

IMPACT OF BEER PACKAGING MACHINES ON PRODUCT QUALITY AND CUSTOMER SATISFACTION

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Abstract

In today's competitive landscape, the precision, efficiency, and hygienic standards offered by advanced packaging technology are no longer just beneficial but vital. From maintaining optimal fill levels to ensuring airtight seals, these machines directly influence the beer's freshness, flavor stability, and overall presentation. Impact of beer packaging machines on product quality and customer satisfaction through the set objectives with a view to providing information to brewery major stakeholders (producers and customers) on ways to achieving all round product quality. Hence, it adopted the method of survey research design through convenience sampling technique to select ninety-eight (98) respondents as sample size for the study and these instruments for data collection were self-developed questionnaire which were personally administered; thus, hypotheses were formulated to guide the study and generated data were analyzed using chi-square statistical tool. The result showed that a significant majority of respondents believe they contribute to high quality output. Specifically, (81.63 %) strongly agreed, and an additional (11.22 %) agreed, totaling (92.85 %) positive responses. Only (4.08 %) were undecided, (2.04 %) disagreed, and (1.03 %) strongly disagreed. This strong agreement supports the hypothesis that efficient packaging machines aid in achieving desired product quality. The Chi-square analysis, with a calculated value of 192.51 exceeding a reference value of 9.4877 at a 0.05 confidence level and 4 degrees of freedom, further confirms this positive relationship. Based on the study, modern beer packaging machines have a statistically significant positive impact on product quality and customer satisfaction. The results suggest that breweries should prioritize investing in modern technology, implement proactive maintenance protocols, and enhance operator training to ensure consistent, high-quality output and secure a competitive market edge.

1. Introduction

One of the world's oldest alcoholic beverages is beer. The beer's flavor, color, and aroma are all influenced by the chemical substances that make it up. According to Keukeleire (2000), beer is frequently referred to as the "liquid bread" because it contains a wide variety of micronutrients, including potassium, phosphorus, magnesium, vitamin B, and biotin. Phenolic acids like vanillic acid and 4-hydroxyphenylacetic acid are also present in beer. Additionally, they contain 8-prenylnaringenin, a phytoestrogen that is extracted from hops flowers and gives them their distinct scent and bitter flavor. The process of brewing and fermenting the starch found in grains such as malted wheat, rice, maize, and oats yields beer. The finished product becomes carbonated and produces ethanol because of the yeast's fermentation of starchy carbohydrates. Hops serve as a stabilizing and preservative element in most contemporary beers, giving them a noticeably bitter taste.

From malted barley or any other grain to the final product, there are at least 10 processing steps involved in the brewing and fermenting process. With an annual worldwide beer output of over 1.34 billion HL in 2002, brewing continues to play a vital economic role in the food sector (FAO, 2003).

Beer is the fifth most common beverage drunk globally, behind tea, carbonated drinks, milk, and coffee (OECD Health Data, 2005). The corporations producing beer around the world have grown to enormous sizes, and the competition between them is getting more intense every day. The major breweries in Nigeria (located in West Africa) are Africana Breweries Limited, Champion Breweries PLC, Consolidated Breweries PLC, Eastern Breweries Ltd, Guinness Nigeria, International Breweries PLC, Nigeria Breweries Dubic Breweries PLC etc. Brands of Breweries in Nigeria include Trophy Lager, Beta malt, Grand Malt, Beta Malt, Amstel Malt, Grand lager, Hero Lager, Castle Milk Stout, Castle Lite, Redds, Eagle lager, Eagle Stout, Life Continental Lager Beer, Savana Grapefruit, Savana Pineapple, Savanna Apple Drink, Savana Soda Water, Star, Gulder, Legend lager, Heineken, Maltina, Rock Lager Beer, Tigre Rock, Kronenbourg, Wilfort dark ale, Maltonic etc. Hence, the beer industries that successfully blend productivity and quality are most successful and, thus, are all competing to win and keep customers. This is because; quality has been not only an essential facet but also a crucial component of human activity (Charisis et. al. 2015).

While beer production processes are generally standardized to ensure taste and consistency, the packaging stage remains critical to preserving product integrity and enhancing consumer appeal. The growing demand for efficiency and precision in the beer industry has led to the increased use of automated beer packaging machines. However, there is a growing concern about how these machines influence product quality in terms of freshness, taste, shelf-life, and aesthetic appeal, and how this, in turn, impacts customer satisfaction. According to Odunukwe et. al. (2025), many local breweries in Nigeria struggle with outdated or substandard packaging equipment, leading to increased product spoilage and customer complaints. Thus, a deeper understanding of the role of beer packaging machines in maintaining product quality and ensuring customer satisfaction is essential for sustainable growth in the brewing sector.

Mbuba (2022) highlights the significance of human capital development in enhancing productivity, which is equally applicable in the brewing industry, where skilled operators are essential for managing sophisticated packaging machines to ensure quality output. The concern raised by Mbuba (2016) on how organizational conflict affects business growth resonates with challenges breweries may face when packaging inefficiencies lead to disputes between quality control units and production teams. Additionally, principles of equity and effective governance discussed in Mbuba (2021a; 2021b) can be extended to advocate for fair access to modern packaging technology, particularly among local breweries striving for competitiveness. The emphasis on adherence to ethical standards in public service (Mbuba, 2018) draws attention to the need for regulatory compliance in beer packaging processes. Product quality in beer manufacturing is significantly influenced by packaging systems. Beer is sensitive to oxygen and light exposure, which can result in off-flavors and reduced shelf life (Olorunfemi et. al., 2024).

