Quality tests of glass containers for foods to ensure their utility of efficiency

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Summary:

Glass containers are used widely as food packaging because they have high ability to prevent the content without changing its properties or interacting with it, because glass is chemically inert and can be shaped with different capacities to suit the nature of content material (liquid- paste- solid granules), and with corresponds to the amount of content to be distributed and displayed. To ensure that the quality of the glass packaging performs its functions and utility efficiency in preventing and protecting the content and to make it easy to get all contents parts, applying tests are required, as example to ensure the quality of the packaging performance during packaging life cycle, tests for measuring the physical and chemical properties for glass container are performed cause test is an effective way to confirm the quality of food glass container to express their efficiency and confirm their quality with quantitative readings that help to evaluate and identify strength and weaknesses points of the product to solve and improve it. So it is necessary to perform the tests according to the content material requirements, the thing which meet the requirements of manufacturing, packaging factory and final consumer.

Research problem:

Needing a study which clarifying the most important set of tests conducted on the glass packaging for the purposes of packaging foods, which insure the utility efficiency of the glass container during all stages in its life cycle.

Research importance:

The research explains the importance of applying tests for measuring the different physical and chemical properties of glass containers used as a food packaging in a way that contributes to raising the performance rates of package, and in a way that guarantees the integrity of both the packaging content and end- user throughout the life cycle of the package.

Research objective:

Reaching the importance and purpose of conducting tests to measure food glass containers quality level and the relationship between applying tests and ensuring utility efficiency of food glass packaging.

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Research imposition:

Clarifying the role of test specifications in the product life cycle leads to increased activation of testing on glass containers to ensure their utility efficiency throughout their life cycle.

Research methodology:

The research follows the descriptive analytical method.

1- Food glass packaging

The food glass packaging is defined as a glass container used to contain foodstuff in its various states (liquid- semi liquid or pasty- solid or granules) and prevent food for long time, starting from the period of packaging and extending to the entire period of products validity till reaching to the final consumer and using the content through the different processes of transporting, storing and displaying. Glass containers used widely for packaging food because it is recyclable by up to 100% and chemically inert with most of food products.

There are many different types of glass containers in size and shape, but all of glass containers are included under one of two groups either jars or bottles, bottles always containing a neck neither jars and mainly used as a packaging for liquids in different viscosity.

2- Glass containers functions

It's very important to choose glass packaging to suit the containing material to achieve the main aim from packaging to save the content, which guarantee achieving desired quality level, the role of glass containers towards content is clear as shown next;

a- Containing food content

It should be considered that the glass container is apple to contain the determined amount of content and to have a suitable closure if its more than one-time usage container. The task of containment is for the package to be able to transfer the volume of the foodstuff to be promoted from the packaging stage until it reaches the consumer's hand, while providing ease of extracting all parts of the material without losing it to pouring, for example as a result of the bad closing mechanism or the breakage and waste of the material during the various stages of transportation or even that the packaging has a shape that does not fit the nature of the viscosity of the content, making it difficult to extract its parts and lose it.

b- Protect and saving food content

The glass is characterized by being a chemically inert substance that does not interact with foodstuffs, and the inner packaging surfaces can be treated to be more solid and chemically resistant. The role of the glass packaging in protecting the nutritional content is shown by reducing and preventing the damages that can occur throughout the life of the content, which starts from its packaging inside the packaging to the consumer's hand and using it throughout its shelf life, while preserving its properties not changing throughout its life. In addition to protecting the content, the packaging plays a role in preserving the nutritional content, preventing and reducing the change of biological properties, and the packaging is not a medium for the growth of bacteria or harmful substances inside it.

c- Provide comfort and safety

The glass packaging achieves comfort and safety during use when its diminutions are compatible with the dimensions of human hands, and it has the mean of safety in opening and

closing without causing leakage of content, and does not cause any obstacles during the extraction of all parts of the content. The packaging also should have a suitable mechanical and chemical properties to withstand its utility and ensure protecting consumer from any dangerous that can happen.

d- Sell product and reach information about it

Glass packaging is the main display for the product, it is the first communication point between both of consumer and the content, at many times the container is the unknown seller which has the main role to convince the consumer to buy a product. A glass container has the label which contains all information needed of content and logo and any information that a producer needs to inform consumer about.

