International Journal of Agriculture and Food Science Technology.
ISSN 2249-3050, Volume 4, Number 5 (2013), pp. 421-430

http://www.ripublication.com/ ijafst.htm

Packaging of Carbonated Beverages

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Abstract

In the recent years, we have witnessed a growing consumption of carbonated beverages like soft drinks and beer, marketed in attractive containers and packaging. Technology has certainly played its part in the increased consumption of carbonated beverages with the adventof glass bottles, cans, plastic bottles, high speed packaging lines and evolving packaging systems.

Packaging carbonated products into either glass, PET or aluminum containers require specialized expertise and different configuration of equipment. For example - In order to transfer a carbonated beverage from a tank where it is stored, into a container, the container must first be sealed and then pressurized. In its simplest configuration a counter pressure filler pressurizes the container with CO_2 or any other pressurizing gas (counter pressure) to the same pressure as the tank in which the product resides, then fills it with product, then the counter pressure is relieved (allowed to escape back to the bowl / atmosphere in a controlled manner) and then finally the container is closed (capped or crowned).

Similarly, there are different configurations of equipment for packaging of carbonated beverages post - filling. For example – Warmer, Labeller, Crater / Recrater, Shrink Packer, Carton Erector, Carton Sealer, Date Coder, Palletizer, etc. Servo versions of all these equipment are available for high speed applications.

The well-known adage in the Beverage Industry is that packaging will sell the product to the consumer only once. Henceforth repeat purchase by the consumer depends solely on the product contained within the packaging. However, if the packaging fails to offer the expected

functionality, the consumer may choose an alternative brand (in similar or even a different packaging format) irrespective of the product quality.
In order to have a brief understanding of the packaging line formation for carbonated beverage application, this paper, highlights the various configurations of packaging equipment for different types of containers used in India.

Keywords: Carbonated; packaging; containers; filling.

1. Introduction

In a world undergoing continual change, with a population well above seven billion, the challenge facing the beverage industry is perhaps increasingly complex. To provide products that are wholesome, durable, acceptable in character and even interesting to the consumer has been the objective for many years.

It is not the product alone, however, which encourages and develops sales. The container and packaging must play their part in safeguarding the beverage, offering appropriateness to the intended outlets and affording maximum convenience to the consumer. Packaging technology during the past few decades has risen to these challenges by a series of major breakthroughs interspersed with periods of refinement and improvement. The milestones are many and varied and are described briefly in this paper.

2. Line Layouts

2.1 Glass Bottle Filling Line

The bottles used in a glass bottle filling line can be either single-trip or returnable. But considering the cost factor, in Indian market, returnable bottles are preferred more than the single-trip bottles. Hence, only 15-20% new bottles are added every year to the existing lot.

If a container is to be filled efficiently then the complete filling line and other necessary processes must be correctly designed. In a typical glass bottle filling line, the first operation is to unload the empty bottles or crates onto a conveyor. For very low speed operations this is still done manually, but as this activity is very labour intensive, most modern production lines do this automatically. Returnable glass bottles are packed in plastic crates, mostly in 12s for large bottles and in 24s for small bottles, which have been stacked on the pallet to a pre-determined stacking pattern. A de-palletiser is used to remove each layer of crates from the pallet and send them to the decrater for unloading of the bottles from the crate to the bottle conveying system.

From the decrater, bottles are fed to a bottle washer, which fully washes the returnable glass bottles to minimise microbiological contamination of the product to be packaged by the container, ensuring that no extraneous objects such as pieces of glass, etc. are present, and removing any old labels, ink jet coding and small particulates such as sand and dust. After washing it is necessary to inspect bottles for soiling, chipped necks, residual liquid and foreign objects usually down to some 2.5 mm which is the optical limit of most bottle inspectors. It is even possible to remove scuffed bottles.

