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ARTICLE

# Survey of Yogurt Powder Storage in Ambient Export Countries A Safety Evaluation Standard Compliance and Comparative Analysis

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**Abstract**

Yogurt powder is fermented milk processed in the form of dry yogurt, and has advantages such as stability, storability, convenience, and portability. China and Vietnam are important export target countries because of the increased demand for dairy products. Therefore, we surveyed dairy product standardization in order to establish an export strategy. Lactic acid bacteria counts are unregulated in Korea and Vietnam. In China, lactic acid bacteria counts are regulated at $1\times10^6$ colony-forming units (CFU)/mL and detected at 6.24±0.33 Log CFU/mL. All three countries have regulated standards for total bacterial counts. In China, total bacterial counts of milk powder are regulated to n=5, c=2, m=50,000, M=200,000 and detected at 6.02±0.12 Log CFU/mL, exceeding the acceptable level. Lactic acid bacterial counts appeared to exceed total bacterial counts. Coliform group counts, *Staphylococcus aureus*, *Listeria monocytogenes*, and *Salmonella* species were not detected. Acidity is not regulated in Korea and Vietnam. In China, acidity was regulated to over 70°T and detected 352.38±10.24°T. pH is unregulated in all three countries. pH was compared to that of general fermented milk, which is 4.2, and that of the sample was 4.28±0.01. Aflatoxin levels are not regulated in Korea and China. In Vietnam, aflatoxin level is regulated at 0.05 ppb. Therefore, all ingredients of the yogurt powder met the safety standards. This data obtained in this study can be used as the basic data in assessing the export quality of yogurt powder.

**Key words:** yogurt powder, ambient storage, reconstitution property, high viability, export

## Introduction

The domestic dairy market is well established, and mainly engages in competition and brand differentiation (Yoon, 2011). The Korean government recently announced dairy performance and damage caused by foot-and-mouth disease, taking into account the import results for cheese, milk, etc., as well as the raw materials, including duty-free dairy products. The 2013 raw material index was introduced, although domestic raw material production had recovered from the decrease due to foot-and-mouth disease, which had caused an increase in dairy prices. Consumption more than raw material supply results in increasing imbalance, which could be related to seasonal variations, Current conditions show an increasingly self-sufficient dairy market, with a decline in the consumption of raw milk because of limited domestic market structure and decrease in import of dairy products.

Overall, new business is being developed in the dairy industry; the growth rate is not high and the high-value creation strategy in foreign markets is expected through exports (Kang, 2014).

Powdered yogurt is produced by freeze drying and spray drying liquid yogurt (Kumar and Mishra, 2004). Yogurt powder is simple, portable, has consumer appeal, and facilitates the expansion of exports at room temperature. Improving the awareness of domestic dairy and the dairy industry will provide economic benefits (Yoon, 2011). Dairy exports have a market share of 50% in domestic exports to China, being the largest share among the Asian countries (Jung, 2014).

Korean dairy production has begun to increase in China, while the melamine shock is decreasing. The preference for safety has increased for imports compared to that for domestic goods and the demand for dairy prod-

