Cost of quality model in the practice of apple juice processing business unit in Batu City: a comparison

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Abstract. The paper compares the cost of quality models in a different business unit of selected apple juice producers. Data and information were carried out through observation and interviews with key informants and related parties. Further data were analysed using the Activity Based Costing (ABC) approach to get a quality cost model for each business unit. The primary cost analysis shows a similar proportionality between the cost of prevention, appraisal, and cost of failure among three business units. Results illustrated that the higher the production capacity, the higher quality costs that occur or are budgeted for. From the calculation of quality costs, it is known that most of the quality costs come from appraisal costs. The cased business units indicated the high appraisal cost, which does have an impact on the low number of defective or failed products.

1. Introduction
Quality and reliable products at realistic costs always become a fundamental goal for producers. In recent years, customer expectations for quality at low cost are only increasing. As manufacturers strive to achieve their goals, they finally achieve at the point where a trade-off has to be made between improving quality and lower costs. To guide this trade-off decision, the Cost of Quality (CoQ) approach that has been developed. CoQ is one of the methods used to translate quality measures in a company into a more quantitative form. The calculation of CoQ aims to facilitate the process of evaluating and measuring the quality of the process and the resulting product. The quality cost model can be used as a recording tool and facilitate the distribution of information in every part of the company in an effort to improve the efficiency of the quality management system.

Quality cost management programs are considered as one of the most effective management tools for collecting and analyzing costs for maintaining quality in manufacturing processes. In a quality management program, measuring and reporting the cost of quality is the first step that must be done. Quality cost information can be used to pinpoint key opportunities for corrective action and provide impetus for quality improvement. The cost of quality is directly related to profitability [1]. Given the importance of quality management programs for companies, every company is required to immediately design and formulate quality cost programs, including small and medium-sized companies (SMEs).
Evaluation using a quality cost approach can be widely applied in an industry [2]. The application of the concept of quality control in SMEs is carried out by identifying product quality objectives, processes that occur, quality costs and defining sources of information until the product is processed for reporting [3]. Quality cost control can be considered as a means of supporting the full implementation of total quality management (TQM) in the company [4].

Building a quality cost model can be done by identifying possible cost elements. This stage can use various standards, one of which is the UK standard as a cost guide for. The development of the cost model is carried out with the stages of analyzing problems, opportunities, as well as priority actions and the most effective factors in the cost of failure in quality costs.

The trade-off between cost and quality needs to be done when the company needs to maximize quality at a low cost. The optimal quality inspection strategy can be achieved by modeling the costs of each strategy and classifying each failure cost that occurs [2]. CoQ models in practice of apple juice producers can be identified, measured and improved and should be considered an important metric for business units as manufacturers [5].

2. PAF model overview
Cost of quality is the cost incurred to prevent low quality products, or is a cost that arises as a result of producing a product that has low quality [6]. The PAF (Preventive – Appraisal – Failure) model is a quality-related cost for quality costs [7] which is classified into four categories: prevention, appraisal, internal failure, and external failure. Prevention cost refers to all costs that occurred to prevent nonconformance such as Quality Planning, New Product Reviews, Calibration and Maintenance of Production Equipment, Quality Audits, Supplier Capability surveys, and Quality Training and Education [8].

Appraisal costs refers to all the costs involved in striving to detect a non-conformed unit through inspection and test. To ensure the reliability of the production process, Activities related to quality costs are carried out during raw material selection, processing, and quality control. Cost assessment starts from the material acceptance procedure to determine specifications and raw material requirements. Inspection activities carried out are quality control carried out by the laboratory and quality verification at critical control points [9].

The cost of failure is further divided into internal and external failure costs. Internal failure costs include costs of rework efforts, scrap, re-inspection and retesting while external failure costs occurred when the wrong unit was sent to the consumer and the product was damaged during shipping [2]. Instance of external failure costs are warranty claims, complaint adjustment, and loss of sales.

3. Business unit characteristics
The study conducted a comparison on three apple processing BUs with the following characteristics:

| Characteristics                  | Business unit |
|----------------------------------|---------------|
|                                  | A             | B             | C             |
| Establish                        | 2 years       | 18 years      | 15 years      |
| Daily capacity                   | 2700 cup      | 2160 cup      | 16,000 cup    |
|                                  |               | 570 bottles   |               |
| Weekly production intensity      | 5 times       | 2 times       | 6 times       |
| Total manpower                   | 2 persons     | 5 persons     | 15 persons    |
| Quality assurance system         | Undocumented  | SOP           | SOP           |
| Product quality standards        | Exist         | Exist         | Exist         |

Quality assurance activities are carried out according to the BPOM standard output for apple juice products. Distribution of quality-related information is carried out verbally and assistance to employees
on duty. The first BU (unit A) only has 2 employees who impact the distribution of work that is quite a lot for each person. Workers have to do several types of work in a day, starting from production, controlling product quality during production, and carrying out cleaning activities at production sites.

The second BU (B unit) is part of a company which is engaged in various apple processing businesses. In the apple juice processing unit, the number of employees involved in the production is 5 only 5 persons. There has been a documented quality assurance effort in the form of a Standard Operational Procedure (SOP) in production activities along with the desired final product quality standard.

