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# SELECTIVE INVENTORY CONTROL THROUGH MULTI-CRITERIA CLASSIFICATION: AN EMPIRICAL STUDY OF A DAIRY PROCESSING SME IN CARCHI, ECUADOR

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## ABSTRACT

*Inventory management is important in the small and medium-sized dairy enterprises (SMEs) in developing economies, where capital constraints and perishable inputs require strict control. This paper uses a multi-criteria selective inventory classification model to 38 production inputs in MILMALAC S.A., a cheese and yogurt factory in Montufar, Carchi Province, Ecuador. Four independent classification methods were used with daily Kardex records of March 2024: ABC analysis (annual consumption value), HML analysis (unit price), VED analysis (production criticality), and FSN analysis (frequency of consumption). The four categories were amalgamated into a composite grid, producing a four-character grade of every item, which was subsequently categorized into seven inventory groups (I to VII). The findings showed that 7 items (18.4) in the Category A contributed to 66.0% of the total annual consumption value (USD 76,239.19), whereas 25 items (65.8) in the Category C contributed to 11.3% of value. The VED analysis revealed 14 items (36.8) to be Vital such as bacterial cultures, liquid rennet, and citric acid. Class I (highest priority) was composed of 6 items that needed to be strictly controlled in procurement, ordered using EOQ, and tracked as perpetual inventory. Each class was suggested to have differentiated procurement and inventory policies, such as EOQ lot sizing, safety stock levels, and reorder points of the top 15 items. The results indicate that multi-dimensional inventory classification offers practical decision support to dairy SMEs with limited resources to minimize the chances of overstocking low-value products and protect the supply chain of essential production factors.*

**KEYWORDS**: Inventory Management, ABC Analysis, VED Analysis, Dairy Industry, Selective Inventory Control, Ecuador SME.

## 1. INTRODUCTION

One of the most important issues of small and medium-sized enterprises (SMEs) in the food processing industry, and especially in the dairy production industry, is inventory management, as the inputs can be perishable biological cultures and stable chemical additives (Heizer et al., 2020). The dairy sector in the highland provinces of Ecuador has witnessed a consistent growth and Carchi Province has become a significant production center due to the favorable climatic conditions and the long-standing livestock culture (Chamorro, 2026). Although this has increased, most dairy SMEs still operate their inventories using empirical techniques, without systematic classification systems that would allow them to adopt different control policies to different items of inputs, depending on their economic importance, criticality, and movement patterns (Plinere & Borisov, 2015).

The inherent dilemma with inventory management is to have an optimal balance: enough inventory to keep the production going without having to spend a lot of financial capital on idle inventory and the carrying costs (Muller, 2019). This is especially acute in the case of dairy processors which use a very diverse set of inputs; such as bacterial cultures with very cold-chain sensitive requirements, chemical coagulants with very long shelf lives, and fast-moving preservatives used in a wide range of product lines. A uniform inventory policy to all products is bound to result in either high holding costs of low value materials or high risk stockouts of essential production inputs (Ramanathan, 2006).

In manufacturing settings, selective inventory management methods, the most popular of which is the ABC analysis according to the Pareto principle, have become commonplace in order to focus the management on high-value products (Flores and Whybark, 1987). Nonetheless, single-criterion classification techniques have their own shortcomings: ABC analysis is useful in terms of reflecting the annual consumption value but fails to capture the criticality of an item, whereas VED analysis is useful in terms of reflecting the criticality but fails to capture the economic magnitude (Bhattacharya et al., 2007). It has thus been proposed that multi-criteria classification methods that combine two or more techniques (ABC, HML (High-Medium-Low by unit price), VED (Vital-Essential-Desirable by criticality), and FSN (Fast-Slow-Non-moving by consumption frequency)) can be combined into composite frameworks with the potential to produce more refined and actionable inventory policies (Reda et al., 2014; Douissa and Jabauer, 2020).