The returnable glass bottle washer can be either single- or double-ended. Bottles are fed by conveyor into the washer infeed, where they are channeled into rows and hence into the washer bottle pockets which are made of either steel or plastic. Bottles are conveyed throughout the washer in these pockets which are attached to an endless chain. A typical treatment, where the carrier chains dip in and out of soak tanks (caustic zone), cycle allowing sufficient time to 'soak' in each part of the cycle, would be:

1. Pre-warm the bottles to 30°C by rinse water,
2. Empty the residue from the bottles,
3. Pre-rinse using warm water at ca. 55°C,
4. Invert the bottles to empty them,
5. Immerse the bottles in a ca. 1.5% caustic solution at some 60°C,
6. Rinse the bottles at some 60°C and then empty the caustic solution out,
7. Repeat steps 5 and 6 at some 80°C,
8. Rinse with warm water at some 60°C and invert the bottles to empty the contents,
9. Rinse at some 50°C and empty the bottles,
10. Repeat step 9 at 30°C and empty the bottles,
11. Final rinse with clean treated water and empty the contents of the bottle.

When using glass, it is most important that the rate of temperature rise and fall of the bottle is well controlled so as not to introduce thermal stresses which could lead to bottle weakening. These are normally given as - not more than an increase of 42°C or a decrease of 28°C in any individual step. Within the washer old labels are removed during the soak operations and conveyed away from the machine to a compactor. Pumps circulate caustic lye (Sodium Hydroxide), which assists the flushing of label material into the drum filters, thus minimizing the build-up of paper pulp in the soaking baths. A sluice system allows broken glass to be deposited into bins. Bottles are jet washed internally by rotating cross-flow spray nozzles, the bottles being self-centered in the pockets to maximize this jetting action within the bottle.

While the bottles are being washed, crates go through a crate washer that removes any debris and attempts to keep the crates in reasonable condition. After the washer, the bottles are fed by conveyor through an empty bottle inspector to the filler and crowner/capper monoblock. Closures are fed to the crowner/capper by pneumatic transport/belt conveyor to the closure hopper.

The patch labeller is usually placed after the pasteurizer in a typical glass bottle filling line. But, if no pasteurization is required, like that of in carbonated soft drinks, then the labeller can be placed just after the filler or can even be monoblocked with the filler. Generally, in India, there is no trend of using labels for carbonated soft drinks in glass bottles. Instead, pre-printed glass bottles are used. In that case, the entire labeller is eliminated.

After labelling, the bottles and crates meet up and the bottles are re-crated and subsequently palletized. For single-trip glass bottles, a rinser replaces the washer and packing is done either on a wraparound shrink wrapper or packed into a case prior to palletisation.

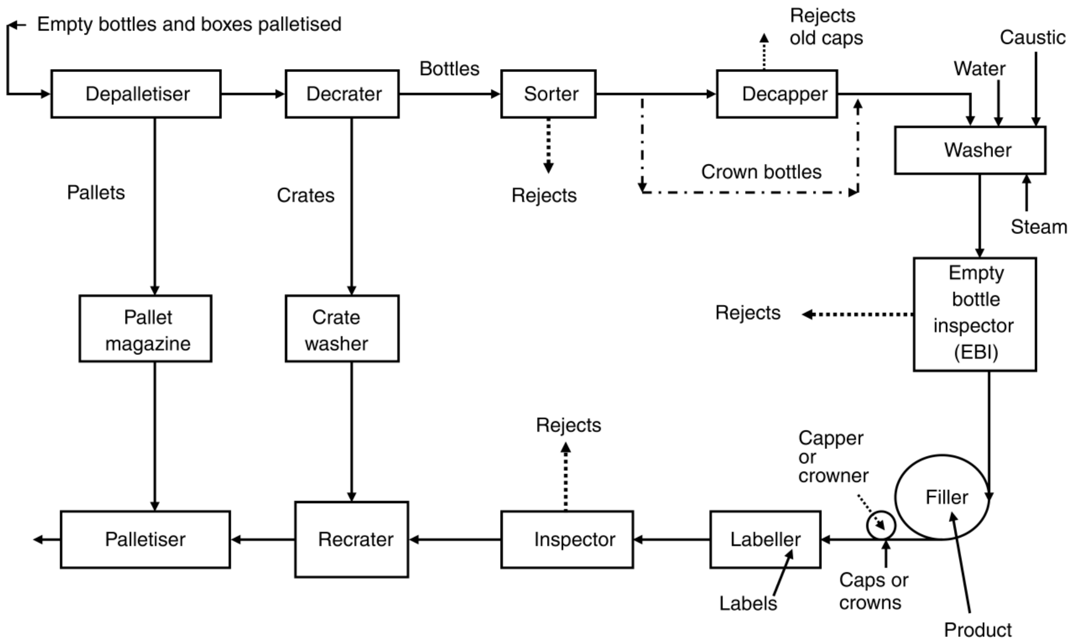


Figure 1: Typical returnable glass bottle filling line.

