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Research Article

Comparative Research of Standard and Management of Food Additives at Home and Aboard and Economic Benefit Analysis of Rational Use

Ya Chen
Pingdingshan University, Henan, 467000, China

Abstract: This paper aims to avoid the incidence of unnecessary matter and bring considerable economic benefits by reasonablely using food additives. It firstly describes that China is weak in the system for the food additives supervision and management field by comparative analysis. The standard management system should be improved and long-acting standardization management mode is needed. In the case of the high speed of development in our country, integration of category yield of food additives with international and its reasonable use is important rule concerning with national food safety. Effective research and development of food additives and its proper use can provide long term power for growth of economic benefit.

Keywords: Criteria, food additives, management, rational use

INTRODUCTION

Chapter 10, Article 99, Paragraph 4 of Food Safety Law of the People's Republic of China stipulate that definition food additives is synthetic or natural material which is used to improve the quality, color, aroma and taste and meet the need of anticorrosion, refreshment and processing technic (Food Safety Law of People's Republic of China, 2009). It can be divided into natural food additives and synthetic food additives according to the source. And there are 23 kinds such as antioxidant, colorant, preservative and emulator according to the functions.

Rise and development of modern food industry promote the status of food additives. Food processing and manufacturing enterprises adopt different kinds and request of food additives that are developed by new technology on food formula, which also push the development of food additives market. With the increase of quantity demand of food additives, categories and relative output are also increasing. So far, there are 25,000 kinds of food categories and 5,000 kinds of commonly used additives. 3,000 to 4,000 kinds can be used directly. America is a country which consumes the largest amount and categories of food additives in the world. So far, more than 2300 kinds can be used directly. 2922 kinds are on the list of food additives that was released by American FDA, among which 1,100 kinds are used in Japan, 1,000 to 1,500 kinds are allowed by EU and 2,171 kinds are allowed to use in China (Yongmei, 2007). In view of production and marketing scale, general output of world food additives market in 1998 is 18.4 billion dollars. In 2003, world sales of food additives are 20.5 billion dollars. In 2008, world market sales of food additives are 30.8 billion dollars (Report on Market Analysis and Investment of Food Additives Industry in China, 2008).

Food industry in China has entered into high speed development stage and has taken the first place of national economy for several years. However, compared with developed countries, Chinese food additives industry has a large space. Output of food additives in 2007 increase 18% compared with that of 2006. Total output of main product is 5.24 million ton and sales income is 5.29 million, which increase 15 %. Export value is more than 2.7 billion and total demand of national food additives in 2010 is 4.8 million. Therefore, we can find that food additives industry have vast potential for future development (Xin, 2010) and the economic benefits it brings are limitless. So it is necessary to do systematic and analysis and evaluation.

MATERIALS AND METHODS

Method of domestic and foreign standard overview comparison: Our country stipulates basic rule of using food additives in Food Safety Using Standard of Standard Food Additives (GB2760-2011). Food additives according to this standard should conform to relative request of quality standard specification. Functions of food additives in the standard can be divided into 23 kinds. It clearly states that every food additives can have one or more functions and list out common functions of food additives in detail. It defines the range of application of food additives and every food additives have relative classification code.

As showed in Table 1, it refers to some countries or organizations that have relative standard specification such as CAC, EU, USA and Japan.

Table 1: Relative standard of food additive oversea

Country/ organization	Overview of standard
CAC	Codex Alimentarius Commission was founded in 1962 by FAO and W.H.O. It has several committees and wording term according to tasks. Its subordinate Food Additives and Contaminant Codex Commission are responsible for evaluating safety of food additives and contaminant and formulating relative standard. So far, commission have assessed safety of more than 700 kinds of food additives and formulated lots of relative standard (Aijin, 2007).
EU	Basic order of managing food additives is 89/107/EEC, which contains definition of food additives, categories of food additives that are allowed to be used and general rule of launch and using. It divides food additives into 3 kinds: Order of 94/36/EC of European parliament and council is the detailed stipulation of pigment; Order of 94/35/EC of European parliament and council and its revision order of 96/83/EC and 2003/115/EC are detailed stipulation of sweetening agent; Order of 95/2/EC and its revision order of 96/85/EC, 98/72/EC,2001/5/EC,2003/52/EC and 2003/114/EC are detailed stipulation of all food additives except pigment and sweetening agent (European Parliament and Council, 1988).
USA	Federal food, medicine and cosmetic endow Food and Drug Administration with power of managing food and food ingredients. A new kind of food additives or pigment should apply to FDA before coming into the market. Manufacturer should provide proof materials to prove that food additives can reach the expected process function and ensure that it will not do harm to health in the case of expected consumption. Additives which will be added in Meat and poultry products must be permitted by Ministry of Agriculture. Part 70~74 and 80~82, Roll 21 "food and drug" of Federal Law is detailed stipulation of pigment and Part 170~186 is stipulation of other food additives except pigment (Aijin, 2007).
Japan	On Dec.18, 2006, Japan announced to revise implementation regulations of food hygiene law and standard and specification of food additives. It specified that additives refers to synthetic additives which will not do harm to health and divided into food additives which have been applied application standard and food additives which have not formulated application standard. According to the functions, food additives can be divided into 30 kinds, such as sweetening agent, emulator, PH modifier, water containing soda, condiment, rising agent and nutrient supplements (Xuexia *et al*, 2007).