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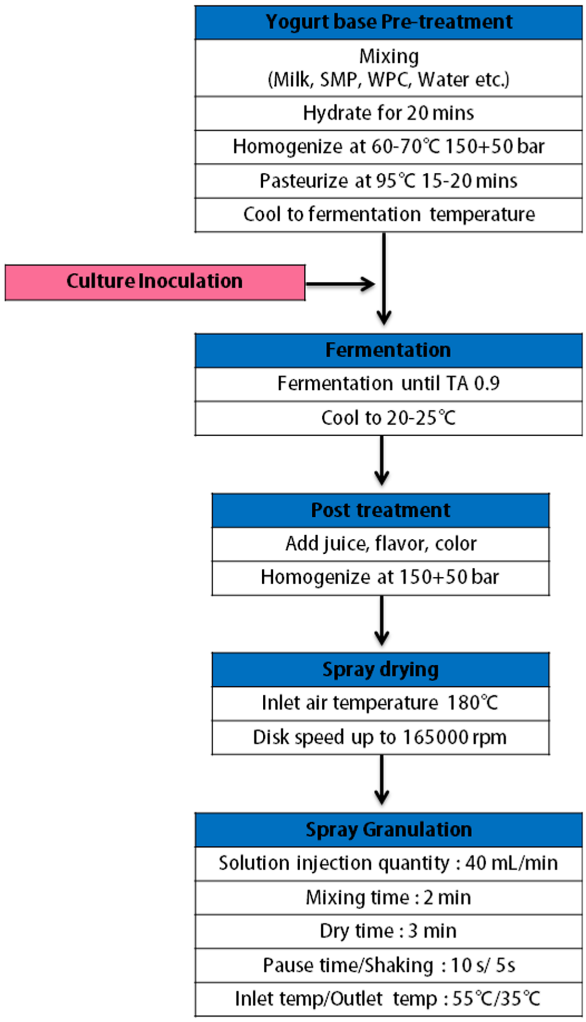


**Fig. 1. Manufacturing process of yogurt.**

ucts has increased overall. Korean export of infant formula has also steadily increased (Yang, 2009).

China's dairy market is higher than half of the milk consumed in the country. Also Chinese consumers of 92.6% showed a response rate for Korea milk (Korea Agro-Fisheries Trade Corporation., 2014). Therefore, the market potential for dairy products is also considered to be high in absolute (Lee et al., 2010). Exports in the second half of 2013 to the EU and other major trading partners have increased. Geographical advantages with China and South Korea dairy quality, safety, freshness, and food imports have expanded opportunities of spending income, which are advantages for exports (Kim, 2009).

Consumption of milk and dairy products in Vietnam is gradually increased 15-20%, and float to the new export. Dairy prices have been relatively low in recent years, increasing the purchasing power of various consumers, indicating the growth potential in the Vietnam dairy market (Hong, 2013).

In this study, we explored methods to increase the export of dairy products by using standard comparison and by analyzing the safety of the products at room temperature and the export market for retail (China, Vietnam).

## Materials and Methods

### Standardization of domestic, Chinese, and Vietnamese dairy products

Domestically, standardization of dairy products follows the Processing and Ingredients Specification of Livestock Products. In China, standardization of dairy products follows Guo jia Biao zhun. In Vietnam, standardization of dairy products follows the 'Standardization of Vietnam Food' published by Department of Health in Vietnam (VFA, 2010). However, yogurt powder is unregulated in China and Vietnam. Therefore, we surveyed the standardization of fermented milk including yogurt powder.

### Samples

The yogurt powders were produced by base pre-treatment, culture inoculation, fermentation, post-treatment, spray drying, and spray granulation. The manufacturing process of yogurt powder is presented in Fig. 1.

### Safety analysis according to standardization of dairy product

#### Microbiological experiments

For all microbiological experiments, samples were serially diluted in sterile distilled water, and all experiments were performed in triplicate. All data are reported as the mean of three independent experiments. Microbiological analyses were performed according to the Processing and Ingredients Specification of Livestock Products published by the Animal and Plant Quarantine and Inspection Agency (QIA, 2012) and Ministry of Food and Drug Safety (MFDS, 2014).

#### Lactic acid bacteria (LAB) counts

For LAB counts, samples were plated on the surface of lactobacilli MRS agar (Difco, USA) and incubated at 37°C for 48 h.

#### Total bacterial counts

Total bacterial counts were measured using the total bacterial counts analysis method by Park (2014). To determine total bacterial counts, samples were plated on the surface of Plate Count Agar (Difco) and incubated at 37°C for 48 h.

#### Coliform group counts

For coliform group counts, samples were plated on the surface of deoxycholate agar (Difco) and incubated at 37°C for 48 h.