2.2 PET Bottle Filling Line

For creating the layout of a PET bottle filling line for carbonated beverages many factors need to be considered, like the bottle sizes, bottle design, bottle diameter and the amount of accumulation needed. Where PET bottles are blow moulded directly onto the filling line, the general practise is to buffer the bottles between units. For small bottles up to 600 ml capacity, this is primarily done with empty bottle silos holding several hours of production, while for large bottles they are either buffered on line with a bottle accumulator of minimum 10 minutes capacity or the bottles are palletized and then de-palletised onto the filling line. Buffering on an air conveyor can only be considered for short time filler stoppages up to a few minutes at most.

While a filler can start virtually instantaneously after a stoppage, a blow moulder has to first reach its operating temperature, even though during a stoppage it may only go back to half heat conditions to allow for more efficient re-starts. Any stoppage of the blow moulder will inevitably cause preform and bottle losses. As this machine is probably one of the most efficient on any bottling line, it should not be stopped unless essential. It should be considered the master machine for the line.

Generally, the blow moulder is connected to the filler using an air conveyor in between for minimal buffer. It is not feasible to use both a silo and an air conveyor, as bottles tend to shrink during storage.New and older bottles will have differing fill heights in case of a volumetric filler, a situation often not appreciated by marketing departments who evaluate consumer reactions.

Silos are designed to minimise the risk of bottles being crushed; they should allow a good distribution of bottles within the silo with almost complete emptying being possible. Silos employ catch nets within to lessen bottle damage. From a silo, bottles are fed to an unscrambler which produces an outfeed of bottles in single file to an air conveyor. As the risk of bottle contamination within the silo exists, all bottles need to be rinsed prior to filling although silo sites must be kept as clean as possible to minimise such contamination.

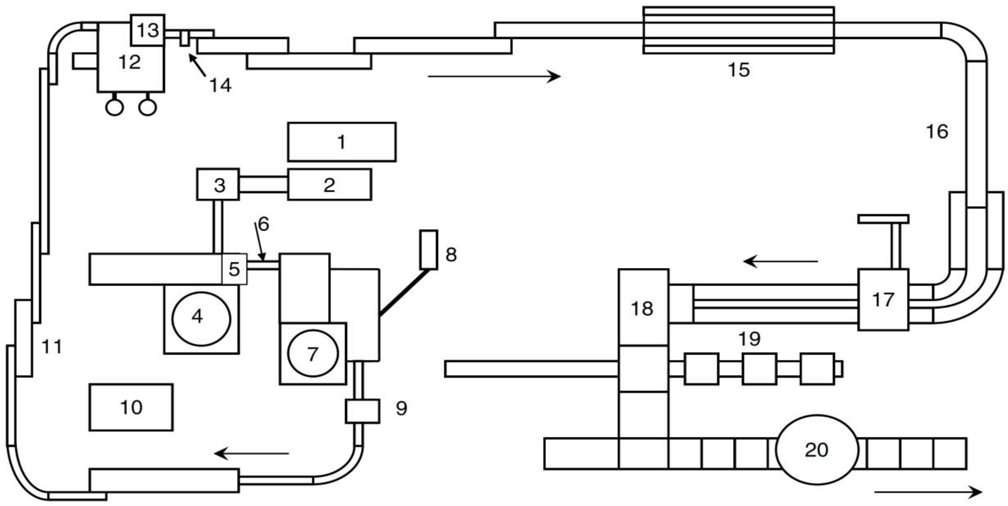
Bottle rinsers, often mono-blocked to the filler/capper, are normally rotary machines that inject fresh water into the bottles in a prescribed manner to ensure good rinsing of all the bottle internal surfaces. Bottles are usually fed to the rinser by air conveyor supported on their neck rings. They are transferred to the infeed worm and starwheel of the rinser with the neck gripped and held by this throughout the whole rinsing operation. The bottles are rotated into a vertical upturned position and rinsed, with pre-set cycle time for jetting with a cleaning agent, followed by sterile water jetting and draining. Rinsers using ionized air as rinsing medium are also available.