Table 2: Oversea management system of food additives

Country/ organization	Overview of management
CAC	Subordinate food additives Codex Alimentarius Commission reviews and approves standard, experimental scheme and safety evaluation of food additives, submits CAC to recheck and then recommend it to the world (Xiaohui *et al*., 2006).
EU	Health and consumer protection council of European Commission is responsible for application and approval of adding food additives into allowed list. Scientific Commission on Food is responsible for safety evaluation of food additives. On Jan.28, 2002, European Union New Food Law, that is Regulation 178/2002 of European Parliament and Council officially took effect and had a revision in 2003, which provides important guiding principle for guarantee quality safety of food additives (Qiu'er, 2009).
USA	American Food and Drug administration is a responsibility organization for managing food additives. It is responsible for approving work of food additives and color additives, supervising food market in authorization of law and recall defective food; American Food Additives Law stipulates application range, maximum quantity and label representation of food additives; Part 70~74, 80~82 and 170~186 in New version of American Federal Law (April, 2005) is about stipulation of pigment and other food additives including articles of general rule, package, identification and safety evaluation.
Japan	On Nov. 16th, 2006, Japan announced revision of standard and specification of food and food additives. Labor Ministry of Japan announced to repeal 42 kinds of food additives (Non-synthetic food additives) in existing list of food additives. Japan have not sold these additives but formulated regulation of non-synthetic food additives and revised existing standard and regulation such as detection mode.

Definition of American food additives is different with that of China. America divided them into direct food additives and indirect food additives. Direct food additive can be added into food directly. Therefore, Ingredients are also brought into food additives. And indirect food additives are package materials and contact materials that is transferred to additives in rational expectation.

On comparison of classification, Japan divided food additives into four kinds on traditional concept: specified additives, existing additives, natural essence and general additives. Specified additives can be divided into synthetic additive that have standard and synthetic additives that do not have standard. Existing additives refers to active additives, which is considered as the most safety and natural additives in Japan. Natural essence and general additives are not restricted by management law but they are also marked ingredient and raw material. EU divides food additives into three kinds of pigment, sweetening regent and other food additives. They can be divided into 25 kinds according to functions. America divides them into 32 kinds in CFR according to functions. And CAC divides them into 23 kinds, which is the same as China.

Method of domestic and foreign management comparison: Food Safety Law in our country establishes segmentation supervising system on supervision and management of food additives. It also clears up assignment of duties of each department. Ministry of Health is responsible for comprehensive coordination and permission, formulation and published standard of new kind of food additives. AQSIQ is responsible for food additives production enterprise, food additives used in production and supervision of import and export of food additives. Business Department is responsible for improving quality supervision of food additives in intermediate links. Food and Drug Administration is responsible for supervision of food additives in catering links. Ministry of Industry and Information Technology is responsible for industrial management, formulating industrial policy and guiding credit system construction of manufacturing enterprises (Zhi, 2010).

As showed in Table 2, it refers to some countries or organizations that have relative improved management system, such as CAC, EU, USA and Japan.