Although the multi-criteria selective inventory classification approach has been used in the heavy manufacturing, pharmaceutical, and automotive industries, it has not been well used in the dairy processing industry, especially in the context of the Latin American SMEs. The current paper fills this gap by using a four-dimensional classification system (ABC × HML × VED × FSN) to the production inputs of MILMALAC S.A., a cheese and yogurt processing firm based in Montufar, Carchi Province, Ecuador. Based on real Kardex inventory data, the study identifies 38 active inventory items, creates a composite matrix, and allocates each item to one of seven priority classes and develops differentiated procurement and inventory management policies to each class. Also, the calculation of Economic order quantity (EDOQ), safety stock and Reorder Level (ROL) are presented on the highest priority items.

The research objectives are as follows: (a) to categorize the MILMALAC S.A. production inputs in terms of ABC, HML, VED and FSN analysis; (b) to combine the above categories into a multi-dimensional table and classify items into priority groups; (c) to calculate the EOQ, safety stock and reorder levels of the highest priority items; and (d) to suggest differentiated procurement and inventory policies based on the operational environment of a dairy SME in Ecuador.

## 2. THEORETICAL FRAMEWORK

### *2.1 Inventory Management in SMEs*

Inventory management refers to the combined planning, coordination, and control of material stocks within the supply chain, including the procurement of raw materials to the delivery of finished goods (Krajewski et al., 2019). In the case of SMEs, inventory maintenance costs are usually 20-30 percent of the total inventory value per year, including the cost of storage, insurance, obsolescence, and the cost of the opportunity cost of capital tied up in inventory (Silver et al., 2017). These costs are further increased in the dairy industry by the perishability of some of the inputs, especially the bacterial cultures and mermelades, which further limits the lot sizes and ordering frequency.

### *2.2 ABC Analysis*

The ABC analysis is based on the Pareto principle (or 80/20 rule) and divides inventory items into three groups according to the value of their annual consumption (Flores and Whybark, 1987). The category A items, which usually constitute 1020 percent of the total number of items, contribute 6080 percent to the total value and should be controlled with the highest level of strictness. The items in category B constitute 20-30 percent of items and 15-25 percent of value and need moderate supervision. Items in category C, which may comprise 50-70 percent of the total number of items, but only 5-15 percent of the total value, may be handled using simplified processes. The main benefit of the ABC analysis is its ability to focus the limited managerial resources on the items that have the most economic impact (Ramanathan, 2006).

### *2.3 HML Classification*

The HML (High-Medium-Low) classification is similar to the ABC analysis except that it uses unit price instead of annual consumption value as the sorting variable (Bhattacharya et al., 2007). The items are ordered in descending order of unit cost and the thresholds of H, M, and L are set by the management. HML analysis is also helpful in controlling consumption at the departmental level, determining the frequency of physical verification, and purchase authorization levels (Plinere & Borisov, 2015).

### *2.4 VED Analysis*

VED (Vital-Essential-Desirable) analysis is an analysis that ranks items based on their importance to the continuity of production (Reda et al., 2014). Vital items are those without which production would come to a standstill immediately; Essential items are those without which production would be disrupted within hours or days; and Desirable items are those without which production can be put on hold a week or longer without halting. In contrast to ABC and HML, VED classification does not use quantitative data alone but instead domain-specific knowledge, usually provided by production managers and technical personnel (Douissa & Jabeur, 2020). Bacterial starter cultures and coagulating enzymes are also Vital in dairy processing since no cheese production can be initiated without them.

### *2.5 FSN Analysis*

FSN (Fast-Slow-Non-moving) analysis is a method according to which items are classified according to the frequency of consumption or frequency of the problem (Bhattacharya et al., 2007). Fast-moving items are being consumed on a regular basis and turnover is high; Slow-moving items are being issued with intervals; and Non-moving items do not show any or minimal consumption over the period of analysis. The FSN analysis is especially useful in the detection of obsolete or excessive inventory that occupies the working capital without producing anything (Muller, 2019).