In order to eliminate the chances of bottle contamination in between the blow moulding and filling stages, a new concept of coupling the Blow Moulder directly to the Filler is catching attention within the industry. Blocking the Blow Moulder and the Filler avoids any exposure of the bottles with the atmosphere and hence prevents bottle contamination as in case of an air conveyor or a silo. Thus, the bottle rinser can be eliminated out of the system.

Because of the carbonated beverages being filled at lower temperature, condensate gets accumulated on the filled containers. This results into problems with labelling or subsequent film wrapping. Hence, after cold filling, the bottles need to be passed through a warmer in which the filled bottles are sprayed with hot water for bringing up the temperature of the bottles up to room temperature. Warmer can be eliminated out of the line if a warm filling method is adopted using a filler with high capacity bowl.

The bottles are passed through air blower for drying prior to labelling.The labels used are primarily plastic, as this allows for bottle creep with the small amount of give in the plastic that paper does not have. The packaging end of the line after labelling depends on the bottle design and also on the aesthetics intended by the manufacturer. A shrink packer(using film only, film and pad or film and tray) and“Pick and Place” or “Wrap-around” type carton packer is included for secondary packaging in the line for PET application.

The packs are then transported on pack conveyors to the Palletiser in which the packs are stacked over a wooden/plastic pallet in pre-determined layer formations to form a multi-layer pallet. Following palletisation, the pallet lots are then stretch wrapped and delivered either by conveyor or fork lift truck to the warehouse. During this process, the bottle will have been coded, as will the pack and the pallet. This gives full traceability throughout the supply chain.



1 Preform loading system
2 Preform feed unit
3 Preformcheck unit
4 Blow moulder
5 PET bottle inspector
6 Airveyor transfer to filler
7 Bottle filler and capper
8 Cap feed
9 Fill level detection unit
10 CIP system
11 Conveying system
12 Plastic labeller
13 Laser coder
14 Label inspector
15 Shrink wrapper
16 Pack conveyors
17 Handle applicator
18 Palletiser
19 Pallet conveyor
20 Stretch wrapper

Figure 2: A compact PET bottle filling line.

3. Key Equipment

3.1 Counter Pressure Fillers

Filling a carbonated beverage into a container at high speed requires a specialized piece of equipment called Counter Pressure Filler. There are a number of different configurations of such fillers. A rotary type counter pressure filler is to be used in case of automated high speed lines. Basically, the rotary configuration allows for time sharing. By increasing the circumference of the filler, more number of valves can be accommodated with equal time for each container to go through its filling cycle.

In the process of beverage carbonation, CO_2 is dissolved under pressure and will remain in solution while it is kept under pressure. The pressure required to maintain CO_2 in solution depends on the content required (called as Gas Volume) in the beverage and the temperature. Higher CO_2 contents require higher pressures at a given temperature and, conversely, lower temperatures for a given content require lower pressures. The filler bowl must, therefore, be kept under the appropriate pressure during the filling process.

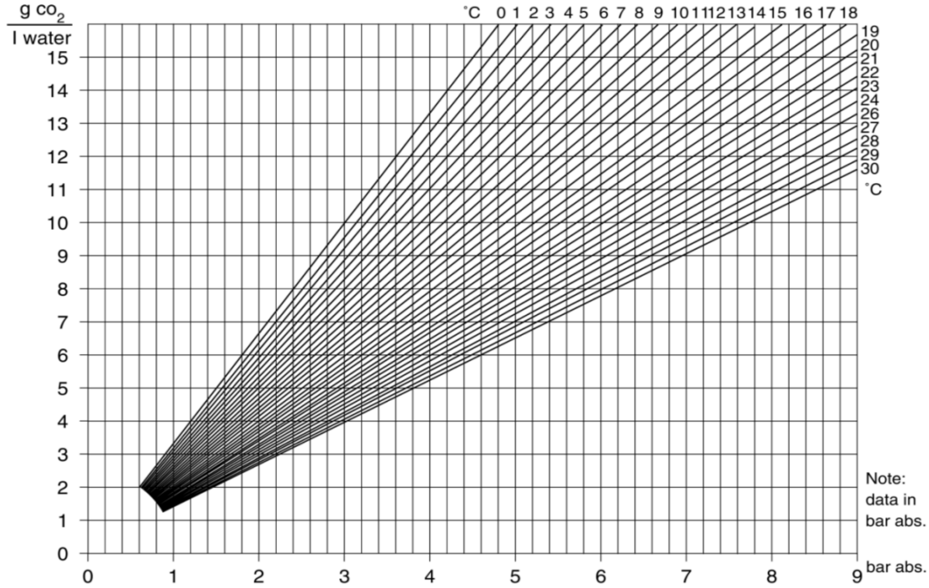


Figure 3: CO2 solubility in water.