4. Activity based costing analysis
Activity Based Costing (ABC) analysis is a cost management system that identifying the cost of each activity required to produce the product. Product costs that occur reflect the costs of all activities consumed, so management can control the activities that occur while also controlling costs. ABC analysis can be used for planning, cost control, and decision making.

The implementation of the quality cost system goes through several stages: (1) Selecting the process for analysis, (2) Define the process and limit the scope of cost data collection, (3) Create a process flow chart and identify each input and output of the process, (4) Cost data collection by interviews. The coding system is used to divide costs into several cost categories with the following code: (A): Prevention costs (B): Assessment costs (C): Internal failure costs (D): External failure costs. In addition, numbers are also used to indicate subcategories of each category, for example, (A1) means quality planning.

ABC uses a two-step procedure to derive accurate costs from various cost objects, trace cost allocations from activities, and then assign costs from activities to cost objects. The potential quality costs resulting from this analysis are then modeled in a simple mathematical equation to obtain an overview of quality assurance activities.

4.1. Identify sources of quality costs and activities
The first step in ABC analysis is to identify each activity carried out related to quality assurance efforts. A number of activities that are considered to cause costs must be identified. In addition, the existing costs have been identified that have been budgeted by the business unit every year. Identification of activities and cost budgets is carried out through interviews with key informants of each business unit. The activities obtained to guarantee the quality of apple juice are as follows:

| Table 2. PAF cost model list. |
|-----------------------------|
| Conformance cost            | Non-conformance cost |
| Prevention Cost (Ai)         | Internal Failure Cost (Ci) |
| A1: Quality planning programs | C1: Re-processing        |
| A2: Maintenance             | C2: Damaged product cost |
| A3: Production site sanitation |                             |
| A4: Pest and contaminants control |                           |
| A5: Training                |                             |
| Appraisal Cost (Bi)         | External Failure Cost (Di) |
| B1: Raw material handling   | D1: Product recall cost   |
| B2: Inspection and monitoring| D2: Warranty claims       |

Reference: [2][9][10][11]
4.2. **Determine the source of the costs of related activities**

After the identification of the quality assurance activities, an analysis of the costs that may arise from these activities is carried out. The calculation of the quality costs is carried out through the calculation of the drafting cost by considering the following matters: (1) portion of hours worked on quality activities, (2) incentives for employees on related activities, and (3) number of employees involved in related activities.

4.3. **Quality cost driver**

Cost drivers are used to calculate the source cost of each unit of activity. Then each resource cost is assigned to the product or service by transferring the cost of each activity by the quantity of each activity consumed in a given period. Cost drivers are measurable factors that are used to assign costs to activities and from one activity to another.

| Table 3. Cost of Quality (CoQ) model on apple juice processor. |
|---------------------------------------------------------------|
| **Category** | **Business unit (IDR/year)** |
|              | A   | B   | C   |
| Preventive Cost | 38% | 32% | 41% |
| Maintenance    | 618,146 | 2,830,365 | 20,675,000 |
| Sanitation      | 3,360,720 | 3,765,720 | 13,500,000 |
| Pest and contaminant control | 200,000 | 200,000 | 1,200,000 |
| Training        | 0   | 0   | 0   |
| **Total**       | 3,979,066 | 6,596,285 | 35,375,000 |
| Appraisal cost  | 60% | 56% | 50% |
| Raw material handling | 3,090,000 | 7,725,000 | 7,920,000 |
| Inspection and monitoring | 3,090,720 | 3,708,000 | 36,000,000 |
| **Total**       | 6,180,720 | 11,433,000 | 43,920,000 |
| Failure Internal Cost | 2% | 2% | 9% |
| Re-processing   | 0   | 0   | 0   |
| Damaged product cost | 138,750 | 2,240,000 | 7,700,000 |
| **Total**       | 138,750 | 2,240,000 | 7,700,000 |
| External Failure Cost | 0% | 0% | 0% |
| Product recall cost | 0   | 0   | 0   |
| Warranty claims  | 0   | 0   | 0   |
| **Total**       | 0   | 0   | 0   |
| **CoQ**         | 10,298,536 | 20,269,285 | 86,995,000 |

Based on the table it can be concluded that the greater the production capacity, the greater the COQ issued. The distributions of each type of cost between these three BUs are slightly different based on quality assurance activities on each BU. The last BU (unit C) has the highest failure value due to the high level of product damage.

Seen from the category, appraisal costs have the largest average in all BUs compared to other cost categories. High amount of the appraisal costs occurs because of the amount of incentives for production employees or quality control who carry out quality inspections at each processing station. Inspection is a crucial thing to do in apple cider processing to ensure excellent quality. However, it can be assumed that the high appraisal costs have an impact on the low number of defective or failed products. The lower
cost of poor quality in internal failure value obtained then indicates relatively small failure management
costs in the process as well [6].

5. Conclusions
The highest quality cost category is appraisal cost, followed by preventive costs and internal failure
costs with a very small proportion for each BU. All cases currently haven’t found the defective situation
therefore no external failure cost is reported. Results indicated that there is a need for additional workers
who specifically supervise the quality of starting from raw materials to final products in the micro-
business unit. All BUs require quality assurance training activities from the company for their employees
on a regular basis.

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