

Research Article

Analysis on the Industrial Design of Food Package and the Component of Hazardous Substance in the Packaging Material

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Abstract: Transferring the hazardous chemicals contained in food packaging materials into food would threaten the health of consumers, therefore, the related laws and regulations and the detection method of hazardous substance have been established at home and abroad to ensure the safety to use the food packaging material. According to the analysis on the hazardous component in the food packaging, a set of detection methods for hazardous substance in the food packaging was established in the paper and the improved program was proposed on the industrial design of food packaging according to the operational mechanism and endangers degree of hazardous component.

Keywords: Detection method, food packaging material, industrial design

INTRODUCTION

Food packaging is a systematic project with the core of food involving a series of issues including food science, food packaging material, food packaging process, food packaging container, food packaging technology, food packaging standard rules and quality control and it is a comprehensive applied science. Currently, there are still improper phenomenon in the packaging enterprise concerning the production, processing and usage of packaging material. The food packaging materials sold in the market includes the paper, plastic, metal and ceramics, wherein, the paper and plastic are used at most, while the safety is worth our consideration (Arvanitoyannis and Bosnea, 2004). The unsafe paper packaging has been a threat to the health of consumers. In order to improve the whiteness of the paper and the sensory indicators, the majority of papers are processed with fluorescent whitening agent. The fluorescent whitening agent is a chemical with powerful carcinogenic activity (Fang and Huaxi, 2014). Although it can whiten the fiber, it is toxic to people and animal, therefore, the food packaging shall use the not-whitening paper. The Ministry of Welfare in Japan has confirmed the carcinogenicity through the animal experiment and prohibited the use of fluorescent whitening agent in the food packaging paper (Taylor and Hefle, 2001). The related departments in the countries have proposed the similar requirements. However, due to the lack of effective supervision, the phenomenon to use the whitening paper as food packaging is still common.

Moreover, the ink pollution in the packaging paper is also very serious and it threatens the consumers' health. In some areas, it is common to package the food with paper. The ink in the newspaper contains the oil-soluble

and toxic substance and it can permeate the food and cause the contamination of food, especially the pollution in the paper packaging for fried food is more severe. In another case, the manufacturer likes to package the food with colored packaging paper to increase the decorative feature. Although the color ink is printed at the outside of food packaging paper in the single side, the printed color paper is folded together and the no-printed side at each piece of the packaging paper also contacts the ink. Even the color wax paper soaked in the paraffin, the color ink can directly contact with food due to the uneven waxing. Therefore, the coating used for the color ink in the packaging paper shall be strictly controlled about the hygiene (Yonghua, 2014). Moreover, many senior food packages use the tinfoil (Kuiper *et al.*, 2001). It is understood that the lead content in 60% of the tinfoil surpasses the permitted hygiene indication. The lead is a recognized "culprit" causing the acute and chronic heavy metal poisoning, therefore, the amount of lead in the tinfoil shall be controlled strictly, meanwhile, the direct contact between the food and tinfoil shall be avoided (Lin, 2014).

As people are increasingly stringent on the environmental requirement, the green food packaging has become the current trend of food packaging industrial development, while the paper packaging material has become an important material in food packaging industry with a good physical property, mechanical operational performance and environmental protection advantages. However, some chemicals such as fungicides, plasticizers, curing agents and fluorescent whitening agent would be added in the paper packaging material during the production and subsequent processing periods, they may be transferred to the food and cause the food contamination and further threaten

Table 1: Residual contaminants in food packaging materials

Chemical residues	Main components	Source	Toxicity
Microelement	Aluminum, chromium, cadmium, mercury and the compounds	Printing ink	Intensive heavy metal, cannot be excreted
Fluorescent whitening agent	Bis triazinylamino distyryl sulfonic acid (salt) and derivatives	Add to improve the paper whiteness	Difficult to decompose after into the body, carcinogenic
Organic chloride	Dioxin, pentachlorophenol, polychlorinated biphenyl	Produce when whitening	Primary carcinogen
Plasticizer	Phthalate, adipate, citrate	Introduce at the subsequent processing of the waste paper	Phthalate has the potential carcinogenicity
Aromatic carbohydrate	DIPNs	NCR	Carcinogenic, mutagenic effect
Organic volatile compound	Alkane, aldehyde, ketone, heterocyclic, propylene, etc.	Unsaturated fatty acid oxidation product in the raw material resin	Mainly reflect in the sensory effect and hypersensitivity effect
Curing agent	Benzophenone	UV curing ink	Different (dimethylamino) diphenyl carcinogenic
Oil-proofing agent	Fluorine alkyl phosphate ester and perfluorinated ammonium salt	To prevent the grease in the food penetrating in the paper	Disorder the fat metabolism, delay children's normal ossification
Fungicide	Hypochlorite, methylene bis thiocyanate	Add to increase the slime pulp	Not reported