The above figure indicates the solubility of CO_2 in water at various temperatures and pressures. During the filling process, it is important that the beverage is handled gently to prevent CO_2 coming out of solution as a result of agitation. As some disturbance of the beverage is inevitable during filling, it is common practice to set the head pressure in the filler bowl 1 bar above the beverage saturation pressure.

In order to maintain the beverage under pressure throughout the filling process it is also necessary to pressurize the container to the same pressure as the filler bowl. This procedure is carried out on a counter-pressure filler. The complete filling process on a counter-pressure filler can be split into the following phases:

1. Evacuation
2. Flushing with gas
3. Pressurising with gas
4. Filling
5. Settling and snifting.

This complete filling process is used for filling beverages like beer which are particularly sensitive to oxygen and which can also be susceptible to foaming. Other types of counter-pressure fillers utilise only some of the above phases. Evacuation can be carried out only in rigid containers like glass bottles.

The rotary fillers can broadly be classified into two types based on the filling process: (i) Level Filling and (ii) Volumetric Filling. Fillers with the level filling concept can further be classified in to three types based on their valve operating mechanism as (i) Mechanical (ii) Electro - pneumatic and (iii) Electronic (probe based). The volumetric fillers can be again of two types based on the type of flow meter used: (i) Mechanical flow meter (turbine type) and (ii) Electromagnetic flow meter

Filler with level filling is the most traditional and commonly used type of filling machines. In this type, the fill level is determined by the length of the vent tube that enters the bottle, during the filling stage. Generally speaking, to change the level in the bottle, the vent tube must also be changed.

In a mechanically operated valve all movements are controlled mechanically. Component parts of the filling valve which are inside the filler bowl (the product valve and gas needle) are operated by a control lever which, in turn, is raised and lowered by cams external to the ring bowl. Pressurisation and filling phases are controlled by this operation. The snift phase is operated by the snift button located at the base of the filling valve being activated by an external cam.

The electro - pneumatic type consists of mechanical filling valves with electro - pneumatic control. This type of filling valve has a product valve and gas needle controlled by a pneumatic cylinder on top of the filler bowl. A pneumatic diaphragm valve operates the snift phase. All operations are electronically controlled, eliminating the control cams on the outside of the filler bowl. As filling phases are controlled electronically, optimum filling is possible at varying speeds. Fill level is controlled by the vent tube and it is still necessary to change the tube for bottles with different fill points, as with the mechanically controlled valve.

In the electronic type, a level probe is integrated into the vent tube. This allows the level control to be operated from the level probe. This type of valve is particularly suitable when bottles with different fill points are being filled as the fill level can be adjusted electronically.

In the volumetric type, a flow meter is placed in the filling path. This allows the mechanical filling valve to be replaced by a completely new streamlined valve as fill volume is controlled by a pneumatic actuator operated with reference to the input received from the flow meter. The entire filling process is controlled by a micro-processor positioned in the centre of the filler carousel. All process steps are controlled not using mechanical cams but through pneumatic control elements.

3.1.1 Oxidation in biological carbonated beverages

In case of biological carbonated beverages like beer and aerated juices or nectars, even a small amount of oxygen entering the beverage during the filling process can result into oxidation. Oxidation harms the product at a minimum by severely impacting its flavour profile and at a maximum by destroying it entirely, making it unfit for human consumption. There are two components to this. The first is air pickup during the fill process. The second is headspace air. Both of these must be dealt with.

The first is addressed with single, double or triple pre-evacuation. Pre-evacuation is the process of evacuating the air from the container to be filled with a product, prior to filling the container. Basically, the container is sealed, evacuated, charged with an inert gas (mostly CO_2) and if required the last two steps are repeated once or twice before final filling. This process protects the product filled in the container from the effects of oxidation. The second is addressed with a fobbing unit which foams the product in the container using high-pressure hot water jet while travelling from the filler to the crowner or capper.