### *2.6 Multi-Criteria Matrix Approach*

The use of composite matrix, which involved the combination of several classification systems, was suggested to address the weakness of single-criterion systems (Flores and Whybark, 1987). Assigning a multi-character code to each item i.e. AFVH to an item of A-class by value, Fast-moving, Vital, and High-priced, the managers receive a multidimensional profile that enables more focused inventory policies. Classes can be formed of items with similar composite profiles, and each of them is controlled by different procurement frequencies, lot-sizing procedures, safety stocks, and monitoring intensities (Reda et al., 2014).

### *2.7 Economic Order Quantity and Safety Stock*

The Economic order quantity (EDO) model calculates the optimal order quantity that will reduce the total costs of ordering and holding inventory: EOQ = sqrt(2CO/I), where C is the annual consumption, O is the ordering cost per order, and I is the annual carrying cost per unit (Silver et al., 2017). The extra stock held to counter the variability in demand and uncertainty in lead time is called the safety stock: SS = (Maximum Lead Time -Normal Lead Time) x Average Monthly Consumption. The level at which a new order is to be placed is the Reorder Level (ROL): ROL = (Normal Lead Time x Monthly Consumption) + Safety Stock (Heizer et al., 2020).

## 3. METHOD

### *3.1 Research Design*

The research design used in this study was a quantitative, descriptive and applied research design. It is an empirical approach, which is founded on primary operational data that is gathered directly through the inventory management system of MILMALAC S.A. The individual inventory item (production input/insumo) is the unit of analysis and the month of March 2024 is the time frame of the study with annual values being obtained by annualizing (×12) of the monthly values.

### *3.2 Study Context: MILMALAC S.A.*

MILMALAC S.A. is a small-scale dairy processing company in the Canton Montufar, Carchi Province, in the highlands of northern Ecuador, on the Panamericana E35 highway (km 50.5, Sector El Capulí). The company started its operation on the 1 st of September 2015 with a starting capacity of 500 liters of milk per day and three employees. By 2024, the company has 15 employees (administrative and operational) and a processing capacity of 10,000 liters per day, but the current usage is around half the capacity because of the shortage of raw milk supplies. The manufacturing plant covers an area of 350 m 2 and has four cold storage rooms that have a capacity of 3-4 metric tons. The company manufactures diversified product range which consists of Cheddar, Holandes, Gouda, Pizza, Mozzarella, Doble Crema, Fresco (block and small), Provolone, smoked varieties, American-style processed cheese, yogurt (strawberry, peach, blackberry, natural), dulce de leche and cream. It has a leased infrastructure and equipment of about 70 percent of the machinery and owned 30 percent of the machinery, some of which is imported.

### 3.3 Data Collection

The primary data were collected in the form of the Kardex inventory management spreadsheet of the company (HOJA INVENTARIO INSUMOS MARZO 2024), where the daily entries (purchases), exits (consumption), and running balances of every production input are recorded. The spreadsheet included 55 worksheets: a monthly production sheet (PRODUCCION MENSUAL) where the daily volumes of milk allocated to each product are recorded; a purchases sheet (COMPRAS) with lot numbers, manufacturing date, expiration date, supplier code; a balances summary sheet (SALDOS) with opening and closing stocks; and 49 Kardex sheets, one sheet per inventory item, with daily movements with full traceability information. Additional contextual information regarding the organizational structure, supply chain, and operational issues of the company were based on parallel academic research carried out in the same company (Chamorro, 2026).

### 3.4 Data Processing

The monthly consumption of each item was calculated as the total of all the daily exits (issues to production) in the respective Kardex sheets in March 2024. The products that were not consumed within the period of observation were not included in the active analysis but reported as non-moving inventory. Annual consumption was calculated by multiplying monthly consumption in March 2024 by 12 ( Cmonthly × 12) to obtain annual consumption. The price of each input was estimated using the current prices in the Ecuadorian wholesale market of inputs used to produce dairy in 2024, and cross-referenced with supplier catalogs (CHR Hansen/Descalzi, Toptrading, Biovitalife/Sacco) found in the company records. The last dataset consisted of 38 items of positive monthly consumption.