Modern packaging machines are designed to create vacuum-sealed, light-resistant, and tamper-proof containers that help retain beer freshness. For example, canning and bottling lines with CO₂ flushing systems reduce oxygen content, thus enhancing product stability. Advanced machines also offer better sealing mechanisms, which are vital for preserving carbonation and taste (Udebhulu et. al., 2024). Furthermore, inconsistencies in packaging, such as underfilling or overfilling, may compromise beer quality and legal compliance. Automatic level sensors and quality control units in contemporary machines detect such anomalies, thereby minimizing waste and quality fluctuations (El-Shafeiy et. al., 2023). Automation reduces human error, increases hygiene, and allows for a faster production rate, all of which contribute to consistent product quality. Breweries that invest in such equipment often record fewer product recalls and better market reception.

Customer satisfaction in the beer market is largely driven by perceptions of quality, packaging aesthetics, and product safety. Packaging acts as the first point of contact between the consumer and the product. Poorly packaged beer bottles or cans—featuring leaks, faded labels, or cracked seals—may convey a message of low quality regardless of the actual product inside (Pascall, 2020). Well-packaged beer enhances brand image, encourages repeat purchases, and builds trust among consumers. Modern beer packaging machines contribute to brand differentiation through high-precision labeling, unique bottle designs, and efficient date coding. These features help consumers identify their preferred brands easily while also building confidence in the freshness and authenticity of the beer (Rodrigues et. al., 2022). In a market where consumers are increasingly quality-conscious and brand-loyal, the ability to maintain consistent packaging standards becomes a key determinant

of success. Studies have shown a strong correlation between packaging quality and consumer satisfaction. For instance, Christian and Sunday (2013) found that Nigerian beer consumers associate well-sealed, attractively labeled, and undamaged beer bottles with superior taste and value. This suggests that packaging not only preserves the product but also adds perceived value, which in turn affects consumer behavior and loyalty.

The motivation for this study stems from the increasing reliance on automation in the brewing industry and the critical role packaging plays in preserving product quality and influencing consumer satisfaction. While significant research has focused on the brewing process itself, there remains a gap in empirical studies that examine how packaging machines contribute to or hinder product integrity and customer experience (Rusman, 2024). Many small- and medium-scale breweries in Nigeria continue to rely on outdated or semi-automated packaging systems, leading to inconsistent sealing, poor labeling, and increased product spoilage (Suiker & Wösten, 2022). These issues often result in customer dissatisfaction, product returns, and damage to brand reputation. Furthermore, studies by Kumar et. al. (2025) has emphasized the aesthetic importance of packaging but have not fully addressed how machine-enabled packaging processes impact functional aspects like shelf-life, carbonation retention, and tamper-proofing. This study is therefore motivated by the need to bridge this knowledge gap by exploring the intersection of automation technology, packaging efficiency, and customer satisfaction.

1.1. Statement of the Hypotheses

As a guide to achieve the objective of the study, the following hypothesis was formulated:

Ho: Beer packaging machines do not contribute to achieving high quality output that will trigger customer satisfaction.

Ha: Beer packaging machines contribute to achieving high-quality output that will trigger customer satisfaction.

2. Methods

The Packaging department is often referred to as the heart of a brewery because the liquid drink produced at the brewery's kitchen (Brewery department) cannot be sold to customers without being packaged in cans/bottles. Hence, various processes from one machine to another involved in beer packaging are shown in Figure 1.

2.1. Research Materials

To obtain the data necessary for this research work, survey research designs were adopted. Hence, the research work was carried out by collecting and analyzing data from only a sample population. Responses were gathered from participants on a Likert-type scale (likely 1–5), capturing perceptions of the contribution of well-functioning packaging machines to high-quality output and customer satisfaction, along with demographic data (gender and years in business). The medium used in collecting data was through the questionnaire documentary method (Figure 2). The collected data were used to analyze all the research questions (using simple percentages) and to test the study's hypothesis using Chi-square. The central aim was to help achieve the objectives set for this work, which is to accept or refute the claims of the hypothesis.

