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SOY DAIRY PERFORMANCE METRICS

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ABSTRACT

Soybean (Glycine max (L. Merr.) has been a crop of interest to address both poverty and malnutrition in the developing world because of its high levels of both protein and oil, and its adaptability to grow in tropical environments. Development practitioners and policymakers have long sought value added opportunities for local crops to move communities out of poverty by introducing processing or manufacturing technologies. Soy dairy production technologies sit within this development conceptual model. To the researchers' knowledge, no research to date measures soy dairy performance, though donors and NGOs have launched hundreds of enterprises over the last 18 years. The lack of firm-level data on operations limits the ability of donors and practitioners to fund and site sustainable dairy businesses. Therefore, the research team developed and implemented a recordkeeping system and training program first, as a 14-month beta test with a network of five dairies in Ghana and Mozambique in 2016-2017. Learning from the initial research then supported a formal research rollout over 18 months with a network of six different dairies in Malawi and key collaboration from USAID's Agricultural Diversification activity. None of the beta or rollout dairies kept records prior to the intervention. The formal rollout resulted in a unique primary dataset to address the soy dairy performance knowledge gap. The results of analysis show that the dairies, on average, achieve positive operating margins of 61%, yet cannot cover the fixed costs associated with depreciation, amortization of equipment and infrastructure, working capital, marketing and promotion, and regulatory compliance. The enterprises in our sample operate only at 9% of capacity, which limits their ability to cover the normal fixed costs associated with the business. The challenge is not the technology itself, as when operated, it produces a high-quality dairy product. The challenges involve a business that requires too much capital for normal operations relative to a nascent and small addressable market.

Key words: soymilk, return on capital, operating margin, benchmarking, development

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INTRODUCTION

Development practitioners and policymakers have long sought value-added opportunities to move local communities out of poverty by introducing processing or manufacturing technologies [1, 2, 3, 4]. These technologies enable entrepreneurs to transform locally produced raw products into higher valued food or feed ingredients or products [4]. By doing so, policymakers hope to augment local food shed output, the local availability of the macro and micronutrients, and economic development and job creation [3]. Soy dairy production technologies sit within this development conceptual model. Using equipment appropriate for small-scale commercial operations, entrepreneurs transform locally produced soybean into a variety of value-added dairy products. These products range from milk, cheese, yogurt, and ice cream to *okara*, a high fiber and protein ingredient for livestock feed and baked goods for human consumption.

To our knowledge, no research to date benchmarks soy dairy performance, though donors and NGOs have launched hundreds of soy dairy enterprises. As a result, two research questions remain unaddressed, which are the subject of this manuscript. The first question is whether the small commercial-scale soy dairy model creates an economically sustainable enterprise. Secondly, if the soy dairy enterprise model is not sustainable, why? Answering these research questions fills a gap for development policymakers and practitioners. The lack of performance data limits the ability for donors and practitioners to fund and site processing units that sustainably operate as businesses. The operating businesses too need performance data by which to benchmark their own operations and continually improve. The research team built, tested, and then employed a unique primary dataset to address this knowledge gap. The goal of this manuscript is to support more effective development of the soy dairy model by providing evidence-based managerial guidance to donors, NGOs, policymakers, and entrepreneurs seeking to establish successful soy dairy businesses.

Specifically, the research team beta tested a data collection framework with five soy dairy businesses over a 14-month period in 2016-2017 that operated in Ghana and Mozambique. Bringing the practice of financial recordkeeping to soy milk operators and building a research quality dataset is difficult when financial recordkeeping is not commonly practiced. Managers minimally use financial and production information and firms have few resources or incentives to invest in managerial or financial accounting. As a result, the research team engaged in significant managerial capacity building before attempting to construct a research quality dataset.

An opportunity arose to leverage the experiences from the beta-test by partnering with the consulting firm Palladium that was rolling out six new soy dairy businesses in Malawi. Palladium wanted to leverage the research team's financial recordkeeping experience, and too had similar questions about business viability. Together the research team implemented a financial recordkeeping rollout and data collection activity with six soy dairies in the Fall of 2017. The team began data collection starting in January, 2018 and continued until June, 2019 with funding from USAID-Malawi's Agriculture Diversification activity. USAID's Agriculture Diversification project was a five year multi-million dollar effort from 2016-2021 to develop the soybean value chain in Malawi.

The literature on small commercial-scale food processing, in general, does not conduct analysis at the firm level. Most articles focus on the engineering technology [5, 6] or look at food processing entrepreneurs at the industry or policy level [7, 8]. There is a small set of firm-level dairy articles from India [9]. The article, while thorough, provides little guidance in our case because the Indian dairy processing sector has a long history in the country, milk is a traditional beverage for consumers, the subject dairies are relatively sophisticated businesses utilizing financial recordkeeping and capital financing, and their business are orders of magnitude large than soy dairies, processing in the range of 5,000 liters per day. The authors find no relevant firm level studies that provide detailed financial and operational evaluations of actual small food processing enterprises beyond the few soy dairy articles discussed below.

To date there have been twelve articles published on the subject of soybean for household or microenterprise use in developing country settings. Five of those articles have been peer-reviewed and published, six are research reports, and one is a magazine article. The literature reflects two general subjects of interest: the processing of soybean for human consumption, a food science question, and the viability of the activity or enterprise for the conversion of soybean into a foodstuff, an economic question.

The high quality and quantity of the protein and oil found in soybean though has long been known and documented [10]. Soybean requires processing prior to utilization to eliminate the anti-nutritive components, especially trypsin inhibitors [11]. The productivity of soybean, both in terms of yield and nutrients per hectare, appeals to soybean practitioners, donors, and policy makers because of its potential to provide low cost macro- and micronutrients that are in short supply in many developing country settings.

The soy dairy production process involves cooking water-soaked and ground soybeans under heat and pressure to produce soymilk and a by-product called *okara*. The firm may sell the milk or further process the milk into tofu, yogurt, cheese, or ice cream. The *okara* serves as a good source of fiber and protein to fortify local foods or feed livestock [12].

The developers of the small-scale soy processing units propose a number of benefits at the home and small commercial level; including improvement in household nutrition, increases in family income, women's empowerment, local economic development, and public health gains [13].

In 2000, a Canadian non-profit formed to produce and distribute commercial soybean processing units in order to facilitate adoption of soybean at the microenterprise level [13]. Thus began the small-scale commercial soy dairy era. The organization sought to address the soybean processing challenges facing small commercial operators, and by doing so promote rural economic development. Collaborating with Africare, Malnutrition Matters implemented its first soy-processing system in 2004 [14]. Since

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then, donor organizations have placed over 1,000 soy processing units in over 40 countries [15].

Many local organizations chosen to receive a small-scale processing unit present specific goals to assist women and their families. An Ethiopian project, for example, educated women on the health benefits of soy and further instructed them on how to incorporate soy into their cooking [16]. Part of the appeal of the technology is not only the production of nutritional products for consumption and sale, but soy processing units save labor for women per unit of nutrition produced [14].

Soy dairy promoters assume operators will use the machine four hours every day, producing about six batches, or 84 liters per day (assuming the manufacturer's standard of 14 liters per batch [14]). By doing so, they will generate sufficient food, income, and return on capital [14]. For example, a dairy project in Guinea reinvested 300,000 GNF (about $100 USD) of their project profits to buy equipment to create *attieke*, a cassava-based couscous widely eaten in Guinea [17]. The commercial aspects of soy dairy production also increase demand for soybean that benefits farmers in the community by providing a new local market [18].

