

Research Article

Experimental Study of Microwave Sterilizing Pathogenic Microbes in Tofu

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Abstract: Sterilization is an important method to defend deterioration, moldy, rancid of Tofu. Tofu with different thickness is treated by microwave; the treated samples were cultured in the laboratory and observed the killing of the pathogenic microbes in the Tofu. The results show that microwave has the function of killing microbes in Tofu, among them, the sterilizing effect on bacteria and mold is the best under the condition that the time of microwave treating is 10 min and the thickness of Tofu is 5 cm, the sterilization rate is 74.48 and 70.73%; the sterilizing effect on epiphyte and actinomycetes is the best under the condition that the time of microwave treating is 10 min and the thickness of Tofu is 10 cm, the sterilization rate is 85.65 and 83.25%.

Keywords: Experimental study, microbes, microwave sterilization, tofu

INTRODUCTION

Tofu is a high quality plant protein food and the gel product with three-dimensional network structure that soybean protein combined each other under the effect of coagulant. And it has been known for thousands of years in our country for its rich nutrition, unique flavor (Yang *et al.*, 2011). Tofu is full of human body's essential amino acids, oligosaccharides, unsaturated fatty acids, dietary fiber, lecithin, cephalic, calcium, phosphorus, iron and vitamins, nutritious and easy to digest (Li, 2004). However, nutrition, water activity, pH value of Tofu are suitable for microbial growth and reproduction, it is prone to spoilage and the shelf life is short, these greatly restrict the local characteristic food sales in different places and the scale of production, which is the problem expected to solve by manufacturers and consumers.

At present a large number of studies were carried on Tofu preservation and fresh-keeping, mainly focus on physical preservation and preservatives, research hot point lies in how to use broad-spectrum and high effect, low toxicity and natural method to optimize Tofu preservation conditions and prolong the shelf-life (Gao *et al.*, 2008; Yang *et al.*, 2013). But the chemical preservative has certain toxicity and limited to use. It is very difficult to achieve the effect of prolonging the shelf life under low temperature sterilization and high temperature sterilization will change the nutritional ingredients (Zhang and Wang, 2012). Studies Meixu *et al.* (2009) show that the primary microbes are bacteria, yeast and molds in Tofu. As long as these primary microbes are killed, the fresh Tofu shelf life can be extended. Microwave has a very good sterilization effect on these microbes (Geng *et al.*,

2013a, 2013b), the pulse electric field and microwave are applied to the dried Tofu sterilization (Qi *et al.*, 2015) and good effect is got. Therefore, at the view of process, microwave sterilization effect on Tofu is explored through experiment, theoretical support of microwave sterilization application in Tofu fresh-keeping is provided.

MATERIALS AND METHODS

Material: Culture medium Potato Dextrose Agar (PDA) culture medium: potato 200 g, water 1000 mL, glucose 10 -20 g, agar 17-20 g; beef extract peptone medium: beef extract 5 g, peptone 10 g, sodium chloride 5 g, agar 20 g, water 1000 mL, pH7.0-7.2; Gauseme culture medium: Soluble starch 2 g, KNO₃ 0.1 g, K₂ HPO₄ 0.05 g, MgSO₄ ·7H₂O 0.05 g, NaCl 0.05 g, FeSO₄ ·7H₂O 0.001 g, agar 2 g, water 100 mL, pH 7.2-7.4.

Instrument: Microwave sterilizer (2450 MHz), maximum power is 500W, single sterilization area is 5×10⁻²m² (0.1 m×0.5 m).

Method: Sampling and Sterilizing take the fresh Tofu (the thickness is 5, 10 and 20 cm, respectively) and sterilized by microwave, the processing time is 3, 5, 10 min, respectively, repeat 3 times and the no sterilized as CK.

Microbes separated: Separated Fungi, bacteria, actinomycetes and mold take 10 g Tofu, mash them and load into the sterilized triangular flask filled with 100 mL aqua sterilisata, prepare into suspension, then put on shaking table with 150 r/min and shaking 20 min at

Table 1: Sterilization effects of fungi in Tofu by microwave

| Processing time/min | Thickness of Tofu | | | | | |
|---------------------|-----------------------|--------------------|-----------------------|--------------------|-----------------------|--------------------|
| | 5 cm | | 10 cm | | 20 cm | |
| | Total bacterial count | Sterilizing rate/% | Total bacterial count | Sterilizing rate/% | Total bacterial count | Sterilizing rate/% |
| 3 | 133 | 60.06±2.75a | 200 | 57.10±2.43a | 200 | 50.00±2.67a |
| 5 | 133 | 60.06±3.04a | 267 | 42.83±2.30a | 200 | 50.00±2.9a |
| 10 | 67 | 79.88±3.78b | 67 | 85.65±3.56c | 133 | 66.75±3.21b |
| 0(CK) | 333 | - | 467 | - | 400 | - |