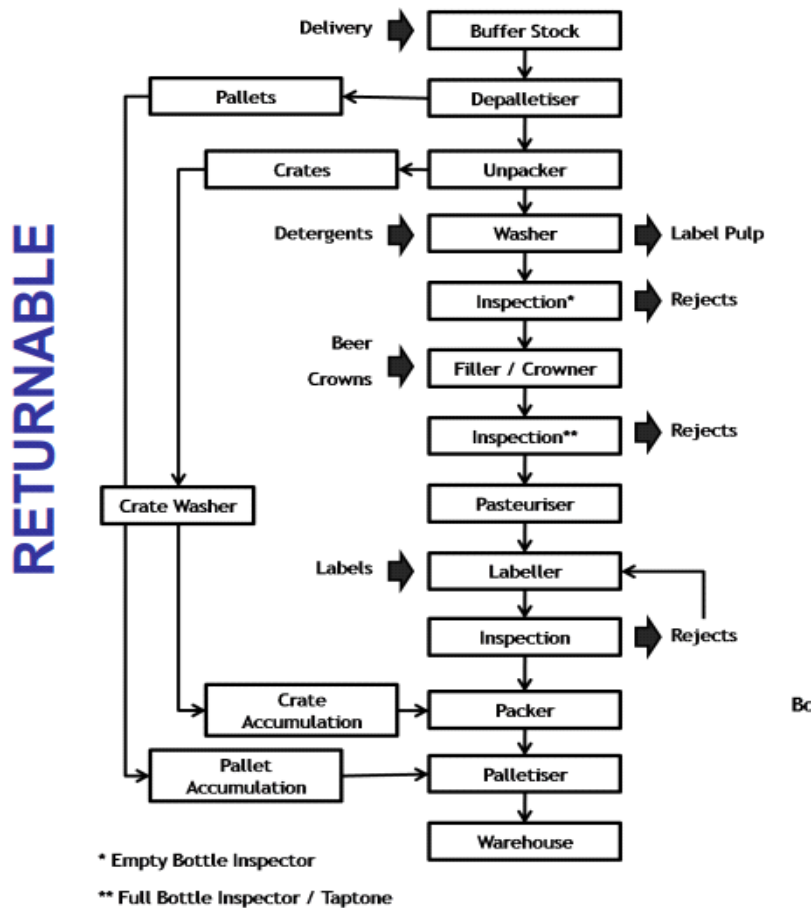


Figure 1: Generic Process Flow of typical Packaging Department of Brewery Processing Returnable Bottles (Krones Manual, 2021)

Table 1. Questionnaire documentation for assessing the impact of beer packaging machines on product quality and customer satisfaction

| Part A: Demographic Data | | | | | | |
|--|--|---|---|---|---|----|
| 1. | Name of Customer: | | | | | |
| 2. | Number of years in business: | [0-3] [3-5] [5-10] 10 & above | | | | |
| 3. | Sex: | [Male] [Female] | | | | |
| 4. | Marital Status: | [Single] [Married] [Separated] [Divorced] | | | | |
| PART B: METHOD OF FILLING | | | | | | |
| In each question below, you have five options namely | | | | | | |
| SA= Strongly disagree | | | | | | |
| A= Agree | | | | | | |
| U= Undecided | | | | | | |
| D= Disagree | | | | | | |
| SD=Strongly Disagree | | | | | | |
| Tick (v) in the column that suits you. | | | | | | |
| S/N | Research Questions | SA | A | U | D | SD |
| 1. | In general, well-functioning packaging machines contribute to achieving high quality output that will trigger customer's satisfaction. | | | | | |
| 2. | A fresh and well pasteurized beer help to attain product shelf life. | | | | | |
| 3. | Customers check for date coding information on bottles before drinking. | | | | | |
| 4. | Management continuous support drives employee to take issues of quality control very seriously. | | | | | |
| 5. | Regular training on process quality control methods for front-line team improves and sustains bottle beer quality. | | | | | |
| 6. | The neatness and design of the surface of bottles used to package beer attracts customers to patronize the product. | | | | | |
| 7. | Customer is not interested in the beer freshness, the ingredients, preservatives and smoothness of the beer. | | | | | |
| 8. | Adherence to good operating practices and specifications during manufacturing by the production team leads to quality output delivery. | | | | | |

| Part A: Demographic Data | |
|---------------------------------|--|
| 9. | Trade return to the company due to customer dissatisfaction results to time and material loss and, increases organizational cost. |
| 10. | At beer packaging machines areas, Standards creation and execution as well as frequent machine operation document review helps to increase operator's efficiency on quality at source. |
| 11. | Good and consistent quality features on packaging containers and in the liquid content leads to customer satisfaction. |
| 12. | As a customer, I am not interested in the label dressing consistency on packaged beer bottles that I am buying from the manufacturer neither do I verify the information contained on the label. |
| 13. | Customers are not interested in Leakers on beer bottles batches and in overall crown crimping configuration. |
| 14. | Filling volume in bottles is the least consideration before customers buy the bulk product from the manufacturers. |
| 15. | The first thing that customers consider before making purchase is the purchase cost and not the product quality |

2.2. Sample Size determination

This was used to determine the sample size from a population of 130 people using Equation (1) (Yamane, 1967):

$$n = \frac{N}{1 + N(e)^2}$$

Where Sample Size, N = Finite or Total Population, e = Level of Significance (5 % or 0.05). That is, sampling from a definite population (N=130) in Equation 1 gives:

$$n = \frac{130}{1+130(0.05)^2} = \frac{130}{1.325} = 98 \text{ approx.}$$

2.3. Simple Percentage

A simple percentage shown in Equation 2 was used to analyse all the items raised in the questionnaire. For each response alternative, the number of respondents obtained was divided by the total number of respondents and then multiplied by 100. This was done to compare the differences in the response trend and then draw a logical conclusion regarding the research findings. Thus:

$$\frac{F}{N} * 100\%$$

Where F= Frequency of respondent and N Total number of respondents

2.4. Chi-Square (χ^2)

The hypothesis testing was done using the Chi-square statistical analysis tool. Thus, mathematically, the Chi-square is given by the formula as shown in Equation 3:

$$\chi^2 = \sum \frac{(Fo - Fe)^2}{Fe}$$

Where: χ^2 = Chi-square, Fo = Observed frequency, Fe = Expected Frequency and \sum = Summation. The level of Significance is 5 % (0.05) and the Degree of Freedom (DF) is n-1, where n is the number of questionnaire's response items.