Operators can grind the soybean using a processing unit that involves pedal power for locations where electricity is unreliable. Where reliable electricity exists, the system employs an electric grinder (Figure 1). Both the pedal and electric grinders process the soybeans 10 to 20 times faster than manual processing methods [16].

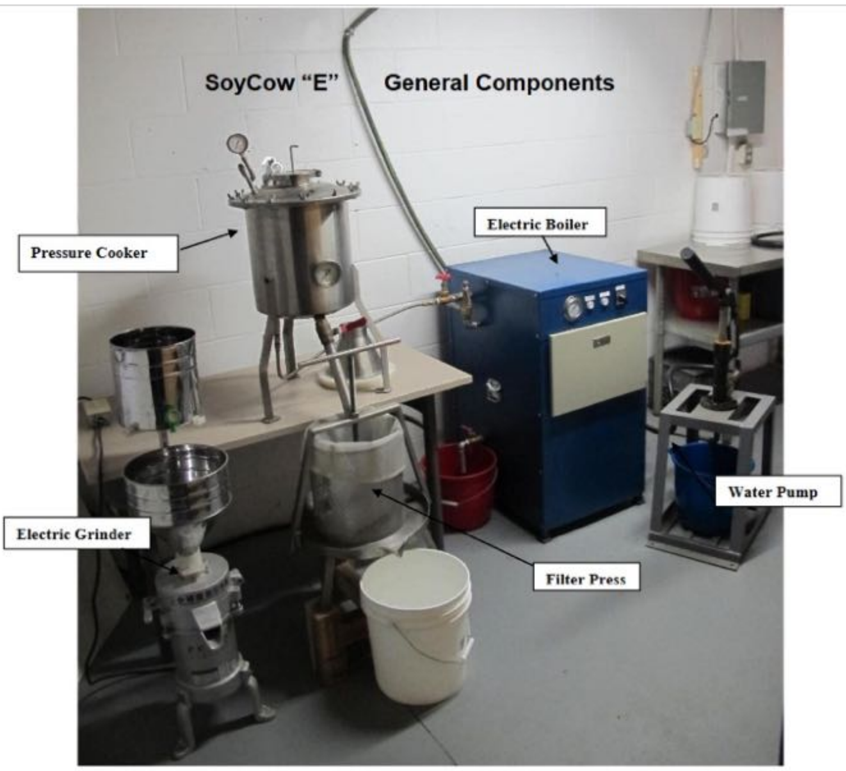

Figure 1: A Soy Dairy Processing Unit "SoyCow "E"" [13]

The soybean-processing unit includes a steam (or electric) boiler and pressure cooker in addition to the grinder. The boiler, fed by wood or gas, is significantly more efficient than an open-fire or stove [17]. A stainless steel pressure cooker batch cooks the ground soybean mash in less than thirty minutes. Finally, operators manually operate a stainless steel press to separate the liquid (milk) from the *okara* [14].

A typical batch utilizes about 2 kilograms of soybean and 12 liters of water and makes 14-15 liters of milk every 30-45 minutes [14]. A project in Kenya reported that its soy dairy processing equipment yielded a 6:1 ratio of milk to soybean [18]. The process generated 15 liters of soymilk out of 2.5 kilograms of presoaked beans in 22 minutes [18]. Four dairies as part of a soy dairy project in Guatemala showed an average milk yield of 5.1 liters of milk per kilo of soybean. The dairies on average utilized a batch size of 2.85 kilograms of soybean that yielded 14.5 liters of soymilk and 1.6 kilograms of *okara* [15]. The Guatemalan system serves 600-1,000 children per day when operated 3-4 hours [15].

Both in Zambia and Namibia, the locally produced soy products benefit those who are stricken with HIV/AIDS and require supplemental nutrition [19]. The authors state that access to transportation, ample storage space [15], packaging materials [19], and sometimes refrigeration [20] are necessary if a soy dairy project is to become an enterprise activity.

There are varying expectations in terms of the required labour. A 2008 study states that 20-30 people are required to sustain an enterprise [19], while a separate study looking at the Vitagoat system reports that only 5-10 people are needed to run the soy dairy microenterprise [16]. In fact, two people at a time can actually operate the machine [15].

Equipment and parts originate from factories in India and Thailand and technical support centers reside in Ghana, Kenya, and South Africa [14]. The capital costs of one pedal powered machine, not including taxes, shipping, and duties, is $5,900 [14], while the costs of an electric model range from $5,900 to $11,900 depending on the model [21]. Sopov & Sertse [16] estimate $6,000 USD to manufacture a Vitagoat in India plus $4,000 USD for on-site training, transport, and import taxes, for a total of $10,000 [16]. The sum does not include additional capital costs associated with operating a dairy business such as the building and food grade readiness, branding, working capital for raw material procurement, storage, finished product inventory holding, refrigeration and packaging equipment, transport vehicles, food production supplies, and utility hookups.

Sopov & Sertse [16] estimate that a Vitagoat project will pay for itself after 2-3 years of 3-4 hours of operation per day [16]. Harrington and Cohen [19] estimate such a system would need a consumer base of 500, which would mean each individual would need to consume about 100 milliliters of soy dairy products per day [19]. Africare recommends that markets should be within 10km of the production plant of the implementing organization [19]. The issue of proximity and market size relate to

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soymilk's high level of perishability, the high cost of packaging, and costs of transportation. In this way, Harrington and Cohen [19] indirectly raise a central tenet of efficient and profitable soy dairy operation, demand density and cold chain management [19]. The further the dairies are from markets, the more reliant they will be on packaging and the integrity of the cold supply chain, which are capital intensive and technically challenging.

To date very little soy dairy profitability analysis exists. In 2005 in Guinea, soymilk sold for 1000GNF ($0.50 USD) per liter, with the cost of the raw soybean being 17% of the retail price [17]. A Vitagoat (a soy processing unit that does not require electricity) project in Cote d'Ivoire reported profits of 1,300 CFA ($2.65 USD) a day [19]. Three projects in Guinea between March 2005 and August 2007 (30 months) showed very high soymilk yields (8.5:1) from their soybean. The manufacturer recommends a ratio of a little over 6 liters of milk for kilogram of soybean, or 164 grams of soybean per liter of milk [14]. The three groups collectively used 232 kilograms of grain to produce 1,974 liters of soymilk over 30 months (66 liters per month), or 120 grams of soybean per liter of milk [17]. They consumed 16% of their soymilk and sold 84%, and reported a small operating margin of $278 USD or 14% over the cost of soybean over the 30-month period. Unfortunately, the costs of inputs, labor, and depreciation were not included in the analysis.

Chianu *et al.* [18] estimate operating a soy dairy unit in Kenya could have operating margins over variable costs between $2,000 USD and $7,000 USD when producing 12-13 batches a day or 190 liters per day and a milk yield ratio of 7.3:1 [18]. At such levels, the unit would have to operate for about 10 hours per day, not including cleaning and maintenance. Soybean requirements would be 26 kilograms per day or about one metric ton per month. A market size of 95,000 would be necessary to consume the 190 liters per day or 3,800 liters per (20-day) month, assuming a market penetration of 10% and consumption levels of 100 ml once a week per consumer.

