NEW DEVELOPMENTS IN GRAPE PUNNET PACKAGING

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ABSTRACT

Over the past decade the demand for punnet packaged grapes has been steadily increasing in first world countries. As this mode of packaging is inherently more labour intensive than carton packaging, productivity is a significant challenge for producers. The emphasis on productivity has broadened to include minimisation of “give-away”, or overweight punnets as well as minimisation of waste caused by the packaging method. Hence, in this study the focus is on punnet packaging effectiveness. The table grape market in Europe is well organised and enforces stringent quality control measures, including strict control of conformance of individual punnet mass to the specification.

The South African table grape industry makes use of developing world seasonal labour, making accurate weighing of punnets a management challenge.

This study was undertaken at one of the largest grape packaging facilities in the southern hemisphere where new methods for punnet packaging were compared with conventional methods measuring labour productivity, “give away” as well as waste. Three packaging methods, namely manual packaging with a generic electronic scale, microcontroller assisted combination packaging and a new custom microcontroller supported scale, were investigated. Especially the new method employing a departure from assembly line concepts yielded encouraging results.

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1 INTRODUCTION

Over the past few years, the first world countries have shown an increased interest in grapes packed in 500 g transparent polymer containers, known as punnets. Producers are realising a price premium for punnet packaged relative to conventionally carton packaged grapes. According to a French market study, done by Inter-professional Technical Centre for Fruit and Vegetables (CTIFL), up to 70% of fruit display shelf space in European hyper- and supermarkets is dedicated to pre-packaged fruit [1]. Supermarkets prefer to sell pre-packaged grapes that decreases the handling of grapes. In this way, a higher quality product is delivered to end user with more consistent conformance to health and safety regulations. Pre-packaging of grapes reduces mechanical damage to the grapes and is also a good way to present the product [3]. Pre-packaging restricts customer access to the product, improving hygiene [2]. The supermarket’s loss between grapes-in and grapes-out is also less, since the customers cannot sample the grapes while shopping.

The packaging of grapes is more labour intensive than packing in 4.5 to 10 kg cartons. It requires up to twenty mass adjustments for punnet packaging compared to one for a carton. These factors have created a need in the industry for higher packing productivity.

The conventional method for packing punnets follows the philosophy of FW Taylor employing division of work to achieve economy of scale benefits. During the past packing season, a large packing warehouse implemented a newly developed system that was inspired by overseas developments, the manager’s vision to reduce handling as well as a need for incentivised remuneration. The new method departs from Taylor’s strategy by integrating process steps at a single workstation [4], [5].

2 RESEARCH PROBLEM AND OBJECTIVE

The aim of the study is to determine if it is more productive and effective to pack the grapes by division of work elements or integrating the task elements for single operators. The effect of double handling, mass conformance and waste, on productivity, effectiveness and quality are the aspects that are evaluated.

3 LITERATURE REVIEW

Waller defines productivity as a measure of how well resources are used, impacting upon production cost and ultimately profit [6]. In the classic sense productivity is calculated by dividing output quantity by inputs [7]. In this case punnets packed by the key resource, namely number of workers, per time unit, is the productivity measure.

Paton, Clegg, Hsun and Pilkington reflects on the F.W. Taylor philosophy of “Scientific management” that it is of key importance that management should have full knowledge and control of production processes, thereby making the process independent of worker contribution to methods. The workers’ role becomes limited to execution [8].

Although older references tend to define productivity as the specific input over output efficiency measure, some define productivity as a broader concept. Wild proposes a multi-level model for productivity that includes raw material utilisation, the value adding process efficiency and other macro-economic factors [9]. This approach was taken a step further by Eli Goldratt in his Theory of Constraints philosophy superseding classical productivity measurement with defining the goal of operations as making money, implying that all factors impacting upon this goal should be considered and not operational speed in isolation [10], [11]. A similar evolution has taken place integrating the concept of quality into productivity. Kolarik cites Juran, Deming and Ishikawa to illustrate the fundamental link between the two concepts as well as the contemporary work of Christopher and Thor [12].