#### *Staphylococcus aureus*

*Staphylococcus aureus* was determined by plating on the surface of Mannitol Salt-Egg Yolk agar (Difco) and incubation at 35°C for 48 h.

#### *Listeria monocytogenes*

*Listeria monocytogenes* was assessed by surface plating on PALCAM (Polymyxin Acriflavin LiCl Ceftazidime Esculin Mannitol) agar (Difco), followed by incubation at 37°C for 48 h.

#### *Salmonella* species

The growth of *Salmonella* species was assessed in samples surface-plated onto Triple Sugar Iron agar (Difco) and incubated at 37°C for 48 h.

### Aflatoxin

The Beacon kit was used to detect aflatoxin. First, 50 μL standard, sample, and conjugate were added to the appropriate test wells. The test wells were incubated for 30 min at 25°C. The wells were washed with washing buffer and 50 μL of substrate A and B were dispensed into each well. The wells were incubated for 15 min at 25°C. Next, 50 μL of stop solution was dispensed into each test well. The absorbance of the wells was read at 450 nm.

### Physicochemical experiment

#### pH

pH was measured using the pH extraction method by Wi (2014). Sample pH was determined by blending 5 g of sample with 50 mL distilled water. pH values were measured using a pH meter (pH meter F-51, Japan) that had been calibrated at pH 4.0 and 7.0.

#### Acidity

Acidity analysis was performed according to Standardization Administration of China (SAC, 2010b). Acidity was measured by adding 96 mL of distilled water to 4 g of the sample, and the solution was titrated with 0.1 M KOH solution until a reddish color persisted for more than 30 s. The acidity was calculated using the following equation:

$$\text{Acidity}(^\circ\text{T}) = \frac{C_1 \times V_1 \times 12}{m_1 \times (1-w) \times 0.1}$$

$C_1$: mol concentration of KOH solution
$V_1$: 0.1 M KOH solution titer (mL)
$m_1$: sample weight (g)
w: mass fraction of moisture

### Statistical analysis

Analysis of variance was performed on all variables measured using the General Linear Model procedure in SAS software (SAS, 2010). Duncan's multiple range test ($p<0.05$) was used to determine between treatment mean applied. All data were expressed as the mean ± standard deviation.

## Results and discussion

### Standardization of domestic, Chinese, and Vietnamese dairy products

#### Korean dairy standards

Standards of domestic dairy products followed by the announcement of agriculture, forestry, and livestock quarantine headquarters "livestock products processing standards and component standards." The standards for Fermented milk powders are contained in Chapter 2. Fermentation by livestock standards and specifications of the 'livestock processing and ingredient standards Standard' 1. Dairy fermented milk flow. Fermented milk is milk or milk products fermented by lactic acid bacteria and yeast. This means that other food or food additives, such as a sanitary added. Powdered yogurt powder is a fermented milk product. Fermented milk powder and powdered milk solids are defined as more than 85% fermented milk. Standards for fermented milk powder include regulations on properties, water, milk solids, and *E. coli* (Table 1). Fermented milk powder has a unique color flavor, and odor, and moisture must form no more than 5.0% and milk solids 85% or more, with respect to the *E. coli* group n=5, c=2, m≤3, M=10.

#### China dairy standards

Chinese fermented milk standards include sensory conditions, physical and chemical conditions, and microbial conditions (Table 2). Sensory condition, color, and flavor

**Table 1. Domestic component of fermented milk powder standard**

| Type | Fermented milk powder |
|---|---|
| (a) Properties | Has its own color and flavor and be free of odor already |
| (b) Moisture (%) | Less than 5.0 |
| (c) Milk Solids (%) | More than 85 |
| (d) Nonfat solids (%) | - |
| (e) Milk fat | - |
| (f) Lactic acid bacteria or yeast can | - |
| (g) Coliforms | n=5, c=2, m=<3, M=10 |