Conté [17] similarly estimates the potential soy dairy profitability when producing and selling milk, tofu, and yogurt in Cote d'Ivoire [17]. The model assumes operating 5 hours a day and 250 days per year for 10 years. Thus, the dairy would theoretically supply 26,000 liters per year, or 2,167 liters per month to the market. The estimates include the cost of the initial capital investment, plus variable and fixed costs. The soy dairy unit could net $42.27 USD per day, and pay back its initial investment of $10,000 in less than a year, if the business plan became reality. The authors admit depreciating the soy dairy unit over ten years may be unrealistically optimistic, and thus the payback unrealistically quick, given the small scale and startup nature of the business. The analysis also omitted an analysis of the necessary accessible market to consume 2,167 liters per month as well as the fixed costs of the building, working capital for raw material and finished product inventory, food business equipment and supplies, packaging, refrigeration, and transport equipment, utility hookup, and food safety compliance.

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MATERIALS AND METHODS

Each of the six enterprises in the present study owns and operates one soy processing unit rated at 14-15 liters per batch. All six processing units are the same. They originate from the same supplier. They are the same make, model, year of manufacturing, and year of installation. They also use the same fuel source.

Palladium and the Soybean Innovation Lab (SIL) collected the data in this study over 18 months, from January, 2018 to June, 2019, from six soy dairy enterprises in Malawi; one at a university and five cooperatives. None of the cooperatives had been producing soy milk prior to receiving the soy processing unit. The Agriculture Diversification activity (Ag Div) advertised the program, looking for operating cooperatives that were producing soybean and wanted to expand into a value-added enterprise. Ag Div then selected the recipients, coordinated the shipping and installation, managed the training on plant operation, small business management, and recordkeeping, and visited each cooperative once a month to provide additional technical support, and collect the financial and operational data.

The Soybean Innovation Lab (SIL) provided training and paper bookkeeping forms to assist each dairy to collect their daily production and financial records. None of the dairies utilized financial recordkeeping prior to the project. The Ag Div team then visited each dairy monthly, discussed operations, and collected the daily financial and operating entries for the month. Similarly, each month the SIL research team would review the data for errors and omissions, meet with the project managers to clean and fix data errors, suggest improvements in recordkeeping, and discuss the dairies' financial and operational performance to date.

In summary, data management, which replicated an earlier beta project in 2016-2017, began with the Ag Div team training and implementation of basic bookkeeping with the subject dairies. These financial records recorded daily by the dairy managers served as the raw data for the analysis. The Ag Div team collected those data, worked to improve recordkeeping quality control, and followed up on data discrepancies and SIL data questions during their monthly visit to each dairy. Each month, SIL researchers reviewed, cleaned, validated the data, then met with the Ag Div team about questions, discrepancies, inconsistencies, errors, and omissions. The Ag Div would then follow up on the SIL data related questions during their monthly visits with the dairies. At the conclusion of the project, the SIL team then organized, cleaned, summarized and analyzed the data in terms of financial and production performance, which are presented in the results and discussion section that follows.

These daily bookkeeping reports reflected the daily production output, inputs used, cost of inputs, as well as other costs such as rent, electricity, transport etc. (Table 1). All summary statistics and analytical metrics, such as soybean used per liter of milk, were calculated by the SIL research team from the daily reports. The authors define direct costs as the sum of cost of goods sold and business operating expenses, and operating margin as the difference between total revenue and operating costs.

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RESULTS AND DISCUSSION

Operating expenses and Costs of Goods Sold

The results originate from 510 daily reports on production and costs across the six dairies. This high quality data set results from the intimacy between the Ag Div team rolling out the soy dairy program in Malawi and the cooperatives. The Ag Div team committed, with the help of the Soybean Innovation Lab, to an intensive training rollout with the cooperatives to establish business recording keeping practices. The Ag Div team also actively followed up with the cooperatives to both collect data on a monthly basis and continually improve the quality of internal record keeping.

Soybean

One of the most important metrics for soy dairy operators is the cost of the raw material, soybean per liter of milk, a component of the cost of goods sold (COGS). Low cost of goods sold may result from three sources; low costs of the raw material, efficient use of the raw material in the final milk product, or excessive water use that results in an inferior product in terms of quality. In this case, there was a significant (289%) range in soybean costs per liter across the six dairies (Table 2). Dairy 4 had the lowest soybean cost of goods sold at $0.03 USD per liter, while Dairy 3 had the highest soybean cost of goods sold of $0.10 USD per liter. The dairies average $0.16 USD soybean COGS per liter.

Soybean comprises 18% of the total cost to produce a liter of soymilk among our sample six dairies (Figure 2). It is important to note that producers blend soybean from a variety of sources, because as a commodity-based process the lack of complete homogeneity in terms of variety, moisture, source, protein level, or quality has little bearing on the quality of the finished product. Therefore, sourcing from a variety of suppliers can theoretically yield similar quantities and qualities of milk. This characteristic reflects the "sow's ear-silk purse" principle of the economy of commodities that is common to many food businesses. Buyers take advantage of the low prices and raw material availability from a variety of suppliers, which creates a relatively heterogeneous raw material supply, for example with respect to soybean,) to keep costs low, and then leverage processing technologies (soy dairy) to create a value added homogeneous high quality product (soymilk). Processors discount soybean based on quality characteristics, such as mold, cracks, or foreign matter, allowing them to make the purchase, but not overpay for poor quality [22]. Thus, most variation in milk yield per kilogram of soybean does not result from the soybean itself, but results from managerial differences, therefore, are controllable. High end markets, such as the food-grade markets in Asia, will by-pass the commodity supply markets and contract for specific varieties or characteristics, such as non-GMO or clear hilum[1].

[1] The hilum is the position where the seed connects to the pod. The hilum color is only of importance to high end food manufacturers. They prefer the clear hilum, which varies by variety from clear to dark brown, to assure finished products are as white as possible

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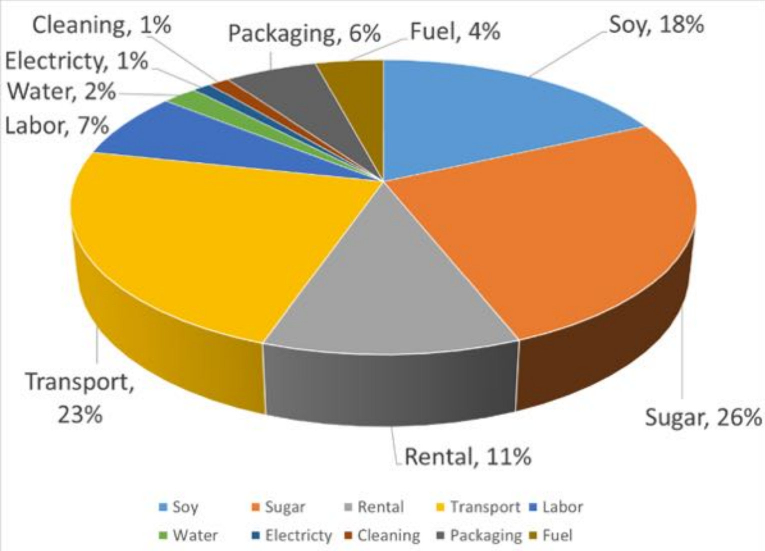

Figure 2: Average Percentage of Total Operating Costs across 10 Categories for the Six Study Dairies

The cost of soybean per liter of milk is a function of the quantity of soybean used per batch, so a recipe decision, and the cost of the raw soybean, a procurement characteristic. The six dairies average about 0.18 kilograms of soybean per liter of milk, but the yield ranges widely, 83%, from the most to least efficient user of soybean (Table 3). The recommended amount is 2.3 kg soybean per batch, or 0.16 kg per liter [23]. Dairies 1, 2, 4, 6 use about 0.15 kilograms per liter of soymilk while Dairies 3 and 5 use significantly more soybean, in excess of 0.20 kilograms per liter of milk production. High (Low) levels of soybean use arise from a variety of causes: inefficient equipment operation, excessive water use, poor quality control, or simply preference differences in milk taste and consistency (thicker/richer vs. thinner/lighter).