With the rapid development of categories and functions of food additives in China, various kinds of food additives speed to market. Management of national food additives is falling behind oversea and cannot adopt development request. It leads to illegal businessmen's misuse of food additives which is not through safety evaluation. On comparison of oversea approval system, food additives in America must apply to FDA. And manufacturer should provide craft, material of ingredient, including chemical process information, manufacturing technique, specification standard and test value of sample analysis, information of stability, analytical method of additives and effect of consumers' health level. Then it needs to do long time of animal toxicity test. In America, food additives need human test material when it is necessary. Processing time of food additives in FDA is 15 days. It will be published and solicit suggestions in federal registration within 30 days after acceptance. One year is needed to go through the approval of FDA. Approval time of EU is several month. However, only when food additives on condition of positive process effect and doing no harm to health of consumers can it reaches assessment criteria. On domestic supervision, issues of Food Safety Law clearly specify responsibilities of every department. Although responsibilities of every department are clear, confusion of supervision edge, shuffle and regulatory gaps are easy to appear in basic practice facing with complicated food additives chain according to segmented regulatory model. In addition, low quality, weak professional technology level and insufficiency of time effectiveness may lead to poor regulation on food and food additives.

RESULTS AND DISCUSSION

Evaluation result of food additive: Food additives are a complex systematic project. Besides specific standard for measurement, management standard is also needed in order to improve effective management at home. In view of five dimension standards, input standard U_1, management ability standard U_2, policy implement standard U_3, industry development standard U_4 and safety standard U_5 expand 15 specific index: supervisor amount of food additivses U_{11}, supervision expense input of food additives U_{12}, informational level of supervision department U_{21}, efficiency of supervision department U_{22}, professional ability of supervisor U_{23}, supervision policy stability of food additives U_{31}, law enforcement of government U_{32}, people's satisfaction U_{33}, proportion of production value on GDP U_{41}, industrial concentration U_{42}, industrial increasing rate U_{43}, pass rate of food additives U_{51}, safety accidence amount U_{52}, certified rate of HACCP U_{53} and QS target rate U_{54}. Give every index weight coefficient by weight sets. It can be concluded by measure effect of management standard of index that:

$$U_1 = \{U_{11}, U_{12},\}$$
$$U_2 = \{U_{21}, U_{22}, U_{23}\}$$
$$U_3 = \{U_{31}, U_{32}, U_{33}\}$$
$$U_4 = \{U_{41}, U_{42}, U_{43}\}$$
$$U_5 = \{U_{51}, U_{52}, U_{53}, U_{54}\}$$

Second and third level of index weight sets can be concluded by evaluation factor of weight sets.
Second level of index weight sets:

$$A = \{A_1, A_2, A_3, A_4, A_5\}$$

Third level of index weight sets:

$$A_1 = \{A_{11}, A_{12},\}$$
$$A_2 = \{A_{21}, A_{22}, A_{23}\}$$
$$A_3 = \{A_{31}, A_{32}, A_{33}\}$$
$$A_4 = \{A_{41}, A_{42}, A_{43}\}$$
$$A_5 = \{A_{51}, A_{52}, A_{53}, A_{54}\}$$

Evaluate second and third level of index by fuzzy evaluation method:

$$V = \{V_1, V_2, V_3, V_4, V_5\}$$
$$= \{veryhigh, high, common, relatively\ low, low\}$$

Assign fuzzy evaluation and obtain assignment sets:

$$H = \{H_1, H_2, H_3, H_4, H_5\} = \{100, 80, 60, 30, 0\}$$

Collect data of evaluation factor by questionnaire and evaluate single standard. For instance, evaluation matrix of policy enforcement standard is:

$$R_3 = \begin{bmatrix} R_{11} R_{12} R_{13} R_{14} R_{15} \\ R_{21} R_{22} R_{23} R_{24} R_{25} \\ R_{31} R_{32} R_{33} R_{34} R_{35} \end{bmatrix}$$

R_{ii} refers to evaluation membership of supervision policy stability, R_{2i} refers to evaluation membership of accidence of food additives, R_{3i} is evaluation membership of people's satisfaction on policy. I = 1, 2, 3, 4, 5. Similarly, R_1, R_2, R_3, R_4 and R_5 can be obtained.

A comprehensive evaluation is made on management standard by fuzzy evaluation method. First, make comprehensive evaluation on U_i and judge out single factor B_i, Take U_3 as example, multiplication of matrix can get:

$$B_3 = A_3 R_3 = (A_{31,}, A_{32}, A_{33})$$
$$\begin{bmatrix} R_{11} R_{12} R_{13} R_{14} R_{15} \\ R_{21} R_{22} R_{23} R_{24} R_{25} \\ R_{31} R_{32} R_{33} R_{34} R_{35} \end{bmatrix} = (B_{31}, B_{32}, B_{33}, B_{34}, B_{35})$$

