Products /Reference Profitability of Milk Products), Milk Production for Income Generation*"Days/Month"),Maximum S Cheese Production Capacity). This formulation does not allow any milk to be allocated to specialized cheese production until an initial investment in Specialized Cheese Production of 5000 Pesos takes place (which activates the cheese allocation switch). In addition, following the initial investment, the reference multiplicative effect formulation allows more cheese to be allocated to specialized cheese production up to the maximum production capacity. Material is conserved because the maximum amount that can be allocated is the amount of milk available for income generation activities.

The Smooth Monthly Net Margin variables all use similar formulations: Smooth Monthly NM Milk=SMOOTH3(Monthly Net Margin from Milk, Smooth NM Milk AT) with an initial value that is set as a function of numerous constants in the model to initialize the variables in dynamic equilibrium. The equation uses a 3rd order exponential smooth formulation with respective Net Margins from Milk, Cheese or Goats as the input. The delay time is longer for Goat Production. The output of these variables is represents producers' expectations about profitability and is used to make investment decisions.

The desired adult goats and desired forage resources are given by similar equations: Desired Adult Goats=Adult Goats*Effect of Profitability on DAG(Expected Profitability/Reference Profitability). This reference multiplicative formulation allows the number of desired goats to change based on the ratio of profitability to reference profitability. Desired forage resources also includes an additional lookup function for forage availability. However, this might be an excessive use of the reference multiplicative effect.

The cheese maturation rate is a fixed delay of cheese production. Cheese maturation = DELAY FIXED (S Cheese Production,Cheese Maturation Delay,S Cheese Production). The goat maturation rate is a higher order delay of the kidding rate: Goat Maturation Rate = DELAY N(MAX((Kidding rate-YG Mortality Rate-YG Sales Rate),0), Maturation Delay, Kidding rate-YG Mortality Rate-YG Sales Rate, 8). This might need to be a higher order delay to better represent the maturation of young goats to adult goats.

Goat purchases are determined by: MAX (INTEGER (MIN (Allowable Goat Purchases based on Cash Available to Purchase,Indicated Purchase Rate)), 0). This formulation only allows whole goats to be purchased and prevents negative goat purchases. It is given by the minimum value of Allowable Goat Purchases (based on available cash) and the indicated purchase rate (based on Desired Adult Goats).

Cheese Allocation Switch = SAMPLE IF TRUE (Invest in S Cheese Production=5000, 1, 0) When enough cash is available to make the initial investment in goats, this formulation returns one, which begins allocating 50% of milk available for income generation to specialized cheese production.

Initial Investment in Specialized Cheese Production=(IF THEN ELSE (Available Cash>Initial Investment Needed to Begin Specialized Cheese Production, PULSE(Investment TIme, Investment Duration), 0)*(Initial Investment Needed to Begin Specialized Cheese Production))/Investment Delay. This formulation is problematic because it requires an investment time specification. Ideally, this equation would make the initial investment any time there is sufficient cash available and then become inactive.

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