The six dairies reside within a 200-kilometer radius of Malawi's capital city Lilongwe. Costs of raw soybean though range significantly across the six dairies. Dairy 4 has the lowest average cost of soybean over the study period at $0.19 USD per kilogram ($190 USD per metric ton) to a high at Dairy 3 of $0.47 USD per kilogram ($470 USD per metric ton). Thus, Dairy 3 incurs a 155% raw material cost premium compared with Dairy 4, which is significant considering soy is a top-5 cost item for producing soymilk. The average raw soybean cost across our sample is $0.35 USD/kilogram or $350 USD per metric ton. World price over the same period averaged $390 USD per metric ton [24].

A key metric the authors do not fully analyze is the variance in price across time for each dairy. Soybean dairies procure/utilize soybean sparingly because they do not regularly operate their production plants, due to limited demand. So, the resulting price data are too thin for price variance analysis. Price variance though is a critical aspect of soybean procurement as local prices vary tremendously, being quite low during harvest and rising thereafter. Variance in soybean price results from basis differences among regions and countries, so dairies for example located closer to the center of production, or to a capital city or port, may experience more stable prices. In addition, optimizing procurement practices, working capital, storage capacity, production schedules, and purchase volume can significantly reduce the annual cost of soybean for a dairy. Wide seasonal swings in soybean costs adversely affects cash flow and may warrant investments in storage to smooth out costs throughout the year.

Sugar

Sugar comprises 26% of the total cost of inputs to produce a liter of soymilk and is the largest ingredient item in terms of cost. The six dairies average 0.09 kilograms of sugar per liter of soymilk, with the range being significant, 0.05 to 0.18 kilograms per liter. Optimality cannot be determined because the variation may be due to sweetness preferences among a dairy's customers. The sugar content simultaneously affects the nutritional value of the drink and the acceptance of a soy-based beverage, which can present an unfamiliar flavor in many communities when presented in an unsweetened form. Sugar is the largest of the top six cost areas (soy, sugar, rental, transport, labor, and packaging) for producing a liter of milk.

The costs of sugar range 29%; from a low of $0.87 USD/kg in Dairy 4 to a high of $1.12 USD/kg in Dairy 1. Most published soymilk recipes recommend adding sugar "according to taste" (see https://www.tropicalsoybean.com/recipes). The few recipes that do recommend a specific sugar level present a wide range for the sugar:soybean ratio, for example 1:3.5 (https://www.allrecipes.com/recipe/47388/soybean-milk/) or 1:8 (https://www.thespruceeats.com/korean-homemade-soy-milk-recipe-2118535). The six dairies produce comparably a very sweet soymilk using a sugar:soybean ratio on average of 1:2.1, and range from 1:1.2 to 1:3.2.

Transport

Only two dairies utilize transportation or at least record transport costs to move their products to market. Those dairies report that transport costs comprise 23% of the total cost of inputs to produce a liter of soymilk. Bicycles with coolers serve as the transportation vehicle. On average, these businesses spend $0.24 USD per liter on transportation. Dairy 5 spends $0.29 USD per liter of soymilk, while Dairy 3 spends $0.19 USD per liter of soymilk. The six dairies do sell some product directly from their production plants, but most will transport either on foot or with a bicycle the milk or yogurt to the sales location, and may not account for the associated unpaid labor.

Building Rental

Building rental on average comprises 11% of the cost to produce a liter of soymilk. Two dairies do not report rental charges as they operate from donated space. None of the dairies own their own facility. Dairies 1 and 2 spend $0.12 USD per liter of soymilk for rent, while Dairy 4 pays only $0.002 USD per liter of soy milk for rent. None of the building facilities meets food safety regulatory compliance, though all have access to water and electricity.

Packaging

For small-scale soy dairies, packaging is a major bottleneck to the sustainability of the enterprise. On average, packaging comprises 6% of a soy dairy operation's costs, and there is a direct positive relationship between packaging cost (fixed and variable), and potential market size, product shelf life, brand management, and losses due to spoilage. That being said, serving a larger market that matches the capacity of the processing unit requires significant capital to acquire proper packaging and labeling equipment, build both demand and a brand outside of the small local market, and establish a cold supply chain to reliably service the product.

Sachets are the cheapest form of packaging for soymilk and serve as the dominant packaging solution among our six dairies.

Figure 3: A frozen soymilk sachet from Malawi [25]

The costs of caps and tops, sealers for Polyethylene Terephthalate (PET) bottles, and hand-filling all reflect costs in addition to the actual bottle cost, that make hand-filled and tied sachets the preferred approach.

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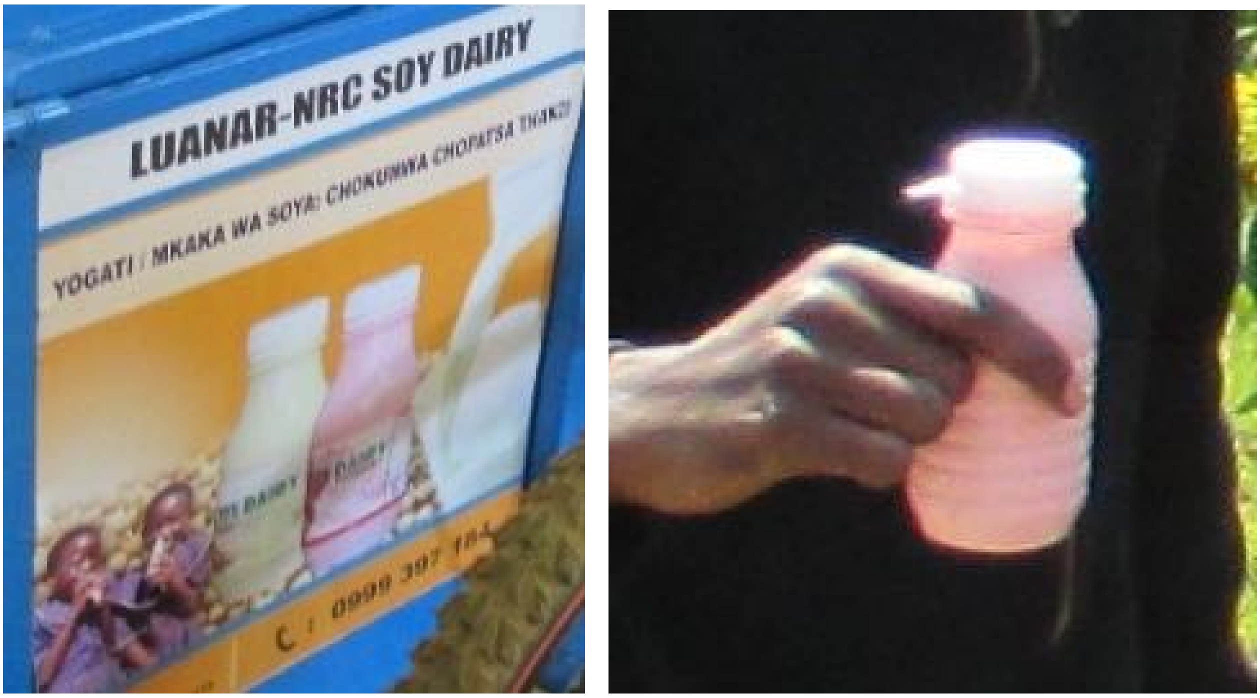

Figure 4: PET or High Density Polyethylene (HDPE) plastic bottles [25]

Though relatively inexpensive, sachets suffer from poor product presentation, limits on labeling, high levels of breakage, and poor shelf life. Packaging costs range 265% among the dairies from a low of $0.0076 to a high of $0.0278 per liter.