3- Food glass container lifecycle

Life cycle of food glass container is defined as all stages that the glass packaging goes through to carry out the packing of foodstuffs starting from its manufacture and transfer to the packing factories for packaging, transporting, storing and stacking them on the shelves for display, up to the final consumer and leading to a period of use throughout the content period.

The glass container facing many types of stresses and shocks throughout its life, which require having an appropriate mechanical and chemical resistance to ensure utility efficiency during its lifecycle and that achieves by inspection during each stage of production and manufacturing and by applying tests which evaluate different characteristics to determine the efficiency of glass container during its life cycle.

4- Quality definition and quality assurance

Quality is defined as the extent to which the specifications of a product or service match the required specifications, and they disappear with attributes of the same thing and can be measured, such as length, width, weight, proportions, and material properties, and that concept, according to the ISO 9000 system, as judging things as beautiful or good have not become sufficient, quality in its modern concept measures the extent of congruence in a quantitative way that can be read.

By applying the concept to the field of manufacturing glass containers for food preservation, we find that you must ensure the integrity of the package and its existence has been tested in accordance with the tests for applications specific to safety details, and when passing the packages for their testing that is a guarantee that does not accept the doubt that the packaging packages), the final consumer is included in this, they contribute to raising the marketing rates of the package and raising its price over its counterparts, as an inevitable result of raising the confidence rates of the package over others.

5- Tests role to ensure glass containers quality efficiency

Several laboratory tests are conducted on food glass containers to test each of its physical properties to measure thermal, mechanical and chemical properties, tests that aim to confirm the integrity of the packaging and its content during use towards the factory and the final consumer. The following tests are the most important laboratory tests and the most applicable to glass containers for food, so as to ensure the efficient use of them throughout their life:

a- Glass containers Vertical load test

This test is applies for knowing the amount of weight that the packaging bears in its vertical direction, which is useful in determining the maximum possible weight of the packages stacked on top of each other (before packing, after the packing stage and during the stages of transportation, storage and stacking on the shelves during display), ensuring that no breakage of the packages occurs as a result of overloading vertically and preserving material content from waste and on the user from avoiding the occurrence of risks as a result of breakage, which reduces damage to the packages and their content.

The vertical load resistance test applied according to the Egyptian standard specifications No. 2424/2007 and technically consistent with ISO 8113/2004, and the test device is a repeated disk, one is a base for fixing the package and the other is tightly touched to the mouth of the package and is able to generate the appropriate pressure or required legal test for it and with an accuracy of not less than 2.5%, the device should be provided with rubber, plastic or cardboard cushions to include an equal distribution of load on the nozzle of the package and to ensure that the metal does not come into direct contact with the surface of the package, which causes clear clarity from the actual result of the test and changes Pillows for each test. The test is carried out by installing the package on the base of the device in a vertical direction. Cushions are placed and pressure is gradually increased on the package at a recorded fixed rate as follows:

- Passing test: which is carried out in the event of ensuring the integrity of the packages according to the specifications that they apply from the limits and values of a pre-determined head bearing and by increasing the strength applied on the package so that they reach the specified value or to which the packs are to be tested and the discs are pulled when the force is reached and the test will produce a check not till break the packages.
- Total Increased Pressure Test: It is conducted in the case of wanting to know the maximum load that the package can carry and then to include it and the pressure is gradually increased on the packages until reaching the breakage of the packages has the subject of the test and the results are recorded and the average strength that was broken is calculated for all the packages under it and they are the maximum strength to be tested by the package under test, which determines the maximum weight that the package can withstand in the vertical direction.

