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Discussion on Status Quo and Quality Inspection of Edible Oil Package

Abstract: The article introduces the actual quality status quo of edible oil bottles through a great amount of testing data, and confirms the existence of quality differences among different bottle manufacturers: certain problems do exist in edible oil bottle packaging. The article can help further perfect the standards on edible oil packaging in China.

Key Words: edible oil, PET, oxygen transmission rate, OTR, water vapor transmission rate, WVTR, sealability

Since the 1990s, there has been great development in edible oil industry in China. The improvements of refining equipments have paved the way for high quality edible oil in sales packages. Now, sales package edible oil has taken the place of bulk edible oil greatly, and has become one of the sunrise industries with great development potentials. The speedy development of sales package of edible oil has promoted the development of its packaging. Thus, how to select more applicable packaging material and improve packaging methods has become a focus for packaging engineers and technicians. To this end, Labthink and Wuhan Institute of Technology have launched a research project on the status quo and quality inspection of edible oil packages. A thorough investigation on domestic edible oil package and its tests have been made with valuable data.

1. Status Quo of Edible Oil Package and Research Subjects of the Project

Sunlight, oxygen, water vapor, temperature, metallic ions and many other factors may lead to ingredient changes and deterioration of edible oil. Most often, edible oil is not exposed directly in sunlight, and the application of colored packaging or light-proof devices can obstruct the influence of sunlight and rays; therefore, oil oxidization or mildew are the most important indexes to evaluate the quality of edible oil. Reduction of oxygen concentration inside packages can reduce possibilities of oil oxidization; addition of water content may prompt increase of mould, including oxidase. Thus, high barrier packaging material is suitable for edible oil packaging.

Nevertheless, the domestic quality inspection system on edible oil package, especially PET package, is not perfect. Eight oil bottle manufacturers and eighteen sales package edible oil manufacturers have been investigated in the project. It's discovered that manufacturers have not paid due emphasis on barrier property of packaging materials, which is a key item for edible oil quality. At the same time, routine items of national standards for package testing, such as sealability and open easiness of pull-rings, are not well enforced.

In view of the investigation results for domestic packaging market of edible oil, the research subject is further divided into the following tasks.

- Measurement and quality evaluation for oxygen transmission rate of whole edible oil bottle.
- Measurement and quality evaluation for Water vapor transmission rate of whole edible oil bottle.
- Measurement and quality evaluation for sealability of edible oil bottle.
- Measurement and quality evaluation for pull-ring open easiness of edible oil bottle.
- Measurement and quality evaluation for suspension performance of handles on edible oil bottle.

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Certain quantities of sales package edible oil samples from enterprises are obtained for tests and analysis.

2. Results and Discussion

Fig. 1 Testing Results of Edible Oil Packages

Sample	Volume	Description	OTR (Oxygen Transmission Rate)[1] ml/pkg.d	WVTR (Water Vapor Transmission Rate) g/pkg.d	Sealability[2]	Open Easiness of Pull-ring N	Handle Suspension Performance
1#	1.5L	With bottle closure	0.4521	0.0784	Qualified	89.66	Qualified
		Without bottle closure	0.0812	0.0803			
2#	1.5L	With bottle closure	0.0856	0.0734	Qualified	97.87 [3]	Qualified
		Without bottle closure	0.0803	0.0738			
3#	5.0L	With bottle closure	0.1983	——	Qualified	89.37	Qualified
		Without bottle closure	0.1909	——			
4#	1.8L	With bottle closure	1.7449	0.0982	Qualified	73.06	Qualified
		Without bottle closure	0.0830	0.1039			

Note: 1. Testing gas is air, with the oxygen concentration of 20.9%;

2. Applicable standard is GB/T 17374-1998;

3. Pull-rings have been pulled to break without opening the bottle closure several times during testing.

2.1 OTR, Oxygen Transmission Rate

Comparing the testing results of samples with bottle closures and those without bottle closures, we can find the oxygen transmission rates of the samples with bottle closures are higher than those without them, more or less. As to sample 2# and sample 3#, the oxygen transmission rates with bottle closures are only slightly higher than those without them. However, the oxygen transmission rates of sample 1# and sample 4# with bottle closures are times, or even tens of times higher than the oxygen transmission rates of those without bottle closures, which is harmful for edible oil preservation. In other words, though high barrier property materials are used, it's a common problem for edible oil bottle package, bag-in-box or other forms of packages that the expected high barrier performance can not be realized: the leakage at the connecting place between the bottle closure and body should be resolved, and the material of bottle closure should not be neglected. At present, nearly all the bottle closures are made of PP, which is inferior to PET in its barrier property. Therefore, we advocate barrier property testing of the whole package. After analyzing the testing results, we think that the increase of oxygen

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transmission rates for those samples with bottle closures is caused by poor barrier property of the bottle closure material, or increased superficial area after applying bottle closure. Thus, the ingredients of the bottle closure materials should be further optimized on the premise of edible oil safety, so as to improve barrier performance against oxygen. Meanwhile, the bottle closure should match the body.