Labor

On average, the soy dairies spent $0.04 per liter on labor to operate their factories, or 8% of the operating costs of production. While not all dairies track and report labor costs, the four dairies that do track the important labor cost category present a range of about 18%, thus have very similar costs per liter. Labor includes all paid labor, both managerial and technicians. Often donors place soy processing units in institutions where operators are already on salary by their institution, so there are no cash costs associated with the dairy's operation. There is one institutional dairy among the six in this study.

Water

Water is a small portion of the cost to produce a liter of milk, only 2% of the operating costs of production. Water does influence the quality of the milk as consumers differ in their preferences as to the beverage thickness. The use of water ranges 37% across the six dairies from a low of 0.88 liters water/liter soymilk in Dairy 4 vs. 1.20 liters water/liter soymilk in Dairy 3. The recommended level of water per batch is 12 liters or 0.92 liters water/liter soymilk. The six dairies average 1.02 liters water/liter soymilk, about 11% above the recommended level.

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Electricity
The average electricity costs are quite low, averaging less than $0.01 per liter of milk or less than 1% of the operating costs of production. Two dairies do not pay for electricity thus report no cost. Soy dairies use either wood, charcoal, or propane as the principal source of energy for heating the milk. Soy processing units utilize electricity for operating the soybean grinder, lights, refrigerators, and freezers. Dairies only minimally use refrigerators and freezers because of the significant additional capital cost.

Cleaning
Cleaning supplies refers to dish soap and bleach used to clean the soy dairy processing equipment and facility. All six dairies report cleaning costs. These costs amount to about a half a cent per liter or less than 1% of the operating costs of production.

Fuel
Fuel involves the costs associated with wood, propane, or charcoal to cook the soy slurry under pressure, as opposed to using an electric boiler. The dairies average about $0.01 per liter of soymilk or 4% of the operating costs to produce a liter of soymilk.

In sum, the dairies range in their 10 operating costs per liter of soymilk from $.013 to $0.63. Dairies 4 and 6 have costs below $0.20 USD per liter while Dairies 3 and 5 have costs greater than $0.50 USD per liter. The six dairies maintain average operating costs of $0.36 per liter.

Operating Margins
The dairies recorded soymilk prices received averaging $0.92 USD per liter with a range of $0.68 - $1.36 USD. Operating margins average $0.56 USD per liter with a range of $0.26 USD for Dairy 3 to $0.87 USD for Dairy 4. On a percentage basis the six soy dairies average operating margins of 61%.

Fixed and Indirect costs
Soy dairy businesses incur fixed and indirect costs that often go unreported, yet significantly affect business viability. None of the dairies in this study, nor those participating in our exploratory research, or any of the hard or soft soy dairy literature, captures non-cash fixed and indirect costs. Four important cost categories for example not captured are: 1) depreciation (accounting for capital replacement expenses), 2) amortization (recognizing capital gifts as long-term debt), 3) marketing and promotion, and 4) product shrink (accounting for spoilage, own-use, or theft).

Donors often gift the capital equipment to soy dairies such as, the processing unit itself and transport vehicles, as the entrepreneurs have limited capital reserves or access to credit to acquire the unit themselves. Standard bookkeeping practice requires that businesses incur depreciation expense equal to the life of the asset. Doing so allows managers and investors to understand a business's true profitability and economic sustainability, by identifying the costs associated with the business's capital base. Recognizing depreciation also assures managers properly prepare for capital replacement as well as match the capital base to the market size. Similarly, a

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sustainable dairy would normally either borrow capital, thus incur amortization expenses (principal and interest), or purchase the equipment out of cash flow in order to acquire the equipment to operate the business. Firms in the short run can ignore fixed charges and operate below break-even, as the costs are not directly cash related. However, the costs are real and sustainable businesses need to show they can pay for the assets they utilize and achieve appropriate returns on capital.

Soy Processing Unit Depreciation

Depreciation of capital equipment such as the processing equipment, bicycles, chillers, refrigerators, freezers, and buildings are important costs involved in soymilk production that entrepreneurs need to account for in their businesses. For simplicity, consider just the soy processing unit and not the complete set of assets required when producing soy dairy products. The processing unit has a capital cost of $10,000 USD, which includes training and setup [26]. Assuming a straight-line depreciation over five years, which is standard for food beverage equipment [27], the processing alone presents an annual depreciation expense of $2,000 USD or $167 per month.

The six dairies operate on average 20% of the days in a month, across the 18 months of the study (Table 4). Dairy 1 achieved the highest monthly operating level in August, the eighth month of the study, by producing soy milk on 71% of the days of the month. The soybean harvest in Malawi occurs around the month of April. Dairies did not operate for an entire month on 10% of the months; so there was some production on most months. Dairies produce on average 2.11 batches on days when operating, with a range of 1.36 by Dairy 4 to 2.97 for Dairy 2. The dairies on average produce 12.03 liters of milk per batch, about 14% below the recommended output of 14 liters per batch, and 24 liters of milk per day on the days when they operate. The dairies, at 2.11 batches per day, operate their facilities at about 1/3rd capacity on those days they operate, assuming the installer's recommendation of six batches per day. Additionally, the soy dairies average operational levels of about 6 days per month, or 31% of a standard operating month (20 days), with a range from 21% of the days with Dairy 5 to 62% of the days with Dairy 1. Low operating levels per month and the low operating levels on a given day combine to reflect an average capacity utilization level of 9% for the six soy dairies. Capacity utilization ranges from a low of 4% for Dairy 6 to a high of 25% for Dairy 1.

Low capacity utilization creates low production output of 147 liters of milk production per month on average for the six soy dairies. Output ranges from a low of 72 liters by Dairy 5 to a high of 416 by Dairy 1. The low capacity utilization becomes particularly relevant when firms need to pay for their fixed costs.

Spreading the fixed costs of $167 USD per month across the average production of each dairy's output adds an average $1.68 USD per liter to the costs of production, raising the total average cost per liter to $2.04 and a loss of $1.26 USD per liter. There is a significant range across the six dairies because of the wide range in equipment utilization. For example, Dairy 4 produces on average only 75 liters of milk per month so incurs equipment depreciation charges of $2.22 USD per liter just from the processing unit alone, and not including other capital equipment such as bicycles,

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coolers, refrigerators, freezers, chillers, or other fixed costs such as marketing and promotion and regulatory compliance. Dairy 1 produces significantly more than the other dairies, on average 416 liters per month or 25% of capacity. As such, fixed costs per liter of milk sold fall to $0.40 USD for Dairy 1. The addition of the depreciation expense raises the total cost per liter to $0.77 USD per liter for Dairy 1.