2.5. Decision Rule for analyzing the adopted hypotheses

When the χ^2 calculated was greater than the critical/table value of χ^2 at a 5 % level of significance, and at DF = 4, the null hypothesis (Ho) was rejected. The rejection of the null hypothesis (Ho) gives the automatic signal for the acceptance of the alternative hypothesis (Ha) (Akilaiya et al, 2002). Pairwise comparisons were conducted using estimated marginal means with the Least Significant Difference (LSD) method to test group differences without adjustments for multiple comparisons. A two-way ANOVA tested the main effects of gender and years in business, as well as

their interaction on perceptions. Parameter estimates identified the magnitude and direction of effects for each group relative to the reference categories. Residual plots were examined to check model fit, detect outliers, and assess assumptions such as homoscedasticity.

3. Results and Discussion

3.1. Simple Percentage Presentation

3.1.1. Do well-functioning packaging machines contribute to achieving high-quality output that will trigger customer satisfaction?

The response trend describing the opinion of respondents to the questionnaire is presented in Table 2. It comprised the percentage representation of the respondents against each response option.

Table 2. Percentage representation of the response alternative in the questionnaire

| Response Alternative | No. Of Respondents | Percentage (%) |
|----------------------|--------------------|----------------|
| Strongly Agree | 80 | 81.63 |
| Agree | 11 | 11.22 |
| Undecided | 4 | 4.08 |
| Disagree | 2 | 2.04 |
| Strongly Disagree | 1 | 1.03 |
| Total | 98 | 100 |

From Table 2, the data showed that 80 respondents representing 81.63 % of the total respondents strongly agreed that well-functioning packaging machines contribute to achieving high-quality output. Also, 11.22 % joined the other respondents to affirm this claim, thus bringing the total majority positive response to 92.85 %. Meanwhile, 4 respondents representing 4.08 % of the total population were undecided, 2 respondents representing 2.04 % simply disagreed, while just a single respondent strongly disagreed. In a related study, Gabriel et al (2022) reported that efficient packaging equipment directly improves product consistency and reduces wastage. In contrast, Kumar et al (2025) observed that while machinery efficiency is crucial, workforce skill plays a more dominant role in determining output quality. Obviously, machine functionality complements human expertise, suggesting that both elements are essential for sustained productivity and competitiveness in manufacturing industries.

3.1.2. Ascertaining whether beer packaging machines contribute to achieving high-quality output that triggers customer satisfaction.

This was done to determine whether efficient and well-functioning machines will help to obtain the desired product quality while manufacturing, as contained in hypothesis 2, using the Chi-square. By implication, it will help to accept or reject the null hypothesis. This was because so many factors could be responsible for quality process failure or quality incident, thus leading to cases of trade return. The results obtained are presented in Table 3.

Table 3. Determination of chi-square (χ^2) for hypothesis 1.

| Response Alternative | Fo | Fe | (Fo-Fe) | (Fo-Fe) ² | $\chi^2 = \sum \frac{(Fo - Fe)^2}{Fe}$ |
|----------------------|----|------|---------|----------------------|--|
| Strongly Agree | 74 | 19.6 | 54.4 | 2959.36 | 150.99 |
| Agree | 13 | 19.6 | -6.6 | 43.56 | 2.22 |
| Undecided | 6 | 19.6 | -13.6 | 184.96 | 9.44 |
| Disagree | 2 | 19.6 | -17.6 | 309.76 | 15.80 |
| Strongly Disagree | 3 | 19.6 | 16.6 | 275.56 | 14.06 |
| Σ | 98 | 98 | | | 192.51 |

Note: The expected frequency (Fe) represented the average of the observed frequency

The analysis of responses on whether beer packaging machines contribute to achieving high-quality output that enhances customer satisfaction revealed overwhelming support. Out of 98

respondents, 74 strongly agreed, while 13 agreed, showing a dominant affirmation that packaging machines play a vital role in quality assurance. The chi-square test yielded a calculated value of 192.51, which is far greater than the critical value at the 0.05 significance level. This led to the rejection of the null hypothesis, confirming that beer packaging machines significantly influence high-quality output and customer satisfaction. This finding agrees with Kustiyawan et al (2023), who emphasized that automation in food and beverage processing enhances consistency and customer loyalty. In a related study, packaging technology was shown to not only improve production efficiency but also reduce wastage, thereby increasing profitability and customer trust (Olorunfemi et al, 2024). Therefore, the present study strongly aligns with the argument that packaging machines are indispensable in sustaining quality standards in the brewing industry, reinforcing the positive role of technological adoption in meeting customer expectations.

Since hypothesis 2 was accepted. It was then established that beer packaging machines contribute to achieving high-quality output, which in turn triggers customer satisfaction. On this note, the state of the packaging machines' ability to deliver high-quality goods will depend on the degree of maintenance and management practices usually carried out on all the machines. As a result, the idea of equipment maintenance exists and is essential to any manufacturing. Equipment requires regular maintenance to prevent breakdowns and ensure production quality and efficiency over time. This is important for systems that are prone to relatively frequent failures that hinder regular operation but may be prevented and rectified with proper maintenance procedures (Sánchez, 2017). If work tools break down or malfunction, production may be halted. These elements lead to delays in the production process and the expenses of replacing and repairing parts. Enterprises that maintain high asset productivity (factories, machinery, cars, etc.) benefit from maintenance management.