**Table 2. Chinese fermented milk standard**

| Sensory conditions | |
|---|---|
| Items | Requirements |
| Colors | A uniform color |
| Flavor | Specific flavor fermented milk |
| Tissue conditions | Serum separation of a small amount accepted, Delicate and a homogeneous Tissue |
| Physical and chemical conditions | |
| Items | Requirements |
| Fat (g/100 g) | 3.1 |
| Nonfat solids (g/100 g) | 8.1 |
| Protein (g/100 g) | 2.9 |
| Acidity ($^o$T) | 70.0 |
| Microbial conditions | |
| Coliforms | n=5, c=0, m=1, M=5 |
| *Staphylococcus aureus* | n=5, c=0, m=0/25 g (mL), M=5 |
| *Salmonella* | n=5, c=0, m=0/25 g (mL), M=5 |
| Yeast | 100 |
| Mold | 30 |
| Lactic acid bacteria | $1\times10^6$ |

are divided into homogeneous color, milky white, or slightly yellow, respectively; the separation of small amounts is allowed. Physical and chemical conditions include fat and non-fat solids and protein were defined as at least 3.1 g/100 g, 8.1 g or more, and 2.9 g or more. The acidity must be less than 70.0$^o$T. In the case of coliform microorganism conditions relative to the allowable value, less than 1 CFU/mL *Salmonella* and 25 CFU/mL of *S. aureus* should be detected. Yeast and fungi counts were, respectively, less than 100 CFU/ mL and 30 CFU/mL and lactic acid bacteria levels were greater than $1\times10^6$ CFU (SAC, 2010a).

### Vietnam dairy standards

Standards for fermented milk were announced in Vietnam in 2010 standard No. 5-5 of national technical regulations for fermented milk processing. The regulations for dairy products define standards for milk and fermented milk. Fermented milk does not change or replace a specific component of the milk, and can be manufactured in a manner in which fermentation and the actions of microorganisms reduce the pH and show no product solidification. Standards related to food safety for the fermentation of dairy products in Vietnam describe maximum standard values as well as criteria for physicochemical standards for microbial contaminants (Table 3). The physicochemical basis of protein content of fermented milk products are not subjected to a heat treatment of milk and should be at least 2.7%. There are limits on pollutants, heavy metals, mycotoxins, melamine, veterinary drugs, and pesticide residues. The microbial fermentation of milk products standardizes the rough heat treatment enteric bacteria fermentation product based on the accepted standard microorganism value of 1 CFU/g and *L. monocytogenes* should be less 100 CFU/g. In non-fermented milk products that undergo heat treatment, *L. monocytogenes* must be lower than 100 CFU/g.

## Safety analysis according to standardization of dairy products

### Microbiological experiments

In the safety evaluation index for exported powdered yogurt, microbiological factors were selected for LAB counts, total bacterial counts, coliforms group counts, *S. aureus*, *L. monocytogenes*, and *Salmonella* species, and

**Table 3. Vietnam fermented milk standards**

| Items | Powdered milk | Skim milk | Cream powder | Serum separation powder |
|---|---|---|---|---|
| Moisture | 5.0 or less | 5.0 or less | 5.0 or less | 5.0 or less |
| Protein | 34.0 or less | 34.0 or less | 34.0 or less | - |
| Milk fat | More than 26.0 42.0 or less | 1.5 or less | 42.0 or less | More than 12.5 (exclude products with raw skim milk) |
| Enterobacteriaceae | n=5, c=0, m=10 CFU/ g, M=- | | | |
| coagulase-positive Staphylococci | n=5, c=2, m=10 CFU/ g, M=100 CFU /g | | | |
| *Staphylococcus aureus* toxin | n=5, c=0, m=25 g should not be found within, M=- | | | |
| *Listeria monocytogenes* | n=5, c=0, m=100 CFU/g, M=100 | | | |
| *Salmonella* | n=5, c=0, m=25g should not be found within, M=- | | | |

**Table 4. Safety evaluation results**

| Items | Results |
|---|---|
| Lactic acid bacteria counts (Log CFU/mL) | 6.24±0.33 |
| Total bacterial counts (Log CFU/mL) | 6.02±0.12 |
| Coliforms group counts (Log CFU/mL) | N.D[1)] |
| *Staphylococcus aureus* (Log CFU/mL) | N.D |
| *Listeria monocytogenes* (Log CFU/mL) | N.D |
| *Salmonella* sp. (Log CFU/mL) | N.D |
| Aflatoxin (ppb) | N.D. |
| Acidity (°T) | 352.28±10.24 |
| pH | 4.28±0.01 |

[1)] Not Detected.

aflatoxin. The results of microbiological experiments are shown in Table 4.