### 3.5 Analytical Techniques

The selective inventory control methods that were used in turn included:

(1) ABC Analysis: The items were ordered by the annual consumption value (annual quantity x unit price) in decreasing order. The percentages were calculated cumulatively and items were categorized as A (cumulative value 50 and below), B (50-90) and C (90 and above).

(2) HML Classification: Unit price was used to classify the items, with the High (>USD 8.00), Medium (USD 1.00-7.99), and Low (<USD 1.00) being the thresholds determined by the management to fit into the input cost of the company.

(3) VED Analysis: Dairy processing expertise guided the classification of items according to their importance to the production continuity. Bacterial starter cultures, liquid rennet, lysozyme, calcium chloride, citric acid, and lactase were vital items without which the production of cheese or yogurt cannot continue. Among the necessities were preservatives, stabilizers, salt, sugar, and mermelades. The desirable products included colorants, flavors, and liquid smoke.

(4) FSN Analysis: Items that were consumed more than 200 units per month were considered Fast-moving (F); 10-200 units per month were considered Slow-moving (S); and less than 10 units per month were considered Non-moving (N).

(5) Matrix Formation: Each item was given a composite four-character grade (ABC + FSN + VED + HML). The next decision rules were used to sort items into seven priority classes (I through VII): Class I = A-category and Vital; Class II = A-category and non-Vital; Class III = B-category and Vital; Class IV = B-category and non-Vital; Class V = C-category and Fast-moving; Class VI = C-category and Slow-moving; Class VII = C-category and Non-moving.

(6) EOQ, Safety Stock, and ROL: In the case of the top-priority items (Classes I–IV), the Economic order quantity (EOOQ) was computed with the help of the Wilson formula EOQ = 2CO/I sqrt and the ordering cost (O) was USD 15.00 per order, and the carrying rate was 20% of unit cost. The calculation of safety stock was done as follows: SS = (Maximum Lead Time -Normal Lead Time) x Average Monthly Consumption where the lead time parameters were 2.0 months (maximum) and 1.5 months (normal)

according to the company procurement records. Reorder Level was calculated as: ROL = (Normal Lead Time x Monthly Consumption) + Safety Stock.

## 4. RESULTS

### 4.1 Inventory Profile

MILMALAC S.A. inventory system includes 38 active production inputs, which were positively consumed in March 2024. These inputs are of six functional categories: bacterial starter cultures (11 items), chemical additives and preservatives (10 items), colorants and flavorings (10 items), salt and sugar (3 items), enzymes and coagulants (2 items), and stabilizers (2 items). The overall estimated annual consumption value of all the 38 items is USD 115,576.02. The summary of the key inventory indicators is provided in Table 1.

***Table 1: Summary of inventory indicators for MILMALAC S.A. (March 2024, annualized).***

| Indicator | Value |
|---|---|
| Total active inventory items | 38 |
| Total estimated annual consumption value | USD 115,576.02 |
| Number of suppliers | 17 |
| Product lines served | 20+ |
| Observation period | March 2024 (annualized ×12) |
| Daily milk processing capacity | 10,000 liters |

### 4.2 ABC Analysis

ABC analysis, which is determined by the annual consumption value, categorized 7 items (18.4) as Category A, which contributes to 66.0 percent of the total annual value (USD 76,239.19). There were 6 items in category B (15.8) with a contribution of 22.7% of value (USD 26,249.92). The rest 25 items (65.8) were under Category C, which is just 11.3 percent of the total value (USD 13,086.90). The distribution is very much in line with the Pareto principle and it is established that a small percentage of items controls the economic scale of inventory investment. The results of the ABC classification are summarized in Table 2.