For reference purposes, the Ag Div dairies on average sell their milk for $0.92 USD per liter ranging from a low of $0.68 USD by Dairy 6 to a high of $1.36 USD by Dairy 5. None of the dairies engage in institutional sales, such as to schools and hospitals. One dairy, located at a university, sells its products to students. All dairies received and utilized a donated bicycle and chiller box to expand their market radius.

The capacity of a processing unit is 1,680 liters per month, assuming single shift operation, 6 batches a day over 20 days, and 14 liters per batch [14]. Depreciation costs fall to $0.10 USD per liter when businesses operate a soy processing unit at capacity, thus can offer milk at a reasonable price, and would achieve profitability and operational sustainability.

The fundamental question for the soy dairy model is whether the market can absorb 1,680 liters per month, and by doing so, sufficiently reduce fixed costs per unit sold to a profitable level. For example, a market size of 42,000 people and a market penetration of soymilk of 10% of the market (4,200 consumers) are necessary to achieve consumption levels of 1,680 liters per month, assuming 100 milliliters purchased once a week. Those consumption levels are 11 times current consumption on average across the six soy dairies.

The actual market sizes for the placement of the six dairies is not known. More relevant though is that the distribution area for the dairies that produce a fresh and highly perishable product will be small, unless significant investment can be made in packaging, cold chain management, and marketing. A fresh product marketing strategy requires that the dairy services a high consumer- dense setting, such as near schools or hospital, or an urban core. However, challenges too persist servicing institutional customers, such as schools and hospitals, because of the need to meet regulatory compliance, the ability for consumers to afford the soy beverage, and the requirement to synchronize production and consumption to avoid large levels of product loss.

The issue then for the business model is the inappropriateness of the large scale of the technology given low market demand. Businesses may operate sustainably in the short run due to positive operating margins when donors provide free capital equipment. However, when firms must pay for capital equipment and associated fixed costs then weak product demand dramatically raises a business's cost per unit sold, as is the case with the six dairies. As noted above the six dairies market only 147 liters per month. That low level of demand can only support a capital base of $926 USD, not $10,000 USD. Lowering the capital investment accordingly lowers fixed costs per unit sold from on average $1.68 per liter across the six dairies to a much more competitive level of $0.10 USD per liter sold.

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CONCLUSION

Anecdotal evidence shows that organizations operate the processing units infrequently at best, and often abandon the processing unit after the donor project ceases providing economic and technical support. Findings from Blumenthal, et al, (2010) present a case study consistent with the anecdotal evidence [15]. The Soybean Innovation Lab, a research for development enterprise, sought to address an important information gap by building an appropriate dataset, the first of its kind, to better understand the business economics of the soy dairy model. Little was known about the actual operating performance of these businesses in terms of their economic sustainability and value as a rural economic development mechanism.

In summary, the soy dairy technology itself performs very well across the six dairies. All six dairies produce high quality milk that approaches recommended quality standards in terms of sensory characteristics. Additionally, the operating margins for the Ag Div dairies are positive. The challenge to profitability, and hence, sustainability, of the soy dairy model is that businesses are not accounting for the fixed and indirect costs. Not including fixed costs distorts the correct incentives to operate at scale. For example, the dairies in this study operate at only 9% of single-shift capacity. Operating their fixed assets so infrequently inhibits businesses from paying their fixed costs, and as a result, the businesses fail to support their capital base. Weak demand sits at the heart of the capacity utilization problem as operators remark in interviews that they “only produce what they can sell”, when asked why they operate so infrequently.

Soymilks and yogurts are novel beverages in many markets, such as sub-Saharan Africa, so demand is not intrinsically strong. There is a low willingness to pay due to low income levels in communities where dairy entrepreneurs in this study operate. The study dairies sell milk for $0.92 USD per liter on average. The price appears high given the competition, historical preferences, and willingness to pay by consumers. The processing unit produces 1,680 liters per month when operated at recommended levels. At such levels, the businesses would over supply a niche set of consumers that have the discretionary income to afford the beverage and preferences for a novel healthy beverage. The relatively high price too precludes the dairies from profitably serving the institutional markets such as schools and hospitals that offer high volumes of demand but a very low willingness to pay.

Tactics such as improved packaging, locating close to population centers, and investment in promotion and marketing all increase the customer base. They simultaneously add additional fixed costs. For example, branded soy beverages from Asia, Kenya, and South Africa achieve wide market penetration, even selling in many secondary urban markets throughout sub-Saharan Africa. These imported products maintain long shelf life, present colorful and informative brands that result from the use of high quality aseptic packaging, which is capital intensive and requires large volumes to reduce fixed costs per unit to a competitive level. These products not only provide competition to local products produced by soy dairy entrepreneurs, but also highlight the criticality of wide distribution for business viability in the beverage space.

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Study Limitations- While the authors capture a number of key operational, revenue, and cost data, they fail to achieve sufficient managerial transformation of these enterprises to permit the production and collection of the full set of data necessary to build formal profit and loss statements and balance sheets. The dairies are independent operations, and as such do not prioritize the bookkeeping activity has highly as the many other tasks associated with operating a commercial business. As a result, the authors are unable to capture unpaid labor, value all assets of the business, food safety compliance, or the value of donated business support services.

Other significant costs not captured or estimated include: raw material, ingredient, and finished product losses and spoilage, fixed marketing and advertising costs, fixed regulatory costs associated with operating a permitted food-grade facility, amortization costs reflecting the cost of capital, and fixed working capital costs from holding raw material or finished product inventory. For example, many commercial processing firms procure soybean at harvest when prices are at their lowest. However, doing so would require significant inventory holding, physical storage assets, and investment in loss prevention, which requires capital, and the associated added costs to the soy dairy business.

Guidance- Practitioners and donors can be confident that the soy dairy technology performs very well. The facilities' output results in products that approximate the manufacturer's standards. The challenge lies not in the underlying technology, but the associated operating business. Soy dairy entrepreneurs need to not only be realistic about market size and market growth over time, but also the matched capital base needed to operate profitably free of donor support. Pro forma business plans need to include fixed costs such as, equipment and building depreciation, working capital (to procure soybean and store product inventory), marketing and promotion, and regulatory compliance. Combining proper capitalization ex ante to the business's inception with ex-post financial record-keeping will allow businesses to be aware of the full costs of their products, the necessary breakeven production level, and the constraints on sustained profitability.

Recognizing the criticality of matching the unit's capacity with market demand warrants that future donor investments target urban markets for siting dairies, rather than rural locations. Ideal locations would have high consumer density, adequate discretionary spending patterns, and reliable infrastructure, such as electricity. Nearness to consumers would allow entrepreneurs to build an effective brand, develop and market new derivative food products, such as yogurts, and easily market by-products to the commercial food sector, such as the *okara*. Operating within such environments would allow entrepreneurs adequate levels of sales on which to spread the high fixed costs associated with producing and marketing soy dairy products.