the consumers' health. In the 1990s, EU has begun to research the chemicals in the paper food packaging material and the main research contents include: determining the hazardous substance in paper food packaging material, establishing the chemical qualitative and quantitative analysis method, carrying out the chemical transferring test, researching the factors influencing the transferring and establishing the transferring model (Wang *et al.*, 2014). The potential residual contaminants in the food package can be seen in Table 1.

In order to more consider the hazards of the packaging material in the food on food packaging industrial design, it is pressing to establish the reasonable and effective analysis method for the hazardous material component in food packaging material. The paper analyzed the common hazardous materials in food packaging and improved the industrial design of food package through the analysis results.

MATERIALS AND METHODS

Hazardous materials in food packaging:

Heavy metal: In the metal element, the heavy metal and compounds have the most toxicity, while Pb, Cd, Hg and Cr are hazardous heavy metals often encountered in the production and living conditions. The hazardous heavy metal pollution has great harm to the environment and human and people cannot excrete the harmful heavy metal accumulated food chain or other means through own metabolism. The origin of heavy metal in food packaging paper is mainly two aspects, firstly, the plant fiber used for paper making absorbs the heavy metals existed naturally in the growth process. On the other hand, for some illegal companies use the waste paper, the ink and filler in the waste paper may contain the toxic heavy metal, so the food packaging paper may contain large amounts of toxic heavy metal, thus posing a serious threat on people's health.

Formaldehyde: Formaldehyde is a more toxic substance ranking second in the list of priority control

on the toxic chemicals in our country. Formaldehyde has been defined as the carcinogenic and teratogenic substances by WHO, it is a recognized allergic reaction resource and one of potential strong mutagens. The possible origin of formaldehyde in food paper packaging product is mainly three aspects: firstly, the accessory ingredient added in the papermaking process may bring the formaldehyde, such as melamine formaldehyde resin, etc.; Secondly, some illegal companies use the waste paper as raw material, the filler and ink in the waste paper may contain the formaldehyde; Thirdly, the adhesion agent used when molding the food packaging container may bring the residual for formaldehyde.

Fluorescent whitening agent: The fluorescent whitening agent is a special white dye to increase the paper whiteness, it can absorb the invisible ultraviolet light, turn to the visible light, eliminate the yellow in the paper pulp and increase the visual whiteness of the paper. For the xylogen in the paper pulp can absorb the visible light with the wavelength of 400-500 nm, so the paper pulp fiber is generally yellow or gray. Adding the fluorescent whitening agent in the papermaking can produce the high-brightness paper. Through adding the fluorescent whitening agent, the paper whiteness can increase more than 10% and it is the main means to whiten the paper. Currently, the fluorescent whitening agent used in the paper industry has the cyclic conjugated system in the chemical structure, toluylene bi-amino stilbene sulfoacid fluorescent whitening agent is commonly used, including 2-sulfonic acid, 4-sulfonic acid and 6-sulfonic acid.

Analysis method of hazardous substance:

Heavy metal: Currently, the lead, Hg, Cd, Cr, As and other heavy metals with significant biotoxicity are mostly concerned in the food testing field. The testing methods include AAS, AFS, EA, ICP, ICP-MS, etc. AAS includes the GFAAS, FAAS and other methods using the atomic absorption spectrophotometer at

different pre-processing conditions. The pre-processing methods for the food sample include microwave digestion, wet digestion and dry digestion. Wherein, the wet digestion and dry digestion are traditional sample pre-processing methods, the microwave digestion is a new digestion method with a quick development in recent years and it has the tendency to gradually replace the dry digestion and wet digestion. Currently, AAS is the most widely used method in the determination of heavy metal.

Formaldehyde: The domestic and foreign scholars have made extensive researches on the determination of formaldehyde and the content in food, hold that formaldehyde is a normal product of cellular metabolism, therefore, it is widely existed in the natural foods. The Codex Alimentarius Commission prescribes that the limited amount of formaldehyde in the cheese is 25 mg/kg and EU prescribes that the formaldehyde transferring limit in the food packaging material is 15 mg/kg. The spectrophotometric method is a commonly used formaldehyde detection method, the principle is as follows: the formaldehyde in food is distilled through the heating of vapour in the phosphoric acid medium, absorbed by the aqueous solution after the condensation, the distillate and acetylacetone react and generate the yellow diacetyl-dihydro-dimethoxy and it is determined by the spectrophotometric. The principle of HPLC is as follows: after the sample is distilled, the formaldehyde in the distillate and 2, 4-dinitrophenyl hydrazone in the acidic condition generate 2, 4-dinitrophenyl. After the extraction of dichloromethane, it is determined by the liquid chromatograph.