### LAB counts

In Korea and Vietnam, there are no standards for the number of LAB in fermented milk and fermented milk powder. China set a standard of $1\times10^6$ CFU/mL in fermented milk. LAB results in powdered yogurt after manufacturing was 6.24±0.33 Log CFU/mL, satisfying the standard for LAB.

### Total bacteria counts

For domestic fermented milk powder in Vietnam and China, fermented milk, based on the total number of bacteria, did not meet the standards. Milk flow in China was n=5, c=2, m=50,000, and M=200,000. Experimental results for the total number of bacteria (6.02±0.12 Log CFU/mL) did not satisfy the standard for total bacterial count. The standard for LAB was $1\times10^6$ CFU/mL; however, meeting this standard would result in exceeding the standard for the total number of bacteria. Therefore, it may be useful to have no specific standards for the total number of bacteria in powdered yogurt.

### Coliform group counts

Standards for the domestic fermented milk powder for *E. coli* were n=5, c=2, m≤3, and M=10. In China and Vietnam, fermented milk values for enteric bacteria were n=5, c=2, m=1, M=5. *E. coli* was not detected in powdered yogurt, satisfying the standard.

### *Staphylococcus aureus*

Domestic fermented milk powder did not meet the standards. In the Chinese fermented milk, values were n=5, c =0, m=0/25 g/mL, and M=5, milk flow was n=5, c=2, m= 10, and M=100, the standards for the Vietnamese formula were n=5, c=2, m=10, and M=100. Experimental results of the prepared powdered yogurt *S. aureus* did not satisfy the standards.

### *Listeria monocytogenes*

There are no standards for *L. monocytogenes* for domestic, Chinese, and Vietnamese fermented milk with respect to *L. monocytogenes*, for which n=5, c=0, m=100 CFU/g, M=100, and set the standard to 100 CFU/g. *L. monocytogenes* was not detected in preparations of powdered yogurt, satisfying the standards.

### *Salmonella* species

For domestic and Vietnam yogurt, there are no standards for *Salmonella* counts, while the standards in Chinese fermented milk are n=5, c=0, m=0/25 g/mL, and M= 5. The results for the preparation of powdered yogurt showed that *Salmonella* was detected at acceptable levels.

### Aflatoxin

In Korea and China, there are no standards for aflatoxin counts, while in Vietnam, aflatoxin levels in fermented milk should be less than 0.05 ppb in manufactured powdered yogurt.

### Physicochemical experiment

To determine physicochemical indicators of safety assessment for the export of powdered yogurt, pH, and acidity was evaluated (Table 4).

### pH

There are no standards for pH in the domestic and export destinations, including China and Vietnam. However, pH was measured to ensure that the powdered yogurt product showed a pH of 4.2, which is typical of fermented milk in water. A pH of 4.28±0.01 revealed that to the value was generally similar to the pH of fermented milk.

### Acidity

Korea and Vietnam do not have set standards for acidity. In China, the pH of the fermented milk should be more than 70°T. The pH experiments for prepared powdered yogurt followed the experimental pH regulations in China GB5413.34-2010, and the results were within the satisfactory standards of 352.38±10.24°T.

In summary, we conducted safety testing of stored yogurt powder, and fermented milk was found to comply with the standard of Korea, China, and Vietnam. This study is expected to provide a basis for the creation and export of storage yogurt powder to the export destination station.

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