***Table 2: ABC analysis summary.***

| Category | No. of Items | % of Items | Annual Value (USD) | % of Value |
|---|---|---|---|---|
| A | 7 | 18.4 | 76,239.19 | 66.0 |
| B | 6 | 15.8 | 26,249.92 | 22.7 |
| C | 25 | 65.8 | 13,086.90 | 11.3 |
| Total | 38 | 100.0 | 115,576.02 | 100.0 |

***Table 3: Top 10 items by annual consumption value (ABC analysis).***

| No. | Item | Unit | Annual Qty | Price (USD) | Annual Value (USD) | Cum. % | ABC |
|---|---|---|---|---|---|---|---|
| 1 | Cultivo Cheddar RSF-736 | unit | 648.00 | 22.000 | 14,256.00 | 12.33 | A |
| 2 | Cultivo Pizza/TCC/ST | unit | 708.00 | 18.500 | 13,098.00 | 23.67 | A |
| 3 | Cuajo Líquido CHY-MAX M | ml | 152,328.00 | 0.090 | 12,947.88 | 34.87 | A |
| 4 | Azúcar | kg | 10,090.08 | 1.100 | 11,099.09 | 44.47 | A |
| 5 | Cultivo Holandés R-704/MOS | unit | 504.00 | 19.000 | 9,576.00 | 52.76 | A |
| 6 | Ácido Cítrico | kg | 2,276.06 | 3.500 | 7,966.22 | 59.65 | A |
| 7 | Cultivo Holandés DOM | unit | 384.00 | 19.000 | 7,296.00 | 65.96 | A |
| 8 | Sorbato de Potasio | g | 374,352.00 | 0.020 | 6,738.34 | 71.79 | B |
| 9 | Cultivo DEM/CHN (Gouda) | unit | 288.00 | 20.000 | 5,760.00 | 76.78 | B |
| 10 | Sal Refinada | kg | 12,162.14 | 0.450 | 5,472.96 | 81.51 | B |

### 4.3 HML Classification

The HML classification, which is based on the unit price thresholds, was used to determine 9 items (23.7%) as High-priced (≥USD 8.00/unit), which are mostly bacterial cultures and yogurt stabilizer. Medium-priced (USD 1.007.99) items (7) (sugar, citric acid, salts, and mermelades) comprised 18.4 percent. Most of them, 22 items (57.9%), were Low-priced (<USD 1.00), which included preservatives, colorants and flavorings in grams or milliliters. The HML summary is presented in table 4.

***Table 4: HML classification summary.***

| Category | No. of Items | % of Items | Unit Price Range (USD) |
|---|---|---|---|
| High (H) | 9 | 23.7 | ≥ 8.00 |
| Medium (M) | 7 | 18.4 | 1.00 – 7.99 |
| Low (L) | 22 | 57.9 | < 1.00 |
| Total | 38 | 100.0 | — |

### *4.4 VED Analysis*

The VED classification, which was conducted with the dairy production expertise, classified 14 items (36.8%) as Vital, 14 items (36.8%) as Essential and 10 items (26.3) as Desirable. All bacterial starter cultures (yogurt, cheddar, holandes, gouda, provolone, pizza, fresh cheese), liquid rennet (cuajo), lysozyme (clerizima), calcium chloride, citric acid, nisina and lactase were categorized as Vital, as any shortage of these products would stop the production of cheese or yogurt at once. Table 5 is a summary of VED classification.

***Table 5: VED classification summary.***

| Category | No. of Items | % of Items | Examples |
|---|---|---|---|
| Vital (V) | 14 | 36.8 | Cultures, Rennet, Lysozyme, $CaCl_2$, Citric Acid |
| Essential (E) | 14 | 36.8 | Salt, Sugar, Preservatives, Stabilizers, Mermelades |
| Desirable (D) | 10 | 26.3 | Colorants, Flavorings, Liquid Smoke |
| Total | 38 | 100.0 | – |

### *4.5 FSN Analysis*

The FSN classification was found to have 16 items (42.1) Fast-moving, 14 items (36.8) Slow-moving and 8 items (21.1) Non-moving (consumption less than 10 units per month). Rapid moving products were potassium sorbate, liquid rennet, cream stabilizer, achiote colorant, lysozyme, caramelo, liquid smoke, sugar and refined salt, which are used in various product lines. Non-moving products were yogurt culture (applied on production days only), fresh cheese culture, provolone culture, yogurt stabilizer and trace preservatives, including sorbic acid and sodium benzoate. The FSN summary is shown in Table 6.