Unfortunately, maintenance receives significantly less attention from researchers and practitioners than manufacturing-related issues, which is one of the reasons for maintenance's poorer efficiency. According to Blanchard (2004), one-third of maintenance expenditures are attributable to either insufficient or needless maintenance efforts. Studies show that, depending on the industrial sector, maintenance costs might account for anywhere between 15 and 40 percent of the product's price (Alsyof, 2006). Therefore, in addition to keeping the equipment in excellent working condition, maintenance is essential to achieving production goals with the lowest cost of ownership and best output. From the perspective of strategy, policy, type, and maintenance form, there are several elements. Nonetheless, scheduled and unplanned maintenance are the key distinctions used in much of the literature. Most maintenance work in the industry are carried out utilizing preventative strategies with specified periods or correctives (Broderick, 2007). Preventive maintenance tasks have predetermined intervals (number of working hours, number of kilometers passed, etc.) to prevent the breakdown of parts, subsystems, and systems. The boxplot in Figure 2 indicates that male respondents consistently rated the impact of well-functioning packaging machines at the maximum score (5.0), showing no variation.

Female respondents displayed more variability, with a median of 5.0, an interquartile range between 4.0 and 5.0, and ratings spanning from 3.0 to 5.0. Notably, three female responses were outliers at (2.0), (2.0), and (1.0). This suggests strong agreement overall, but slightly less consensus among females compared to males regarding the contribution of packaging machines to quality and customer satisfaction. This finding agrees with Nwankwo and Eze (2023), who observed that male workers often present uniform judgments on technical efficiency, while female workers exhibit diverse perspectives. This can be attributed to broader evaluative approaches in quality assessment. The boxplot in Figure 3 reveals that respondents with (1-5), (6-10), and (11-15) years in business unanimously rated the impact at the maximum score (5.0).

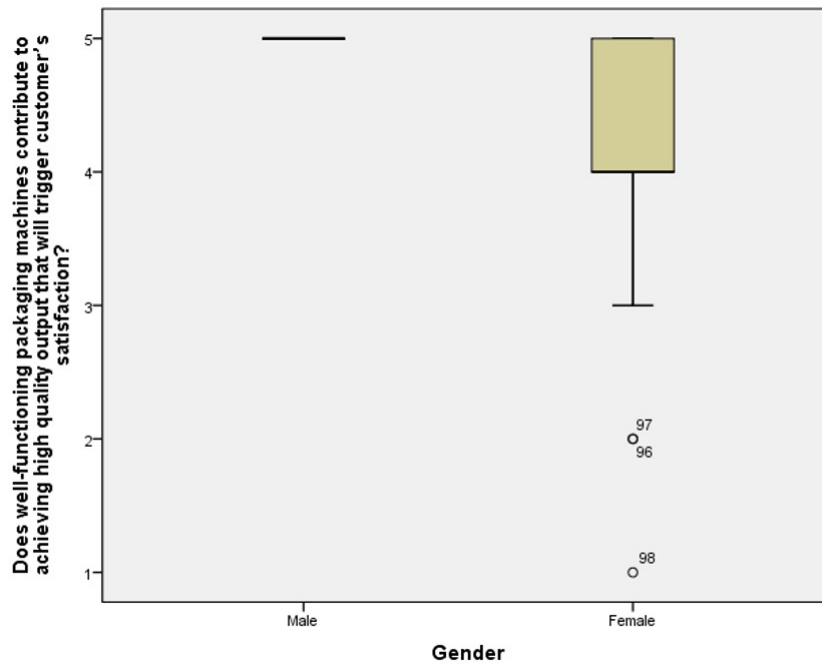


Figure 2: Boxplot showing gender differences in perceptions of whether well-functioning packaging machines contribute to high-quality output and customer satisfaction

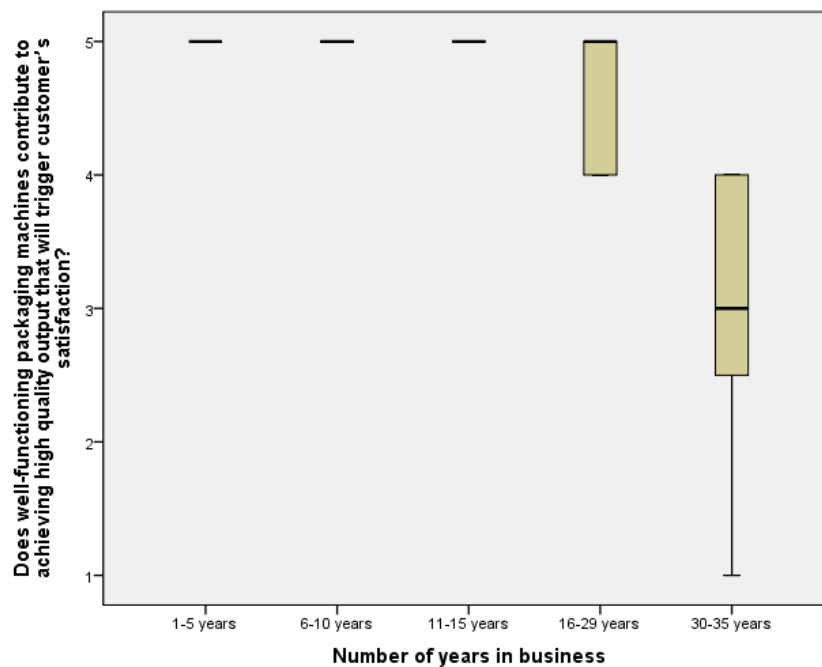


Figure 3: Boxplot showing the effect of years in business on perceptions of whether well-functioning packaging machines contribute to high-quality output and customer satisfaction