Evaluate B_1, B_2, B_3, B_4 and B_5 by other single factor standard matrix to form a comprehensive evaluation matrix B:

$$B = \begin{bmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \\ B_5 \end{bmatrix} \begin{bmatrix} b_{11} b_{12} b_{13} b_{14} b_{15} \\ b_{21} b_{22} b_{23} b_{24} b_{25} \\ b_{31} b_{32} b_{33} b_{34} b_{35} \\ b_{41} b_{42} b_{43} b_{44} b_{45} \\ b_{51} b_{52} b_{53} b_{54} b_{55} \end{bmatrix}$$

Conclude the result of comprehensive evaluation:

$$C = AB = (A_1, A_2, A_3, A_4, A_5) \times \begin{bmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \\ B_5 \end{bmatrix} \begin{bmatrix} b_{11} b_{12} b_{13} b_{14} b_{15} \\ b_{21} b_{22} b_{23} b_{24} b_{25} \\ b_{31} b_{32} b_{33} b_{34} b_{35} \\ b_{41} b_{42} b_{43} b_{44} b_{45} \\ b_{51} b_{52} b_{53} b_{54} b_{55} \end{bmatrix} = (C_1, C_2, C_3, C_4, C_5)$$

All management standard index result of U can be obtained. According to principle of membership maximum, relative evaluation level is comprehensive evaluation level of project when q is maximum. These kinds of evaluation method can promote management supervision of food additives, which can make up lag of domestic information channel, low efficiency of supervision organization and low credibility (Yang, 2009). Integration of Chinese food additives management pattern can achieve development objective of import and export benefits.

Discussion on economic benefits bring by reasonable use of food additives

Function of food additives in food:

- **Keep and improve nutrient of food:** Daily intake of food is to satisfy nutrient need. However, In process of food production or preservation, some nutrient ingredients in food will change. For example, nutrient of food is easy to be oxidized in process of preservation and some food ingredients is easy to be rotten. If we add some anti oxidant or preservative according to stipulation in process of production and processing, loss of nutrient can be effectively avoided. Food nutrient supplements are of great significance in improving nutrient of food, preventing malnutrition, promoting nutrient balance and improving health level.
- **As indispensable ingredients of dietary food:** With improvement of living level, people pursue more and more need of special diet. For example, diabetics who can not eat sugary food become more and more. People have natural love for sweet taste. Therefore, they need special nonsugar food which can satisfy diabetics' love for sweet taste and will not increase the intake of sugar. Sweetening agent which is approved in China has this kind of effect.
- **Improve stability of food and keep texture:** Food additives play an important role in keeping quality and stability of food. For example, emulator should be put into fat emulsion products in form of oily water to keep the stability of water and oil system; ant tackiness agent should be added into food which is easy to damp and caking such as salt and powered sugar. Pigment can make chocolate have special taste; thickener agent and tasty agent can make shrinking square ham sweet-smelling and soft.
- **Convenient for processing and preservation:** Food additives are beneficial for processing of food to adopt mechanization, serialization and automatic production, which can push food industry to modernization. For example, gluconic acid-D-lactone can be used as coagulator of bean curd. It is good for mechanization, serialization production of lactone bean curd (Zhigang, 2010).

Analysis of economic benefits: Analysis of economic benefits brought by rational use of food additives is a complex process. Subject of researching is food additives. Food additives in domestic and oversea market mentioned above all involve supervision of national government and restriction of international covenant organization. Besides, it also involves development of food additives production enterprise, opinion of food additives on food additives and effect of public opinion. Generally speaking, it is a decision-making analysis system which combined expected behavior and actual behavior. In short, we must get a balance result on factors of food additives.

Analysis model of producer and consumer: First is the most basic and broadest model construction. We construct by assumption of producer and consumer of food additives. In view of maximum benefits of two aspects, producer chooses standard and non-standard products. Cost of standard product is C_1. Cost of non-standard product is C_2. $C_1 \rangle C_2$. Suppose price of food additives as P. Cost of non-standard product sold by improper approach is C. Size of C is related to public opinion of government supervision. Benefits of standard product are V_1. Benefit of non-standard product is V_2. Benefit of no purchasing is 0. $V_1 \rangle P \rangle V_2$. Probability of judgment of whether it is standard is supposed as q and q-1. To sum up, we draw up four kinds of models to form matrix.

When consumer purchase producer standard product, producer benefit value is P-C_1 and benefit value of consumer is V_1-P.

When consumer do not purchase producer standard product, producer benefit value is $-C_1$ and benefit value of consumer is 0.

When consumer purchase producer non-standard product, producer benefit value is P-C_2-C, benefit value of consumer is V_2 - P.