***Table 6: FSN classification summary.***

| Category | No. of Items | % of Items | Consumption Criterion |
|---|---|---|---|
| Fast (F) | 16 | 42.1 | > 200 units/month |
| Slow (S) | 14 | 36.8 | 10 – 200 units/month |
| Non-moving (N) | 8 | 21.1 | < 10 units/month |
| Total | 38 | 100.0 | – |

### *4.6 Multi-Criteria Matrix and Class Assignment*

Composite grades were obtained after the combination of all four classification systems and these were sorted into seven priority classes. Table 7 shows the class structure, the composite grade patterns in each of the classes, and the amount of items allocated to each.

***Table 7: Multi-criteria classification: items sorted by class.***

| Class | No. Items | Grade Patterns | Representative Items |
|---|---|---|---|
| I | 6 | ASVH, AFVL, ASVM | Cultures (Cheddar, TCC, Holandés, DOM), Rennet, Citric Acid |
| II | 1 | AFEM | Sugar |
| III | 4 | BSVH, BFVL, BSVM, BNVH | Cult. Gouda, Lysozyme, $CaCl_2$, Cult. Yogurt |
| IV | 2 | BFEL | Potassium Sorbate, Refined Salt |
| V | 11 | CFVL, CFEL, CFDL | Nisina, Cream Stab., Achiote, Smoke, Lactase, Colorants |
| VI | 7 | CSEM, CSEL, CSDL | Mermelades, Grain Salt, Sab. Cheddar, Col. Durazno, $KNO_3$ |
| VII | 7 | CNVH, CNEH, CNEL | Cult. Provolone, Cult. Fresco, Stab. Yogurt, $NaHCO_3$, Preservatives |

### *4.7 EOQ, Safety Stock, and Reorder Level*

Table 8 shows Economic order quantity, Safety Stock and Reorder Level of the top 15 items (Classes I through IV) calculated using an ordering cost of USD 15.00/order and a carrying rate of 20/annum. The lead time parameters were established to be 2.0 months (maximum) and 1.5 months (normal) as per the observed procurement trends.

***Table 8: EOQ, Safety Stock, and Reorder Level for top 15 items.***

| Item | Grade | Class | Unit | Monthly Cons. | EOQ | Safety Stock | ROL |
|---|---|---|---|---|---|---|---|
| Cultivo Cheddar RSF-736 | ASVH | I | unit | 54.00 | 66.47 | 27.00 | 108.00 |
| Cultivo Pizza/TCC/ST | ASVH | I | unit | 59.00 | 75.77 | 29.50 | 118.00 |
| Cuajo Líquido CHY-MAX M | AFVL | I | ml | 12694.00 | 16395.55 | 6347.00 | 25388.00 |
| Azúcar | AFEM | II | kg | 840.84 | 1173.00 | 420.42 | 1681.68 |
| Cultivo Holandés R-704/MOS | ASVH | I | unit | 42.00 | 63.08 | 21.00 | 84.00 |
| Ácido Cítrico | ASVM | I | kg | 189.67 | 312.32 | 94.84 | 379.34 |
| Cultivo Holandés DOM | ASVH | I | unit | 32.00 | 55.06 | 16.00 | 64.00 |
| Sorbato de Potasio | BFEL | IV | g | 31196.00 | 55853.38 | 15598.00 | 62392.00 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Cultivo DEM/CHN (Gouda) | BSVH | III | unit | 24.00 | 46.48 | 12.00 | 48.00 |
| Sal Refinada | BFEL | IV | kg | 1013.51 | 2013.47 | 506.76 | 2027.02 |
| Clerizima (Lisozima) | BFVL | III | g | 2926.00 | 7445.80 | 1463.00 | 5852.00 |
| Cloruro de Calcio | BSVM | III | kg | 84.61 | 233.22 | 42.31 | 169.23 |
| Cultivo Yogur YF-811/812 | BNVH | III | unit | 7.00 | 22.45 | 3.50 | 14.00 |
| Mermelada de Mora | CSEM | VI | kg | 31.50 | 108.69 | 15.75 | 63.00 |
| Mermelada de Frutilla | CSEM | VI | kg | 31.50 | 112.25 | 15.75 | 63.00 |

### *4.8 Proposed Procurement and Inventory Policies*

Based on the multi-criteria classification, differentiated procurement and inventory management policies are proposed for each class, as summarized in Tables 9 and 10.