Those with (16–29) years showed a median of (5.0) and interquartile range (4.0–5.0). Respondents with (30–35) years had a lower median (3.0), interquartile range (2.5–4.0), and minimum rating of (1.0). This finding agreed with Ano and Bent (2022), who observed that younger firms often view new technologies as transformative. Conversely, respondents with 16–29 years showed mild variability, and those with 30–35 years recorded a median of 3.0 and ratings as low as 1.0. In contrast, Cantwell and Marra (2024) reported that longer-established businesses tend to evaluate innovations more critically, balancing benefits with limitations. This suggests strong agreement among less experienced businesses, slight variation among moderately experienced ones, and greater variability, with some dissent, among the most experienced businesses regarding the

contribution of packaging machines. The pairwise comparison in Table 4 shows a statistically significant difference in perceptions between male and female respondents regarding the contribution of well-functioning packaging machines to achieving high-quality output that triggers customer satisfaction. Males rated the impact higher than females, with a mean difference of (1.125) in favour of males (Std. Error = 0.131, Sig. = 0.000). The 95 % confidence interval for the difference ranged from (0.864) to (1.386), indicating consistent significance. Conversely, the mean difference for females compared to males was (-1.125), with the same level of statistical significance. These results suggest gender influences perceptions, with males showing stronger agreement on the machines' positive impact.

Table 4: Pairwise comparison of male and female respondents' perceptions on whether well-functioning packaging machines contribute to high-quality output and customer satisfaction.

| (I) Gender | (J) Gender | Mean Difference (I-J) | Std. Error | Sig. ^d | 95 % Confidence Interval for Difference ^d | |
|------------|------------|-------------------------|------------|-------------------|--|-------------|
| | | | | | Lower Bound | Upper Bound |
| Male | Female | 1.125 ^{*,b,c} | .131 | .000 | .864 | 1.386 |
| Female | Male | -1.125 ^{*,b,c} | .131 | .000 | -1.386 | -.864 |

Based on estimated marginal means
a. The mean difference is significant at the .05 level.
b. An estimate of the modified population marginal mean (I).
c. An estimate of the modified population marginal mean (J).
d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

In line with this, Rožman and Tominc (2024) reported that male employees often express stronger confidence in operational technologies. In contrast, Assaker (2020) found that females tend to evaluate such technologies more cautiously, highlighting potential risks and limitations. In a related study, similar gendered perceptions were linked to workplace roles, where males prioritized efficiency gains while females emphasized quality control. The results in Table 5 reveal significant differences in perceptions based on years in business. Respondents with (1–5), (6–10), and (11–15) years in business showed no significant differences among themselves (p = 1.000). However, all three groups rated the contribution of packaging machines significantly higher than those with (30–35) years, with mean differences of (1.917) and p = 0.000. Similarly, respondents with (16–29) years rated machines' contribution higher than the (30–35) year group, with a mean difference of (1.750) and p = 0.000. These findings suggest that longer-established businesses (30–35 years) perceive less contribution from packaging machines compared to newer businesses. Mabenge et al (2022) noted that younger firms adopt innovative tools more readily. In contrast, longer-established businesses perceived less contribution, possibly due to reliance on traditional methods.

Table 5: Pairwise comparisons of respondents' perceptions on well-functioning packaging machines by number of years in business.

| (I) Number of years in business | (J) Number of years in business | Mean Difference (I-J) | Std. Error | Sig. ^d | 95% Confidence Interval for Difference ^d | |
|---------------------------------|---------------------------------|--------------------------|------------|-------------------|---|-------------|
| | | | | | Lower Bound | Upper Bound |
| 1-5 years | 6-10 years | -4.441E-16 ^{ab} | .134 | 1.000 | -.267 | .267 |
| | 11-15 years | .000 ^{ab} | .122 | 1.000 | -.241 | .241 |
| | 16-29 years | .167 ^a | .229 | .468 | -.288 | .621 |
| | 30-35 years | 1.917 ^{ab,*} | .152 | .000 | 1.615 | 2.218 |
| 6-10 years | 1-5 years | 4.441E-16 ^{ab} | .134 | 1.000 | -.267 | .267 |
| | 11-15 years | 4.441E-16 ^{ab} | .117 | 1.000 | -.233 | .233 |
| | 16-29 years | .167 ^a | .227 | .464 | -.283 | .617 |
| | 30-35 years | 1.917 ^{ab,*} | .148 | .000 | 1.622 | 2.212 |
| 11-15 years | 1-5 years | .000 ^{ab} | .122 | 1.000 | -.241 | .241 |
| | 6-10 years | -4.441E-16 ^{ab} | .117 | 1.000 | -.233 | .233 |
| | 16-29 years | .167 ^a | .219 | .449 | -.269 | .602 |
| | 30-35 years | 1.917 ^{ab,*} | .137 | .000 | 1.645 | 2.189 |
| 16-29 years | 1-5 years | -.167 ^b | .229 | .468 | -.621 | .288 |
| | 6-10 years | -.167 ^b | .227 | .464 | -.617 | .283 |
| | 11-15 years | -.167 ^b | .219 | .449 | -.602 | .269 |
| | 30-35 years | 1.750 ^{b,*} | .237 | .000 | 1.279 | 2.221 |
| 30-35 years | 1-5 years | -1.917 ^{ab,*} | .152 | .000 | -2.218 | -1.615 |
| | 6-10 years | -1.917 ^{ab,*} | .148 | .000 | -2.212 | -1.622 |
| | 11-15 years | -1.917 ^{ab,*} | .137 | .000 | -2.189 | -1.645 |
| | 16-29 years | -1.750 ^{a,*} | .237 | .000 | -2.221 | -1.279 |