Fluorescent whitening agent: The ultraviolet detector and fluorescent detector are used for the detection of fluorescent whitening agent. HPLC is used to determine the content of fluorescent whitening agent in the paper. The ultraviolet detector is used, the wavelength is set as 348 nm, the methanol aqueous solution is the mobile phase. When the concentration is 0-0.14 mg/mL, the linear correlation $R^2 = 0.9997$. The application of reversed phase chromatography is more extensive than that of the normal phase chromatography. The detected linear range is 0.19-141 mg/L, the recovery rate is 98.4-107.3%, the detection limit is 0.019%, RSD is 1.73%. The method is convenient, fast and accurate. It can determine the content of DMF in CBS rapidly.

RESULTS AND DISCUSSION

Influence of hazardous substance on the industrial design of food packaging: Along with the industrial development and the consumption demand, people pay more attention to the food safety today and they hope that the food packaging will develop towards serialization, multi-function, high-performance and

special function under the premise of attaching importance to the safety. The following introduces the several development trends for food packaging material.

Composite paper packaging: It is a kind of super-strength composite paper and it has been developed successfully in the foreign country. The paper is featured with the white appearance, flighty and softness, there is no mark after the repeated folding and the price is low. For the packaging material, the basalt is made into fiber at 2000°C, the Bakelite is impregnated and the clay powder is penetrated and then the film is made. For the rock is the main material, it cannot be brittle, mildew, damaged by worms after the long-term storage. Moreover, the color can be printed, so the usage is wider. In addition, there are air-laid paper, sterilization paper, deodorant paper, anti-charged paper, anti-electromagnetic paper, high-absorbing paper (i.e., stealth material) etc.

Antimicrobial packaging: The food spoilage problem caused by the microorganisms makes the antimicrobial packaging become a hot topic. A kind of new inorganic antibacterial agent is added in the packaging material in Japan, the series of antimicrobial packaging materials have been developed successfully and it has the antibacterial effects on multiple pathogenic bacterium. The main feature of the packaging material is as follows: the anti-bacterial effect lasts for a long time; for the antibacterial agent is gas-phase type, there is no adverse effect on the packaging contents; it has a good stability. In the packaging and processing periods, the thermal stability is high, the concentration is stable and there is no adverse effect on the operating environment. The antimicrobial packaging materials mainly include sheet, absorbing sheet, packaging film, antibacterial packaging paper. The sheet is made through the pressing after the antibacterial agent is mixed in the polyolefin and other resins, the absorbing sheet is made with the base material of super absorbent resin and it usually includes the sheet-type and coating type, such as non-woven fabrics/paper/absorbent resin with antimicrobial agent/paper/non-woven fabrics.

High-barrier packaging: As we all know, the aluminum and plastic composite packaging material has a superior performance, while it is opaque and the experts developed a kind of high-barrier new material successfully. It has a good barrier property, other performances are equal or better than the aluminum and plastic composite material. The GT composite packaging material is made by a layer of inorganic (such as nano silicon oxide or titanium oxide) film with the thickness of 10-100 um deposited on the surface of plastic film. The nano coating has a stable performance. Even after the high-temperature sterilization, the gas barrier property, moisture resistance and transparency

remain unchanged. In recent years, US has developed TLCP successfully, it is composed by a kind of special dense fibrous polymer long chain and it has excellent strength and toughness. The gas barrier property for the liquid crystal polymer with the thickness of 2 μm is equal to that of EVOH with the thickness of 25 μm , while the price is much lower than the latter.

CONCLUSION

Along with the rapid development of food processing industry, the needed package is gradually increasing. The food packaging is directly connected with the food and whether the material selection is proper directly relates with people's healthy. In the future research, we can not only concern the determination of residual contaminant content in the paper, the research on the transferring of food or food simulating liquid is more practical. Meanwhile, we shall constantly improve the degree on the connection between the related standards of food paper packaging material and the international standards. Moreover, the more convenient detection technology shall be researched to realize the field sample detection in order to meet the demand of detection agency.

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