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Table 1: Variables Collected

Variable name	Variable Description	Unit	Time Period	Observations
Soybean	Amount of soybeans used	Kilograms	Daily	510
Soybean cost	Cost of soybeans	MwK/Kilogram		510
Sugar	Amount of sugar used	Kilograms	Daily	510
Sugar cost	Cost of sugar	MWK/Kilogram		510
Salt	Amount of salt used	Grams	Daily	510
Salt cost	Cost of salt	MWK/Kilogram		510
Flavor	Amount of flavor used	Milliliters	Daily	510
Flavor cost	Cost of flavor	MwK/Liter		510
Culture	Amount of culture used	Milliliters	Daily	510
Culture cost	Cost of cultures	MwK/Liter		510
Vinegar	Amount of vinegar used	Milliliters	Daily	510
Vinegar cost	Cost of vinegar used	MwK/Liter		510
Sodium Benzoate	Amount of Sodium Benzoate used	Grams	Daily	510
Sodium Benzoate cost	Cost of Sodium Benzoate	MWK/Gram		510
Stabilizer	Amount of Stabilizer used	Grams	Daily	510
Stabilizer cost	Cost of Stabilizer	MWK/Gram		510
Water 1	Amount of Water used	Liters	Per batch	510
Soymilk 1	# of Soymilk batches	Batches	Daily	510
Transportation	Cost of Transportation	MWK	Daily	510
Labor	Cost of Labor	MWK	Per person, per day	510
Water 2	Total cost of Water	MWK	Daily	510
Electricity	Cost of Electricity	MWK	Daily	510
Cleaning Materials	Cost of Cleaning Materials	MWK	Daily	510
Building Rent	Cost of Facility Rental	MWK	Monthly	510
Packaging Type	Type of packaging used	Bulk, sachet, plastic bottle, or glass bottle	Daily	510
Packaging Volume	Size of the packaging	Milliliters	Daily	510
Packaging Number	Packaging units used		Daily	510
Packaging Cost	Cost of Packaging	MWK	Per unit	510
Fuel	Cost of Fuel	MWK	Daily	510
Soymilk 2	Soymilk Produced	Liters	Daily	510
Soymilk 3	Soymilk Sold	Liters	Daily	510
Soymilk 4	Soymilk Price	MWK/Liter		510
Soymilk 5	Soymilk Sold	MWK	Daily	510
Yogurt 1	Yogurt Produced	Liters	Daily	510
Yogurt 2	Yogurt Price	MWK/Liter		510
Yogurt 3	Yogurt Sold	MWK	Daily	510
Tofu 1	Yogurt Produced	Kilograms	Daily	510
Tofu 2	Tofu Price	MWK/kg		510
Tofu 3	Tofu Sold	MWK	Daily	510
Okara 1	Okara Produced	Kilograms	Daily	510
Okara 2	Okara Price	MWK/Kilogram		510
Okara 3	Okra Sold	MWK	Daily	510

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Table 2: Profit and Loss on a Per Liter of Soymilk Sold Basis for the Six Dairies

	Costs			Dairy 1	2	3	4	5	6	Average Cost	% Operating
	Ingredient										
		Soybean	$USD	$ 0.07	$ 0.05	$ 0.10	$ 0.03	$ 0.10	$ 0.05	$ 0.07	18%
		Sugar	$USD	$ 0.09	$ 0.05	$ 0.12	$ 0.07	$ 0.16	$ 0.05	$ 0.09	26%
		Water	$USD	$ 0.01	$ -	$ 0.03	$ 0.00	$ -	$ 0.00	$ 0.01	2%
A	Cost of Goods Sold			$ 0.17	$ 0.10	$ 0.25	$ 0.10	$ 0.26	$ 0.11	$ 0.16	46%
		% of total costs	%	22%	7%	9%	4%	9%	5%	8%	
	Operating										
		Labor	$USD	$ 0.04	$ 0.04	$ 0.04	$ -	$ 0.04	$ -	$ 0.03	7%
		Transportation	$USD	$ 0.00	$ 0.00	$ 0.19	$ -	$ 0.29	$ -	$ 0.08	23%
		Electricity	$USD	$ 0.01	$ -	$ 0.01	$ 0.00	$ -	$ 0.00	$ 0.00	1%
		Rental	$USD	$ 0.12	$ 0.12	$ -	$ 0.00	$ 0.01	$ -	$ 0.04	11%
		Cleaning	$USD	$ 0.00	$ 0.00	$ 0.00	$ 0.01	$ 0.00	$ 0.00	$ 0.00	1%
		Packaging	$USD	$ 0.03	$ 0.03	$ 0.02	$ 0.01	$ 0.02	$ 0.01	$ 0.02	6%
		Fuel	$USD	$ 0.01	$ 0.01	$ 0.03	$ 0.03	$ -	$ 0.01	$ 0.01	4%
B	Operating Sub Total			$ 0.20	$ 0.20	$ 0.31	$ 0.05	$ 0.37	$ 0.02	$ 0.19	54%
		% of total costs	%	26%	15%	11%	2%	13%	1%	9%	
C	Total Direct Costs (A+B)		$USD	$ 0.37	$ 0.30	$ 0.56	$ 0.15	$ 0.63	$ 0.13	$ 0.36	
		% of total costs	%	48%	22%	20%	6%	21%	7%	18%	
	Fixed Costs										
D		Depreciation		$ 0.40	$ 1.06	$ 2.20	$ 2.22	$ 2.30	$ 1.89	$ 1.68	
		% of total costs	%	52%	78%	80%	94%	79%	93%	82%	
E	Total Costs (C+D)		$USD	$ 0.77	$ 1.36	$ 2.76	$ 2.37	$ 2.93	$ 2.02	$ 2.04	
F	Revenue		$USD	$ 0.92	$ 0.68	$ 0.82	$ 1.03	$ 1.36	$ 0.68	$ 0.92	
G	Operating Margin (G-C)		$USD	$ 0.55	$ 0.38	$ 0.26	$ 0.87	$ 0.73	$ 0.55	$ 0.56	
			%	60%	56%	32%	85%	54%	81%	61%	
H	Net Margin (G-E)		$USD	$ 0.15	$ (0.68)	$ (1.94)	$ (1.35)	$ (1.57)	$ (1.34)	$ (1.12)	
			%	16%	-99%	-236%	-131%	-115%	-196%	-122%	

Table 3: Key Ingredient Usage for Soymilk Production by the Six Dairies

	Key Ingredient Ratios											
	Soy/Batch	Sugar/Batch	Water/Batch	Milk/Batch	Soy/Sugar	Sugar/Soy	Water/Soy	Milk/Soy	Soy/Milk	Milk/Water	Water/Milk	Sugar/Milk
Dairy	Kilograms		Liters				Liters/KG		KG/Liters		Liter	
1	2.00	1.05	12.00	13.39	1.81	0.55	6.00	6.69	0.15	1.12	0.90	0.08
2	2.02	0.69	13.09	13.39	2.98	0.34	6.50	6.66	0.15	1.01	0.99	0.05
3	2.84	1.58	10.81	8.74	1.67	0.60	5.38	4.67	0.21	0.83	1.20	0.18
4	1.96	1.16	12.29	13.84	1.66	0.60	6.24	7.11	0.14	1.14	0.88	0.08
5	1.98	1.14	9.00	7.68	1.79	0.56	4.54	3.88	0.26	0.88	1.14	0.15
6	2.07	0.64	44.29	12.25	3.17	0.32	NA	5.96	0.17	0.28	NA	0.05
Average	2.14	1.05	16.91	11.55	2.18	0.49	5.73	5.83	0.18	0.88	1.02	0.09
	Relative to Average amount											
1	-7%	0%	-29%	16%	-17%	12%	5%	15%	-17%	28%	-12%	86%
2	-6%	-34%	-23%	16%	36%	-32%	13%	14%	-17%	15%	-3%	57%
3	33%	51%	-36%	-24%	-23%	21%	-6%	-20%	19%	-5%	18%	200%
4	-8%	11%	-27%	20%	-24%	22%	9%	22%	-22%	30%	-14%	93%
5	-8%	9%	-47%	-34%	-18%	13%	-21%	-33%	43%	0%	11%	165%
6	-4%	-38%	162%	6%	45%	-36%	NA	2%	-7%	-69%	NA	58%
Max	2.84	1.58	44.29	13.84	3.17	0.60	6.50	7.11	0.26	1.14	1.20	0.18
Min	1.96	0.64	9.00	7.68	1.66	0.32	4.54	3.88	0.14	0.28	0.88	0.05
Range	45%	146%	392%	80%	91%	91%	43%	83%	83%	313%	37%	250%