Based on estimated marginal means
* The mean difference is significant at the .05 level.

| (I) Number of years in business | (J) Number of years in business | Mean Difference (I-J) | Std. Error | Sig. ^d | 95% Confidence Interval for Difference ^d | |
|---------------------------------|---------------------------------|-----------------------|------------|-------------------|---|-------------|
| | | | | | Lower Bound | Upper Bound |

a. An estimate of the modified population marginal mean (I).
 b. An estimate of the modified population marginal mean (J).
 d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

In a related study, Nagy et al (2023) found that SMEs with shorter operational histories valued automation more for competitiveness, supporting the view that business longevity influences technological appreciation. The model in Table 6 significantly explained variance in perceptions ($F = 46.259, p = 0.000, R^2 = 0.715$). Years in business had a significant effect ($F = 27.831, p = 0.000, \text{Partial Eta Squared} = 0.548$), indicating strong influence on perceptions. Gender showed no significant effect ($F = 0.649, p = 0.422, \text{Partial Eta Squared} = 0.007$), suggesting male and female respondents had similar views. The interaction between gender and years in business was not tested due to zero degrees of freedom. The high observed power for years in business (1.000) confirms the robustness of this effect, while gender's low power (0.125) limits its detectability. In a related study, Yousaf et al (2023) found that gender differences rarely explain organizational perceptions compared to experience-based factors. The high observed power for years in business further validates this effect.

Table 6: Tests of Between-Subjects Effects on the perceived contribution of well-functioning packaging machines by gender and years in business.

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared | Noncent. Parameter | Observed Power ^b |
|----------------------------|-------------------------|----|-------------|----------|------|---------------------|--------------------|-----------------------------|
| Corrected Model | 37.502 ^a | 5 | 7.500 | 46.259 | .000 | .715 | 231.295 | 1.000 |
| Intercept | 1324.397 | 1 | 1324.397 | 8168.350 | .000 | .989 | 8168.350 | 1.000 |
| Gender | .105 | 1 | .105 | .649 | .422 | .007 | .649 | .125 |
| Years_in_business | 18.050 | 4 | 4.512 | 27.831 | .000 | .548 | 111.325 | 1.000 |
| Gender * Years_in_business | .000 | 0 | . | . | . | .000 | .000 | . |
| Error | 14.917 | 92 | .162 | | | | | |
| Total | 2221.000 | 98 | | | | | | |
| Corrected Total | 52.418 | 97 | | | | | | |

a. R Squared = .715 (Adjusted R Squared = .700)
 b. Computed using alpha = .05

From Table 7, the intercept ($B = 3.083, p = 0.000$) indicates a strong baseline agreement. Gender had no significant effect ($B = 0.333, p = 0.422, \text{Partial Eta Squared} = 0.007$). Years in business significantly influenced perceptions for groups with 1–5 years ($B = 1.583, p = 0.001$), 6–10 years ($B = 1.583, p = 0.001$), 11–15 years ($B = 1.583, p = 0.000$), and 16–29 years ($B = 1.583, p = 0.000$), all compared to 30–35 years as reference. The largest effect size occurred for 16–29 years ($\text{Partial Eta Squared} = 0.548$). Interaction terms were redundant, indicating no combined influence of gender and years in business. In a related study, similar gendered perceptions were linked to workplace roles, where males prioritized efficiency gains while females emphasized quality control (Festing et al, 2015). These variations suggest that gender perspectives shape how packaging machines' impact on customer satisfaction is interpreted.

Table 7: Parameter estimates for gender and years in business on perceptions of well-functioning packaging machines' contribution to customer satisfaction.