When consumer do not purchase producer non-standard product, producer benefit value is -C_2-C and benefit value of consumer is 0.

Uncertainty of consumer on wether the food additives are standard or not, that is 0 ⟨q ⟨1. Expected benefit of standard product is:

$$E_1 = \mathrm{q}\ (P - C_1) + (1 - \mathrm{q})\ \ (-C_1) = \mathrm{q}P - C_1$$

Expected benefit of non-standard product is:

$$E_2 = \mathrm{q}\ (P - C_2 - C) + (1 - \mathrm{q})\ \ (-C_2 - C) = \mathrm{q}P - C_2 - C$$

If $C_1 \rangle\ C_2$+C, then $E_1 \langle E_2$. And the optimal strategy is producing non-standard product. Although consumer does not buy it, non-standard product is still having market advantage.

If $C_1 \langle C_2$+C, then cost of producing non-standard products by improper approach is more than that of standard product and $E_1 \rangle E_2$. Whether it is brought or not, producing standard product is the optimal strategy.

It can be concluded from the matrix that consumer including factor of public opinion judge producer standard as non-standard. Producer will lose market benefit and be replaced by oversea producer. Supervision of government determines cost of non-standard product. If cost of improper approach is maximized and producer does standard production, then benefits of two parties will be the best.

Analysis model of supervision organization and producer of food additives: Review method of China supervision organization is mixed and can be divided into strict supervision and non-standard supervision. Food additives produced by producer can be divided into standard product and non-standard product. If supervision of organization is restrict, then producer will be punished; if supervision organization neglect its duties, then producer can get benefit in market. Draw model on basis of economic benefit maximum. Benefit of standard production is R_1 and benefit of non-standard production is R_2. Usually, $R_1 \langle R_2$, probability of standard product is q and non-standard product is 1-q. Cost of supervision organization is C. Probability of review is p and probability of no review is 1-p. Loss of dereliction of duty is W. Suppose U_s as expected benefit function of supervision organization, U_f as expected benefit function of producer. It can be concluded combined with model that:

$$U_{\mathrm{f}} = \mathrm{q}[R_1\mathrm{p} + R_1(1 - \mathrm{p})] + (1 - \mathrm{q})[0 \times \mathrm{p} + \mathrm{R}_2(1 - \mathrm{p})]$$

$$U_{\mathrm{s}} = \mathrm{p}[(-C)\ \mathrm{q} + (-C)\ (1 - \mathrm{q})] + (1 - \mathrm{p})[0 \times \mathrm{q} + (-W)\ (1 - \mathrm{q})]$$

Evaluate calculus on benefit function and get first order function $U'_{\mathrm{f}} = R_1 - R_2$ (1-p) = 0, U'_s = - C + W (1-q) = 0, acquire: $\mathrm{p}^* = 1 - R_1/R_2$ $\mathrm{q}^* = 1 - C/W$.

The model reaches balance when supervision organization review in probability of $1-R_1/R_2$ and producer reach standard request in probability of $1-C/W$. It can be concluded from the matrix that review probability of supervision organization, expected benefit of producer standard production R_1 and benefit of producer non-standard producing in market R_2 are related. Review probability and expected benefit of standard producing is negative phase correlated. The better expected benefit of standard producing is, the more standard producer and the lower review probability is. Review probability and expected benefit of non-standard producer R_2 is negative phase correlated. The better benefit of producer is, the more non-standard product is and the larger review probability of supervision organization is. C is related with W. Standard probability and review cost is negative phase correlated. Standard probability and loss of dereliction of duty is positive phase correlated. The higher review cost of supervision brought by non-standard, the bigger review probability of supervision organization under public opinion. To sum up, higher cost of review by supervision will push more non-standard producer into market, which will lead accidence.

CONCLUSION

We can find that application standard at home is not falling behind other countries by reviewing the domestic standard of food additives compared with oversea. Food additives application standard in 2011 stipulates there are 2,300 kinds of standardized food additives and developing standard of food additives such as monosodium glutamate, xylitol, sodium saccharin and taurine is the standard in the world. However, management system is falling behind. So far, there are lots of food safety problems. Many illegal additives which are taken as food additives lead to the confusion of food additives industries. And there are flaws due to lack of management system. Through economical benefit analysis of production operator, consumer, management supervision organization, policy orientation and public opinion, we construct mutual beneficial pattern between systems. Idea of this paper guides the arrowhead of supervision of supervision organization and standardized production orientation of producer. It also draws up road for rapid development pace of food additives and provides a reliable guarantee for international journey.

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