When punnet packaging was introduced in South Africa, there was a strong focus on the fundamental focus of productivity, emphasising efficiency and throughput. The emphasis was on worker performance leading to studies of learning rates [13]. Since then significant progress with worker selection, training and custom equipment development, have been
made. Since 2010, realisation started emerging that the emphasis on productivity should be broadened to incorporate a broader perspective including minimisation of waste as well as give-away or overfilling punnets beyond specification [14].

At several table grape producers, quality assurance is focused on getting produce past the sample inspection of the Perishable Product Export Control Board inspectors. According to Kolarik the paradigm governing management thinking is mass production and sorting. Produce is produced according to a generally accepted process and the best quality is sorted for export and the balance is marketed locally. Some progressive producers have progressed to the statistical quality control paradigm. These producers have their own feedback loops in production to ensure that the bulk of their produce conforms to export requirements. As a rule these producers export through large export agencies. A recent development in the industry with larger producers exporting specifically and directly to supermarket chains in Europe has emerged. This study was performed at such a producer. The meticulous awareness of customer requirements that is mostly different for different customers can be categorised as a total quality management paradigm [15]. In more recent approaches to quality management such as Six Sigma, the term, the voice of the customer is used to describe a more intense focus on customer satisfaction [16]. Breyfogle references Noritake Kano to describe how customer expectations evolve re-categorising earlier quality satisfiers or “wow” factors to “take it for granted” factors. The conformance of the punnet mass to specification is considered to be such a parameter [16]. The supermarket chains anticipate severe consumer dissatisfaction associated with this quality parameter and enforce strict conformance to their specifications.

4 Research Design and Methodology

A study of the three punnet packaging methods employed by one of largest table grape packing facilities in the Southern hemisphere, was conducted over a four week period.

The different systems used at the warehouse where the study was conducted, consisted of:

- Packaging with a conventional electronic scale
- Combination packaging with a microcontroller assisted scale
- Integrated work station with a microcontroller assisted scale

The packing warehouse where the study was conducted uses three shifts per day. Data was manually collected during each shift and supplemented by electronically stored check-weigher data.

The productivity measure for throughput, namely punnets per minute per person was calculated using the total number of acceptable mass punnets per shift, divided by the total number of workers per shift and the shift duration. The total number of workers used for calculations includes the cleaners, trimmers, punnet fillers, scale operators as well as workers that pack and wrap boxes [17].

Random quality checks were performed. During a quality check, the number of bunches, loose berries, and number of defective berries were counted.

5 Background: Packaging Methods

The symbols shown in Figure 1 are used to describe the process flow of the three punnet packaging systems investigated.
The following three systems were investigated:

5.1 System 1 - Packaging With A Conventional Electronic Scale

The process flow chart for this system is shown in Figure 2. Each operator has his/her own scale to weigh the punnet. After mass adjustment the punnets pass over the check weigher, rejecting under- or overweight punnets. Punnets that are accepted by the checkweigher proceed on the conveyor to be packed into boxes and are taken into cold storage.

5.2 System 2 - Combination Packaging With A Microcontroller Assisted Scale

In a similar manner to system 1, cut and trimmed grapes are supplied to the bookshelf type of packing unit. One worker takes the grapes from the crate and fills the punnet, approximately half full and passes it on to the person with the scale. The system uses the principle of combining two partially filled punnets to obtain the required mass. The microcontroller searches for a previously stored matching punnet when a punnet is placed on the scale. If a match is found, a Light Emitting Diode (LED) indicates the location of the matching punnet. If a match is not found, the punnet is stored at a random location indicated by means of a LED.

The contents of matching punnets are combined and passed to another worker to close the punnet and put it on the conveyor. The rest of the process is identical to system 1. The process flow chart is shown in Figure 3.
5.3 Integrated Work Station With A Microcontroller Assisted Scale

The new system comprises an electronic scale and a microprocessor controlled display. The primary display is a vertical bar graph. A green LED at the centre of the bar graph indicates a mass within the specified limits. Red LED’s above and below the green LED indicates under- or over mass punnets graphically.

Bunches are cleaned, trimmed, packed and weighed by one operator. The downstream process including materials handling is identical to systems 1 and 2. The process flow chart is shown in Figure 4.
6 RESULTS AND DISCUSSION

6.1 Productivity

The productivity measure for throughput, namely punnets per minute per person was calculated such that the workforce includes workers that clean, cut and trim grapes, weigh punnets and pack and close boxes. The productivity measure for each shift is shown in Figure 5.