Table 4: Operating Metrics for the Six Dairies

Operating Metrics			Dairy 1	2	3	4	5	6	Average
Operating	Months		18	16	16	9	16	5	13
Soybean	Total	Kilograms	1,118	378	260	99	299	74	371
	Monthly		62	24	16	11	19	15	24
Milk	Total	Liters	7,484	2,517	1,062	526	1,160	441	2,198
	Monthly		416	157	76	75	72	88	147
Batches	Total		559	188	122	38	151	36	182
	Monthly		31	12	9	5	9	7	12
	% utilization		26%	45%	33%	24%	45%	24%	33%
	Daily		2	3	2	1	3	1	2
	Milk	Liters	13	13	9	14	8	12	12
	Total		224	81	73	31	66	27	84
Days	Operating		12	5	5	4	4	5	6
	% operating		62%	25%	26%	22%	21%	27%	31%
	Milk	Liters	33	31	15	17	18	16	24
Overall Capacity Utilization			25%	9%	5%	4%	4%	5%	9%

REFERENCES

1. **Tellegen N** Rural enterprises in Malawi: necessity or opportunity?. Ashgate Publishing Ltd,1997.

2. **Kantor P** Determinants of women's microenterprise success in Ahmedabad, India: Empowerment and economics. Feminist Economics, 2005;**11(3):** 63-83.

3. **Allen T, Heinrigs P and I Heo** Agriculture, Food and Jobs in West Africa. OECD, 2018; 33 pages.

4. **Melembe T, Senyolo G M and VM Mmbengwa** Patterns of Smallholder Farmers' Choice of Value Addition in Gauteng Province, South Africa. Journal of Human Ecology, 2020; **70(1-3)**: 9-14.

5. **Poku K** Small-scale palm oil processing in Africa (Vol. 148). Food & Agriculture Org, 2002.

6. **Ohimain E I, Izah S C and FA Obieze** Material-mass balance of smallholder oil palm processing in the Niger Delta, Nigeria. Advanced Journal of Food Science and Technology, 2013; **5(3)**: 289-294.

7. **Parker RL, Riopelle R and WF Steel** Small enterprises adjusting to liberalization in five African countries. The World Bank, 1995.

8. **Muhanji G, Roothaert R L, Webo C and M Stanley** African indigenous vegetable enterprises and market access for small-scale farmers in East Africa. International Journal of Agricultural Sustainability, 2011; **9(1)**: 194-202.

9. **Thakur A, Dixit AK and KM Ravishankara** Economic analysis of informal dairy processing units in Karnal district of Haryana. Indian Journal of Dairy Science, 2020; **73(2)**: 151-154.

10. **Ugwu DS and UM Nwoke** Assessment of Soybean Products Acceptability and Consumption in Orumba South Local Government Area of Anambra State Nigeria. International Research Journal of Agricultural Science and Soil Science, 2011; **1(8)**: 314-325.

11. **Yuan S, Chang SK, Liu Z and B Xu** Elimination of trypsin inhibitor activity and beany flavor in soy milk by consecutive blanching and ultrahigh-temperature (UHT) processing. Journal of Agricultural and fFod Chemistry, 2008; **56(17)**: 7957-7963.

12. **Malnutrition Matters**. undated. SoyCow 'E' Fact Sheet. https://www.dropbox.com/s/s5veux5ipwqfyja/SoyCow%20%27E%27%20fact%20sheet%2001-21.pdf?dl=0. *Accessed April 2021.*

13. **Malnutrition Matters**. Capabilities Statement – Malnutrition Matters – January 2020. https://www.dropbox.com/s/b30nj0pohvvex4c/MM%20Capabilities%20Statement%202021.pdf?dl=0. *Accessed April 2021.*

14. **Malnutrition Matters**. VitaGoat & SoyCow 'M' Fact Sheet. https://www.dropbox.com/s/fedsde0m4vnfewj/Vitagoat%20_%20SoyCow%20M%20fact%20sheet%2001-21.pdf?dl=0, undated. *Accessed April 2021.*

15. **Blumthal M, Micheels ET, Paulson ND and RC Farrell** A Guatemalan SoyCow Cooperative: Is the Whole Greater than the Sum of its Parts? International Food and Agribusiness Management Review, 2010; **13(4)**: 157-172.

16. **Sopov M B and Y Sertse** Setting up micro-enterprises to promote soybean utilization at household level in Ethiopia (No. 14-014). Centre for Development Innovation, Wageningen UR, 2014.

17. **Conté M, Bonaventure T and DE McMillan** Lessons Learned from Pilot Testing VitaGoat Technology in Guinea. Africare Food Security Review No. 19, December, 2008.

18. **Chianu JN, Vanlauwe B, Adesina A, Chianu JN and N Sanginga** Review of Innovative Agricultural Market Creation in Africa and the Study of Three-tier Model for Soybean Development and Promotion in Kenya. Journal of Life Sciences, 2010; **4(3)**: 43-51.

19. **Harrigan, B and L Cohen** Africare's Experience with VitaCow and VitaGoatFood Processing Systems. Africare Food Security ReviewNo. 18, December, 2008.

20. **Lamb J** Health or Agricultural Development: Boundary Objects and Organizations in a Soya Project in Western Kenya. Consilience, 2011; **(5)**: 53-70.

21. **Malnutrition Matters**. SoyCow 30 Fact Sheet. https://www.dropbox.com/s/e3qfzxu6ww386cp/SoyCow%2030%20fact%20sheet%202021.pdf?dl=0, undated. *Accessed April 2021.*

22. **Martey E and PD Goldsmith** Heterogeneous Demand for Soybean Quality. African Journal of Agricultural and Resource Economics. 2020; **15 (1)**: 27-50.

23. **Malnutrition Matters**. The SoyCow / VitaCow / VitaGoat Business Guide. Malnutrition Matters, 2006; 34 pages.

24. **Index Mundi** https://www.indexmundi.com/commodities/?commodity=soybeans, 2018; *Accessed January, 2019.*

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25. Soybean Innovation Lab. Visit to the Ag Diversification Project, Malawi. Staff Photo. June 2019

26. **Malnutrition Matters** Business Model for VitaGoat/SoyCow M. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=8&cad=rja&uact=8&ved=2ahUKEwic9piHr6nmAhUGLK0KHaC4CnIQFjAHegQIAxAC&url=https%3A%2F%2Fnetwork.changemakers.com%2Fattachments%2Fa14a4897-9008-4f88-a1d4-5ecb91dd94a5.xls%3Fid%3D2712&usg=AOvVaw09sTaWlHeY74jeWEYQYOZf, 2013. *Accessed May 2019.*

27. **IRS** . Cost Segregation Guide - Chapter 7.2 Industry Specific Guidance – Restaurants. https://www.irs.gov/businesses/cost-segregation-guide-chapter-72-industry-specific-guidance-restaurants, 2004. *Accessed online November 2019.*