***Table 9: Procurement policies by class.***

| Parameter | Class I | Class II | Class III | Class IV | Class V | Class VI | Class VII |
|---|---|---|---|---|---|---|---|
| ROL/ROQ | ROL-based | ROL-based | ROL-based | ROL-based | Stock-out triggered | Stock-out triggered | Stock-out triggered |
| Stock levels | Min/Max required | Min/Max required | Min required | Min required | No minimum | No minimum | No minimum |
| Purchase frequency | 3-month pattern | 3-month pattern | 3-month pattern | 6-month pattern | As needed | As needed | As needed |
| Lot sizing | EOQ | EOQ | EOQ | EOQ | Not required | Not required | Not required |
| Safety stock | Mandatory | Mandatory | Mandatory | Mandatory | Optional | Not required | Not required |
| Procurement | E-procurement | E-procurement | E-procurement | E-procurement | Standard | Standard | Standard |
| Monitoring | High | High | High | Medium | Medium | Low | Low |

***Table 10: Inventory policies by class.***

| Parameter | Class I | Class II | Class III | Class IV | Class V | Class VI | Class VII |
|---|---|---|---|---|---|---|---|
| Tracking method | Perpetual (daily) | Perpetual (daily) | Perpetual (daily) | Periodic (weekly) | Periodic (weekly) | Periodic (monthly) | Periodic (monthly) |
| Inventory accuracy | Continuous verification | Continuous verification | Continuous verification | Weekly verification | Spot checks | Not required | Not required |
| Review frequency | Monthly report to GM | Monthly report to GM | Monthly report to GM | Monthly report | Quarterly | Quarterly | Annual |
| Storage norms | Specific cold storage | Designated location | Specific cold storage | Designated location | General storage | General storage | General storage |
| Disposal policy | Yearly review | Yearly review | Yearly review | Yearly review | Yearly review | Biannual review | Biannual review |

## 5. DISCUSSION

The multi-criteria selective inventory classification used on MILMALAC S.A. makes some findings that have theoretical and practical implications on dairy SMEs in Ecuador and other developing-economy settings.

To start with, the Pareto concentration of value was proved by the ABC analysis: 7 items (18.4%) were used to obtain 66.0% of annual consumption value. It is interesting to note that four of the seven items in the Category A were bacterial starter cultures (Cheddar, Pizza/TCC, Holandes R-704, and Holandes DOM) due to the high unit cost of the lyophilized and frozen cultures obtained by local distributors through international suppliers (CHR Hansen, Denmark and Sacco, Italy). Liquid rennet (cuajo CHY-MAX M) was the third most valuable item despite having a low unit price (USD 0.085/ml) because of its extremely high consumption volume per month (12,694 ml), which HML analysis alone could not make, as it is high-value either by price or by volume.

Second, the VED analysis showed that 14 out of 38 items (36.8) are Vital to production continuity. This is a significantly large percentage compared to those reported in heavy manufacturing environments (Bhattacharya et al., 2007), which is biologically speaking, dairy processing: without starter cultures, rennet, or calcium chloride, cheese curd cannot form. The cross-section of the ABC and VED categories was especially enlightening: six out of seven A-class items turned out to be also Vital, which is what Class I designation requires, and which requires the most stringent procurement controls. This overlap indicates that in the dairy processing industry, the economic relevance and operational importance of enzyme and culture inputs are highly correlated, which might not be the case in other manufacturing industries.