b- Glass containers inner pressure test

This test aims to know the amount of pressure that the packaging can withstand without breaking or applying stresses on it, which is useful in packing foodstuffs under an emerging pressure at high temperatures. This test also aims to know the amount of increased pressure that the packaging can bear without breaking as a result of the expansion of carbon dioxide when changing the temperature of soft drinks, which creates differences in pressure on the walls of the inner packaging, and this test is concerned with bottles with a neck intended for filling soft drinks and on jars filled under variable pressure conditions or high temperatures, the test is carried out according to Egyptian Standard 2147/2006, which is technically compatible with ISO 7458/2004.

Test applies by filling containers with water so that the difference in temperature for the packaging and water is ± 5 ° C, pressure is applied to the container filled with water and kept under pressure for a period of (60 ± 2) seconds and the package passes the test if you bear the specified pressure throughout the period without a break or cracks, either increased pressure

test, the pressure is constantly increased at a rate of 1 bar (air pressure) until it breaks from 50% to 100% of the tested containers.

c- Glass containers Thermal resistance test

This test aims to find the amount of tolerance of the glass packaging for the sudden change in temperature, and this test is very important for the glass packages used to fill foodstuffs under high temperatures, as is the case in pastiest and jelly food (jam - sauce). The test is carried out according to Egyptian Standard 2423/2007, which is technically compatible with ISO 7459/2004.

The device used in the test is two basins, each with a capacity of 8 litres of water per kilogram of glass, one of them is a cold water bath basin t1 with a temperature of (22 ± 5) ^{0} C and the other is a hot water bath basin t2 that is set at the temperature to be tested according to it. Both basins should be equipped with a water temperature preservation feature (± 1) ،C, and provide the device with a basket of inert material that does not cause damage to the containers and is divided so that it can accommodate the packages in a vertical direction and equipped with a perforated lid to prevent the buoyancy of the packages when submerged.

The test is done by filling both hot and cold water baths so that the top of the rim of the glass containers is below the surface of the water with a distance of no less than 50 mm, and the containers are submerged in the hot water bath, and it is set to keep its pre-set temperature for a full 5 minutes and then lift the basket and move during a period of time not exceeding 16 seconds for the cold water bath and leave for 30 seconds, then the basket is raised to inspect the containers under test by examining each container to determine if cracks or fractures occurs during the test.

Passing the glass containers under test is determined if the number of tested containers in which fractures or cracks were found is less than the specified or agreed number in the sample, when exposed to the specified temperature difference (the amount of impact), and the increased test determines the percentage of cracks set by raising temperatures gradually 5 ° C at a time and retesting until 50% of the sample size being tested is broken or excluded, while the overall increment test is determined by re-passing the pass on the passed samples until all the containers under test are broken.

d- **Glass containers Spectrophotometric test**

This test is applied on glass containers for food that are used to fill materials that are affected by light, as in case of some soft drinks that are packed in green or honey-coloured glass containers, or as it is in some types of food oils. The test is done by using a spectrophotometer, and the container is cut with an appropriate machine, then you choose a piece of thickness that represents the average thickness of the body of the container and its edges are refined to fit the installation of the device taking into account not to scratch the surface of the glass. Then the sample is washed and dried with caution, and the sample should be carefully wiped with a suitable soft cleaning paper (or the paper for cleaning lenses) before placing it directly in the device, the sample can be fixed with sticky wax material or any other suitable means taking into account not to print fingers or any other signs on the sample that is in the path of light.