From the graph in Figure 5 it becomes clear that the conventional system and the combination system achieve similar throughputs, while the new task integrating system’s throughput is decidedly higher. The cyclical nature of the integrated packaging can be attributed to the fact that a single person is responsible for the entire process and that the effect of better quality grapes from the vineyards have an immediate, measurable effect on productivity. In the case of the conventional and combination packaging a “production line” with division of work is utilised. Work content reduction when higher quality grapes are received, is not reflected in the output, because accurate line balancing is difficult to achieve. Table 1 shows the average packing rate for each system. The difference between the averages of the conventional and combination systems is insignificant. The new task integrating system is 4.9 times more productive than the other two systems.

<table>
<thead>
<tr>
<th>System</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional system</td>
<td>0.424</td>
</tr>
<tr>
<td>Combination system</td>
<td>0.418</td>
</tr>
<tr>
<td>New task integrating system</td>
<td>2.074</td>
</tr>
</tbody>
</table>

Figure 5: Comparison Of Different Packing Systems’ Throughput

6.2 Percentage Giveaway

The percentage giveaway is calculated by subtracting the average mass of a punnet per shift from the specification mass divided by the average mass. Therefore it is an indication of the percentage mass of grapes that is above the specification mass.
From Figure 6 it can be seen that the percentage giveaway for the integrated packaging system is much lower than for the other 2 systems. Comparing the other 2 systems, combination packaging has the largest give away, as shown in table 2.

### Table 2: Average Percentage Giveaway For Each System

<table>
<thead>
<tr>
<th>System</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional packaging</td>
<td>2.14%</td>
</tr>
<tr>
<td>Integrated packaging</td>
<td>0.86%</td>
</tr>
<tr>
<td>Combination packaging</td>
<td>2.46%</td>
</tr>
</tbody>
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#### Figure 6: Comparison Of Percentage Giveaway

6.3 Quality Control

Quality checks were done randomly where the number of loose berries, defective berries and number of bunches were counted. The averages for these criteria are shown graphically in figures 7, 8 and 9. Referring to the Six Sigma approach in paragraph 3, loose berries and minor berry blemishes beyond PPECB specification are classified as defects.

6.3.1 Loose Berries per Punnet

The average number of loose berries per punnet is shown in Figure 7. Conventional packaging has the most loose berries and the integrated packaging has the least loose berries per punnet. The integrated system and combination packaging have the least handling of grapes which explains why these two systems have the least loose berries.
6.3.2 Number of Bunches Per Punnet

As shown in Figure 8, conventional packaging has the most bunches per punnet. A total of three bunches are allowed per punnet, which means that the conventional packaging still conforms to specifications. Integrated packaging is exactly in the middle of conventional and combination packaging. Combination packaging has the lowest number of bunches per punnet, most probably because of the method by which it is packed. This system is the combination of two punnets, usually with one bunch in each punnet.

6.3.3 Number of Defective Berries Per Punnet

The critical part of quality control is to ensure an absolute minimum of defective berries per punnet. The allowable number of defective berries varies for each customer, but from Export Quality Standards [18], five defective berries are allowed per punnet. Figure 9 shows that the integrated packaging system does not conform to standards. The integrated system may have a higher number of defective berries per punnet, because one worker must cut and trim the grapes and also weigh the punnet.
Figure 9: Average Number Of Defective Berries Per Punnet

7 CONCLUSION

The productivity and percentage giveaway analysis clearly indicates that the Integrated packaging system is the better option. Comparing all the quality factors, the Integrated packaging system conforms to all standards and specification, except for the number of defective berries per punnet. Management of the packing facility considers this factor to be easily correctable with intensified supervision in the future.

As it is generally accepted in the table grape industry that less handling of the grapes, generally results in less damage, the integrated packaging system has a distinct advantage in this respect. Combining tasks also seems to increase productivity. This is a significant result as the general trend in industry is division of work into relatively small repetitive tasks. The effect of the individual worker held responsible and remunerated for his/her output is perceived to contribute to the success of the method.

Overall, the integrated packaging system is a good method to implement and will be the most effective if the number of defective berries can be decreased.

8 REFERENCES