Third, the FSN analysis revealed 16 Fast-moving items (42.1%), some of them C-class items like potassium sorbate, cream stabilizer, and achiote colorant. Although the unit values of these items are low, the large volumes of consumption and usage in various product lines (mozzarella, fresh cheese, double cream, yogurt) implies that a stockout would impact a wide variety of finished products at once. These items were appropriately designated as Class V (C + Fast), which implies that they are monitored as medium-intensity items, even though their individual economic impact is low, in line with the suggestions of Roda et al. (2014) that multi-criteria solutions should be used to ensure that low-value but operationally active items are not overlooked when using pure ABC management.

Fourth, some items had negative balances in the Kardex records (e.g., Cultivo DOM at -155 units, Saborizante Cheddar at -1,783 ml), which is a symptom of retrospective record-keeping or unrecorded receipts. This observation is consistent with the observation made by Chamorro (2026) that MILMALAC has a poor inventory system, and the decisions regarding procurement are made on a case-by-case basis. This weakness is directly related to the proposed multi-criteria framework, which is supplemented by perpetual inventory tracking of Class I-III items.

Fifth, the EOQ computations give operational standards in the procurement planning. As an example, the EOQ of Cultivo Cheddar RSF-736 is around 66 units, compared to the monthly consumption of 54 units, indicating that the lot size of one month of supply is the cost-effective order quantity. In the case of liquid rennet, the EOQ of 16,396 ml means that the supply to be ordered is about 1.3 months of supply in one order. These standards can be implemented immediately by the procurement department of the company and are a huge step forward of the present ad-hoc ordering process.

The results of this investigation are aligned with the previous implementations of multi-criteria inventory classification in manufacturing SMEs (Plinere & Borisov, 2015; Douissa & Jabeur, 2020) but advance the literature by showing the relevance of the framework to perishable-input food processing in a Latin American setting. The seven-class hierarchy and the differentiated policies are a useful tool that can be adopted without the complex information systems, which is vital in the resource-limited SMEs. Weaknesses of this research are that it uses one month of data (March 2024), which might not reflect seasonal changes in consumption patterns; it uses estimated instead of actual unit prices of some of the inputs; and it assumes that the lead times and ordering costs remain constant in the EOQ model. The analysis should be expanded to a complete fiscal year, actual procurement costs should be included and sensitivity analysis should be done on the EOQ parameters in future research.

## 6. CONCLUSION

This paper used a multi-criteria selective inventory classification system, which combined ABC, HML, VED, and FSN analysis, to 38 production inputs at MILMALAC S.A., a dairy processing SME in Carchi Province, Ecuador. The main findings are as follows:

The Pareto concentration was validated by the ABC analysis: 7 items (18.4) represented 66.0% of the estimated value of annual consumption of USD 115,576.02. Cultivo Cheddar RSF-736, Cultivo Pizza/TCC, and Cuajo Liquido CHY-MAX M were the three highest-valued items, which make up 34.9 percent of the total inventory value.

The VED analysis showed 14 Vital items (36.8%), and they are biologically or chemically essential in dairy processing. The high correlation between A-class and Vital items shows that economic investment in dairy inputs is focused on those materials the lack of which would stop production.

The four-dimensional composite matrix (ABC × FSN × VED × HML) categorized the items into seven profiles. Class I (6 items) is high-value, production criticality and must have the most stringent procurement and monitoring policies such as EOQ-based lot sizing, mandatory safety stock, continuous monitoring of inventory and monthly reporting to the general management.

The top 15 items were calculated using EOQ, safety stock, and reorder levels, which offer practical procurement levels. As an example, the order quantity of Cultivo Cheddar will be 66 units, the safety stock level is 27 units, and the reorder level is 108 units.

The variousiated policies suggested to Classes I to VII provide MILMALAC S.A. with a systematic, evidence-based framework to substitute its existing empirical method of inventory management. These policies should lead to a decrease in carrying costs of low-priority products, elimination of stockouts of essential inputs, and better procurement planning, which will help the enterprise become more competitive in an ever-competitive dairy market.

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