No bottle closure sample was obtained for the project, and correspondingly, no oxygen transmission rate test and analysis for bottle closure has been done. Yet, this is a research project of great significance. Through this test and comparing with other testing results, we can further clarify the existing problems of oxygen transmission rate of the whole package.

2.2 WVTR, Water Vapor Transmission Rate

After comparison, it can be concluded that samples of the same volume have similar water vapor transmission rates for the whole package. Generally, larger edible oil bottles would have greater water vapor transmission rates. However, the influential factor for water vapor transmission quantity should be the superficial area of the bottle. Edible oil bottles of the same volume would have similar external forms and dimensions. The larger the volume is, the larger the superficial area becomes correspondingly. Therefore, water vapor transmission rate tends to increase with the volume. Theoretically, leakage would easily occur at the connecting place of the bottle closure and bottle mouth; the oxygen transmission rates of the bottle with bottle closure are higher than those without bottle closure. However, there is almost no difference in water vapor transmission rates for them. We think a main cause is that water vapor transmission rate of PP bottle closure is lower than that of PET bottle body, and this can also support the conclusion that the increase of oxygen transmission rate of packages with bottle closures is the result of bottle closure material. Judging from testing data, the PP bottle closure would not change the oxygen transmission rate of the whole package remarkably.

2.3 Sealability

Fig. 2 Testing Requirements of Sealability Standards

No.	Standards	Testing Parameters and Requirements
1	ASTM D5094-2004	Samples are filled with liquid similar to actual products. Then, shake, and produce a pressure difference of 33.7kPa by moving the liquid inside. There should be no leakage within 10 minutes.
2	ASTM D4991-07	Vacuum the external environment, and achieve a 95kPa pressure difference. There should be no leakage within 30 seconds.
3	GB/T 17374-1998	Place the sample inside the outer package in the converted position for 3 minutes. Then, open the outer package, and there should be no leakage.
4	GB/T 17374-2008	As per GB/T 17344-1998
5	GB/T 17344-1998	Fill the sample with gas to the pre-determined pressure of 20kPa. Then, immerge the sample into water or coat it with a layer of certain liquid. There should be no leakage within 5 minutes.

Sealability is the premise for packaging safety and functioning of varied packaging functions. In our research and investigation, we have learned that most manufacturers still adhere to GB/T 17374-1998. In order to stimulate the

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actual tests as the manufacturers, we also adopt the testing method in GB/T 17374-1998 for sealability testing. Though the testing results of samples are qualified, we can see the requirements of GB/T 17374-1998 is quite low among the requirements of the standards in Fig. 2. As a result, the samples would perform varied sealability if stricter testing requirements are applied.

2.4 Open Easiness of Pull-rings

Testing methods for pharmaceutical packaging have been introduced and innovation has been applied, so as to evaluate open easiness of pull-rings on edible oil packages and the influence to our life. It can be seen that open easiness of most samples are greater than 70N, and can be quite convenient for daily usage. However, it should be noted that there exist failure cases for sample 2# that the pull-rings were pulled to break. We hold that we can reduce open failure of the pull-rings, through material ingredient optimization of bottle closure, thickness increase or re-design of external forms of pull-rings.

2.5 Suspension of Handles

The fastness of handles on edible oil bottles would directly influence the safety in usage. We especially carried out this test by introducing testing methods for suspension in GB 13508-92, so as to bring forward certain practical solutions. However, suspension tests in GB 13508-92 can only obtain deformation value so small that can be neglected. Meanwhile, the testing conditions are quite different from actual application. Thus, we fill water into the samples and regulate suspending period, so as to improve testing requirements and stimulate daily situation of the bottle. Though no problem has been found in our tests, we hold that more representative data should be obtained for determination of testing conditions and parameters.

3. Conclusions

At present, we are lacking of a systematic and complete quality inspection standard for edible oil packages in China. Owing to the imperfect standard regulations, there have been great quality differences of the various edible oil bottles: the sealing performance at the bottle mouths, the material of the bottle closures and the corresponding oxygen transmission rate differences of the whole edible oil bottles. Though there are limitations in sample type, sample quantity, testing methods and instrumentation, the data obtained in this project is quite representative, which can clarify certain problems in the production of edible oil bottles. We hope this research can help further perfect the edible oil package standard in China, and better draw the attention of relevant authorities and manufacturers.