3.2 Labeller

Labellers can be classified upon the type of label to be applied on the container i.e. paper or plastic and wraparound or patch. Normally, labels are applied with cold glue as patch for returnable glass bottles and with hot – melt glue as wraparound label for PET bottles.

In a patch labeller, pre – cut labels are removed from the stationary label magazine by means of a controlled cold glue film applied to the front surfaces of the aluminum glue pallets profiled to the shape and size of the labels. Labels are then removed from the pallets by a mechanical gripper cylinder that transfers them to the containers. A system of brushes and sponge rollers then smooth the label on to the bottle.

The wraparound labeller transfers a continuous web of labels from a reel on the reel stand to the container via a cutting drum and a vacuum drum. The label web is cut to individual labels on the cutting drum and held by a vacuum drum where hot glue is applied to a strip along the leading and trailing edges. The labels are then transferred to the container by the rotating vacuum drum itself. A label applicator ensures that the labels are correctly positioned on the containers.

Difference between hot melt glue and cold glue:

(1) Hot melt adhesives have quick bonding property making it suitable for high speed applications unlike the cold glue.

(2) Pressure sensitivity of hot melt glue is more than the cold glue which allows a degree of slip in case of bottle creep. Hence, hot melt glue is mostly used for PET bottles in which bottle creep is unavoidable.

(3) Most of the hot melt glues are not soluble in water. Hence, cannot be used for refillable bottles which need to be cleaned in a Bottle Washer.

3.3 Secondary Packaging systems

The packaging which collates a number of primary packs for distribution from the filler to the retailer and the point of sale is called secondary packaging. There are three main secondary packaging systems used for carbonated soft drinks: (1) Automatic recrater (pick and place type) (2) Shrink packer (3) Wrap-around packer

Each has its benefits and is used for a variety of reasons. It is vital to control secondary packaging to the same degree as product and primary packaging.

3.3.1 Automatic Recrater (Pick and Place type)

Hand loading of bottles into crates is strenuous and labour intensive and to alleviate this situation a fully automatic recrater is used with ‘pick and place packing’.

The bottles are marshaled on a slat conveyor in a configuration to suit the crate pocket arrangement. At the end of the conveying section, modules of bottles are collated, lifted and placed into the crates using pneumatic grippers.

3.3.2 Shrink Packer

A transparent polymer film (which reduces in size when subjected to heat) is used for loosely wrapping a pack of bottles. After passing through a heating tunnel for 5 to 7 seconds, the film would tighten to produce a reasonably firm and stable pack.

In order to retain the bottles in the desired format during the wrapping and shrinking operations, they can also be loaded into a shallow cardboard tray or onto a flat cardboard pad which protects the underside of the film from being punctured when the packs are placed on top of each other during the palletizing operation.

3.3.3 Wrap-around Packer

In a wrap-around packer, the carton is formed around a collation of bottles (with or without cardboard divisions). The basic principle of operation of a wrap-around packer is to place the collation of bottles on, or next to, a cardboard blank and then fold the blank around the bottles, hot-melt glue being applied to the appropriate points.

4. Conclusion

This paper encompasses a bird’s eye view of the packaging industry. The ultra-high level of competition prevalent in the packaging industry, combinedwith mechanical and electronic technological advances and increasing consumer demands will naturally lead to further advancement in the available technology for beverage filling and its applications.

Ongoing refinements to existing systems will lead to emergence of revolutionary new concepts. Zero product loss, instant size changeover, 100% efficient systems are the utopia of every beverage manufacturer, and there can be no doubt that all manufacturers of filling and packaging machinery are fully aware of their customers’ goals. Hygienic, aesthetically pleasing designs, servo control, adaptable minimum change parts and ease of operator interface are areas which are constantly in focus. Filling lines will become even more modular in design, with the advent of the smart lines.This concept endeavors to reduce the overall area requirementfor packaging line installation by the implementation of specialist buffer systems and synchronized machinery segments. All these developments will give an edge to the manufacturers over their competitors in responding to anever-changing market-place.

In a nutshell, the important parameters which have and which will continue to decide the future of the packaging industry are: (i) Flexibility (ii) Sustainability (iii) Productivity (iv) Price Performance (v) Minimal Packaging (vi) Product Security.

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