The sample is placed in the device so that the cylindrical axis is parallel to the level of the longitudinal slit from which the light passes and its centre is as far as possible on the straightness with the centre of the light opening so that the light passing through the hole falls vertically

onto the sample and the light reflection is minimal, permeability of the sample is measured by comparison with air in the specified spectrum area, if the spectrometer is equipped with an automatic recording device, and if the spectrometer is manually measured, it is measured every 20 nanometres in the spectrum area between 290 nanometres to 450 nanometres. The intensity of the light transmitted through the sample for the glass containers used must not exceed 10% at any wavelength in the range from 290 nanometres to 450 nanometres for glass colour brown or honey.

e- Glass containers Polariscopic test

This test aims to ensure the cooling quality of the glass containers, which is the stage in which the stresses are eliminated, which directly affects all properties of the physical and chemical packaging. A cooling defect, besides, it is an important test that is carried out regularly on the samples of the packages to ensure that the cooling process is proceeding in an appropriate manner for the package. Polarized light (light rays traveling in one linear direction) is used to detect the amount of stresses of the glass, and that when the polarized light passes through a sample of glass that has stresses, it deviates from its path, this deviation is directly proportional to the amount of stresses in the glass, which indicates the degree of fermentation quality of the package (Cooling). The test conducted according to the Egyptian standard specification 816 / 2006, which is technically compatible with the American Society for Materials ASTM C148-2000.

The test is based on determining the amount of light delay of the sample and comparing it with reference discs using the polariscopic, in the case of packages with a light delay less than 150 nm, and the polarimetry is used in the case of light delay less than 565 nm, and the degree of polarization of light at all points in the field must not be less than 99%.

f- Chemical durability test for Glass containers

The chemical resistance test aims to know the chemical tolerance of the glass packaging and its inability to interact with its contents and the degree of the solubility of some components from the inner packaging surfaces in water, which can harm the properties of the content material and directly affect human health. So sometimes it is necessary to take due precautions and ensure that the used packaging will not be affected by its exposure to different temperatures due to the melting of any of its internal surface components with the substance content. Most of the food glass containers are made from soda-lime glass and their chemical resistance is tested by conducting a test of the resistance of the glass pellets to water at a temperature of 98 degrees Celsius.

The test is done by grinding a portion of the glass containers and sifting it with sieves of specific diameters, then washed the granulated glass granules with water and acetone, and then dried, to collect 2 grams of glass granules with a granular size ranging from 300-500 microns. 60 minutes at 98. The glass is evaluated by the degree of water resistance of the glass by calibrating the extracted solutions, and the average results values are expressed in millilitres of the hydrochloric acid solution used for calibration per gram of the sample. The acid equivalent can be calculated from the extracted alkali (Na2O) in micrograms per gram of glass granule. The glass is classified according to the acid consumed and the equivalent of alkali, expressed as Na2O. The glass ranks are determined by Table No. (1) and their suitability for filling different materials.

Table (1): Limits of the values of the glass granular resistance to water at 98 ° C. for 60 minutes

Alkali equivalent and expressed as Na2O per gram of glass granule (g / (g	Consumption of HCl solution (0.01 ml / L) per gram of glass granule (ml / g)	Rank
Less than or equal to 31	Less than or equal to 0.1	HGA1
Greater than 31and less than or equal to 62	Greater than 0.1 and less than or equal to 0.2	HGA2
Greater than 62 and less than or equal to 264	Greater than 0.2 and less than or equal to 0.85	HGA3
Greater than 264 and less than or equal to 620	Greater than 0.85 and less than or equal to 2	HGA4
Greater than 620 and less than or equal to 1085	Greater than 2 and less than or equal to 3.5	HGA5
The term HGA indicates the resistance of the glass pellets by the method of testing the water pellets.		

6- Quality relationship to the different production processes:

A questionnaire was conducted to verify the extent of application of the tests in the production stages (glass packaging industry - packing), and the questionnaire targeted the quality officials of the packaging production factories as well as the packing factories for foodstuffs (final product exit), and questions focused on the opinion of those in charge of the industry on the importance of applying quality tests and its impact on the quality of the containers and the product, as well as the extent to which these tests are applied in the production stages to reach the final product, the following has been shown:

- Wide number of glass food containers manufacturers exceeds the number of pharmaceutical glass containers manufacturers and all manufacturers of glass packages have shown the importance of conducting quality tests for glass packages and that they significantly affect the quality of the package.
- Manufacturers of glass containers and packing operators have indicated that conducting quality tests on glass containers is effective in all stages of the glass packaging (the life cycle of the packaging) with a noticeable degree, and that the vast majority perform tests on the glass containers (packaging factories), or contract on containers as a packaging with acceptable specifications and test results (Packing factories).
- From the answers, it became clear the importance of performing the tests for the questionnaire sample (manufacturers – packaging factors), for the mechanical properties (thermal shock - vertical load - internal pressure), physical (light transmittance) and chemical (chemical resistance to water), and their effect on the final quality of the glass containers to ensure its utility efficiency, which raises production rates, reduces defects and raises marketing rates.
- Some tests are carried out in ways that are specific to the institution and values and limits outside the specifications sometimes, or according to the user data of the test device and are not

based on a reference method for a local or international standard. This is due to the factory's lack of awareness of the existence of a test specification and the absence of legislation binding tests. Tests for standard specifications in the field of glass containers. Accordingly, care must be taken to monitor production sites and alert them to go to conducting quality tests in order to ensure efficient use of the product.

7- Results:

1- The relationship of glass container quality tests with the functions and uses has been clarified.
2- Quality tests are an important guarantee to ensure glass containers quality performance throughout their life.

8- Recommendations:

1- Activating the role of conducting tests in a way that ensure the quality of the food glass packaging, reducing the percentage of spoilage from it and preserving the content throughout its life.
2- Making a comprehensive specification explaining the relationship of quality tests to the utility efficiency for food glass containers.

References:

- Abdelmene Mohamed Haouda "Al Mouasafat w al makayesss- Mokawmat Anaser Al taqneya fi Al Dowal Al Naeya"- Dar el Nahda Al arabeya- Misr- 1997
- Fathi Ahmed Yehya Al Alem- " Nezam Edaret Al gawda Al shamla w Al Mouasafat Al Alameya"- Derasah Elmeya we Tatbeqeya"- Dar Al Yazoury – Al Ordon - 2010

1- Anna Embled & Harry Embled, "Packaging technology, fundamental، material and processes" Woodhead Publishing, USA, 2012.
2- Anon, Packaging material module, Glass, International Trade Center, 2010.

Egyptian standards

- Mem.Kaf.Mem 2424-2007, ISO 8113-2004- "Al Aweya al Zogageya – Ekhtebar Mokawmet el Heml el Raasy"
- Mem.Kaf. Mem 2147-2006, ISO 7458-2004- "Al aweya al zogageya – Ekhtebar Mokawmet el Dakht El Dakhely"
- Mem.Kaf. Mem 2423-2007, ISO 7459-2004- "Al Aweya Al Zogageya – Ekhtebar Mokawmet al Sadm Al Harary we Tahamoul al Sadm Al Harary"
- Mem.Kaf. Mem 816-2006 "Al Aweya Al Zogageya – Ekhtebar Esteqtab Al Doa"
- Mem.Kaf. Mem 2425-2007 "Ekhtebar Nafazeyat Al Doa Lel Aweya al Zogageya Al Mostakhdama Fi Tabeyat Al Mostahderat Al Dawaaeya Alaty Tataathar Bl Doa"
- Mem.Kaf. Mem 4894-2005, "Ekhtebar Mokawmet Hobibat Al Zogag lel Maa End Daraget hararet ^{0}98 Celicious Wa Al Tasneef"

Websites references

3- http://glassplantconfidential.com/glass-container-terminology-201.html
4- https://www.agrintl.com/de/produkt-kategorie/glass-de/
5- https://www.agrintl.com/product/ramp-pressure-tester-2/
6- https://www.dpmglass.com/production/strength/
7- https://www.kruess.com/en/produkte/polarimeters-en/p3000/
8- https://www.idavid.be/gemological-instruments/polariscope.html
9- http://glassplantconfidential.com/glass-container-terminology-202.html