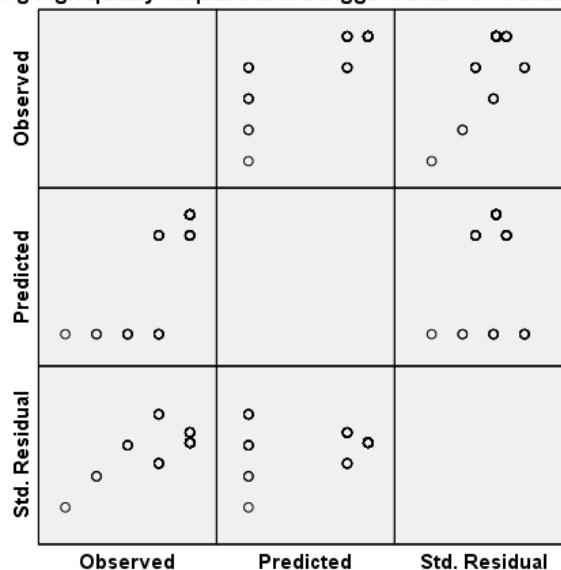
| Parameter | B | Std. Error | t | Sig. | 95% Confidence Interval | | Partial Eta Squared | Noncent. Parameter | Observed Power ^b |
|--------------------------|----------------|------------|--------|------|-------------------------|-------------|---------------------|--------------------|-----------------------------|
| | | | | | Lower Bound | Upper Bound | | | |
| Intercept | 3.083 | .116 | 26.526 | .000 | 2.852 | 3.314 | .884 | 26.526 | 1.000 |
| [Gender=1.00] | .333 | .414 | .806 | .422 | -.488 | 1.155 | .007 | .806 | .125 |
| [Gender=2.00] | 0 ^a | . | . | . | . | . | . | . | . |
| [Years_in_business=1.00] | 1.583 | .441 | 3.593 | .001 | .708 | 2.459 | .123 | 3.593 | .945 |
| [Years_in_business=2.00] | 1.583 | .440 | 3.602 | .001 | .710 | 2.456 | .124 | 3.602 | .946 |
| [Years_in_business=3.00] | 1.583 | .436 | 3.633 | .000 | .718 | 2.449 | .125 | 3.633 | .949 |
| [Years_in_business=4.00] | 1.583 | .150 | 10.551 | .000 | 1.285 | 1.881 | .548 | 10.551 | 1.000 |

| Parameter | B | Std. Error | t | Sig. | 95% Confidence Interval | | Partial Eta Squared | Noncent. Parameter | Observed Power ^b |
|--------------------------|----------------|------------|---|------|--------------------------|----------------|---------------------|--------------------|-----------------------------|
| | | | | | Lower Bound | Upper Bound | | | |
| | | | | | [Years_in_business=5.00] | 0 ^a | | | |
| [Gender=1.00] * | 0 ^a | . | . | . | . | . | . | . | |
| [Years_in_business=1.00] | 0 ^a | . | . | . | . | . | . | . | |
| [Gender=1.00] * | 0 ^a | . | . | . | . | . | . | . | |
| [Years_in_business=2.00] | 0 ^a | . | . | . | . | . | . | . | |
| [Gender=1.00] * | 0 ^a | . | . | . | . | . | . | . | |
| [Years_in_business=3.00] | 0 ^a | . | . | . | . | . | . | . | |
| [Gender=1.00] * | 0 ^a | . | . | . | . | . | . | . | |
| [Years_in_business=4.00] | 0 ^a | . | . | . | . | . | . | . | |
| [Gender=2.00] * | 0 ^a | . | . | . | . | . | . | . | |
| [Years_in_business=4.00] | 0 ^a | . | . | . | . | . | . | . | |
| [Gender=2.00] * | 0 ^a | . | . | . | . | . | . | . | |
| [Years_in_business=5.00] | 0 ^a | . | . | . | . | . | . | . | |

a. This parameter is set to zero because it is redundant.
b. Computed using alpha = .05

The scatterplot matrix in Figure 4 compares observed scores (range ≈ 1–5), predicted scores (range ≈ 2–5), and standardized residuals (range ≈ -2 to 2). Observed and predicted values align closely, showing that the model explains a substantial portion of the variation. Standardized residuals mostly fall within ±2, indicating no serious outliers or model misspecification. Clusters appear for specific response levels, suggesting categorical influence from predictors such as years in business. The narrow spread of residuals supports the assumption of homoscedasticity. In a related study, Carrizosa et al (2021) also emphasized that residual clustering reflects categorical predictors' influence. Narrow residual spreads indicate model robustness and minimized specification error. In contrast, poorly fitted models often present wider residual dispersion and outliers, underscoring that the present model demonstrates reliability and consistency across predictor categories.

Dependent Variable: Does well-functioning packaging machines contribute to achieving high quality output that will trigger customer's satisfaction?



Model: Intercept + Gender + Years_in_business + Gender * Years_in_business

Figure 4: Observed, predicted, and standardized residual values for perceptions of packaging machines' contribution to customer satisfaction, considering gender, years in business, and their interaction

4. Conclusion

The findings of this study conclusively demonstrate a significant and positive relationship between the efficiency and performance of beer packaging machines and the twin objectives of achieving superior product quality and enhancing customer satisfaction. Most respondents, representing an overwhelming (92.85%) of the total sample, affirmed that well-functioning packaging machines are instrumental in producing high-quality output. This strong qualitative

consensus underscores the industry's widespread belief in the technology's importance. This belief was quantitatively supported by the Chi-square analysis, which yielded a calculated value of (192.51), far exceeding the critical table value of (9.4877). This statistically significant result confirms the study's primary hypothesis, thereby firmly rejecting the null hypothesis and providing concrete evidence of the correlation. In essence, the study establishes that modern, precise, and well-maintained packaging technology is a critical determinant of a brewery's long-term success. Beyond mere production, these systems are vital for preserving the beer's intended flavor profile by preventing oxygen ingress and maintaining proper carbonation. This technical integrity ensures the product's shelf life is maximized and that every bottle or can consistently meets the consumer's high expectations for freshness and taste. This consistency in quality directly contributes to positive consumer perception, builds brand trust, and cultivates the long-term loyalty essential for a competitive edge in the global market.

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