Different letters mean significant differences at 0.05 levels

Table 2: Sterilization effects of bacteria in Tofu by microwave

| Processing time/min | Thickness of Tofu | | | | | |
|---------------------|-----------------------|--------------------|-----------------------|--------------------|-----------------------|--------------------|
| | 5 cm | | 10 cm | | 20 cm | |
| | Total bacterial count | Sterilizing rate/% | Total bacterial count | Sterilizing rate/% | Total bacterial count | Sterilizing rate/% |
| 3 | 1.6×10 ³ | 44.06±1.56a | 3.45×10 ³ | 24.51±0.98a | 3.73×10 ³ | 22.45±0.83a |
| 5 | 1.37×10 ³ | 52.10±2.08b | 2.97×10 ³ | 35.01±1.75b | 3.32×10 ³ | 30.98±1.12b |
| 10 | 0.73×10 ³ | 74.48±3.21c | 1.47×10 ³ | 67.83±3.17c | 2.13×10 ³ | 55.72±1.89c |
| 0(CK) | 2.86×10 ³ | - | 4.57×10 ³ | - | 4.81×10 ³ | - |

Different letters mean significant differences at 0.05 levels

Table 3: Sterilization effects of actinomycetes in Tofu by microwave

| Processing time/min | Thickness of Tofu | | | | | |
|---------------------|-----------------------|--------------------|-----------------------|--------------------|-----------------------|--------------------|
| | 5 cm | | 10 cm | | 20 cm | |
| | Total bacterial count | Sterilizing rate/% | Total bacterial count | Sterilizing rate/% | Total bacterial count | Sterilizing rate/% |
| 3 | 200 | 33.50±1.26a | 267 | 33.25±1.5a | 600 | 30.80±0.97a |
| 5 | 200 | 33.50±1.02a | 267 | 33.25±0.92a | 533 | 38.41±1.19b |
| 10 | 67 | 74.91±3.48b | 67 | 83.25±3.85b | 267 | 69.20±2.86c |
| 0(CK) | 267 | - | 400 | - | 867 | - |

Different letters mean significant differences at 0.05 levels

room temperature. After 10 min, take 1 mL and load into the test tube with 9 mL aqua sterilisata and mix well. Dilute by the gradient, prepare a series of mass concentration diluent. Take 0.2 mL suspension that dilutions are 10⁻⁴, 10⁻⁵, 10⁻⁶, spread on PDA medium plate and separate fungi and mold, spread on beef extract peptone medium plate and separate bacteria, spread on Gausserime culture medium plate and separate actinomycetes. The culture plates are inverted and cultured in biochemical culture box at 26°C and after 2 days, the bacteria were observed and counted. After 4 days, Fungi and actinomycetes were observed and counted.

RESULTS AND ANALYSIS

Sterilization effects of fungi in Tofu by microwave:

It can be seen from Table 1 that sterilizing rate for fungi is the highest and reached to 60.06% when processing time by microwave is 3 min and 5 min for 5 cm thickness Tofu; sterilizing rate is the highest and reached to 85.65% when processing time by microwave is 10 min for 10 cm thickness Tofu and that sterilizing rate when processing time by microwave is 10 min is significantly higher than sterilizing rate when processing time by microwave is 3 min and 5 min.

Sterilization effects of bacteria in Tofu by microwave:

It can be seen from Table 2 that sterilizing rate for bacteria is the highest and reached to 44.06, 52.10 and 74.48%, respectively when processing time by microwave is 3, 5 and 10 min, respectively for 5cm thickness Tofu, the thickness is more, the sterilization effects is worse; it can be seen that the processing time is longer, the sterilization effects are better, the sterilization effects are the best when processing time by microwave is 10 min for 5, 10 and 20 cm, respectively thickness Tofu, the sterilizing rate is 74.48, 67.83 and 55.72%, respectively.

Sterilization effects of actinomycetes in Tofu by microwave:

It can be seen from Table 3 that the sterilization effects for actinomycetes are the best when processing time by microwave is 10 min, among them the sterilizing rate is the highest and reached to 83.25% for 10 cm thickness Tofu. There have certain sterilization effect for actinomycetes when processing time by microwave is 3 min and 5 min, the sterilizing rate for actinomycetes is no difference for 5 cm and 10 cm thickness Tofu.

Sterilization effects of mold in Tofu by microwave:

It can be seen from Table 4 that sterilizing rate for mold is the highest and reached to 40.00, 48.00 and 70.73%,

Table 4: Sterilization effects of actinomycetes in Tofu by microwave

| Processing time/min | Thickness of Tofu | | | | | |
|---------------------|-----------------------|--------------------|-----------------------|--------------------|-----------------------|--------------------|
| | 5 cm | | 10 cm | | 20 cm | |
| | Total bacterial count | Sterilizing rate/% | Total bacterial count | Sterilizing rate/% | Total bacterial count | Sterilizing rate/% |
| 3 | 27 | 44.00±1.35a | 32 | 28.89±1.24a | 35 | 22.22±0.89a |
| 5 | 24 | 48.00±1.30b | 33 | 34.00±1.31b | 35 | 30.00±1.17b |
| 10 | 12 | 70.73±2.86C | 17 | 58.54±2.54c | 22 | 46.34±2.21c |
| 0(CK) | 45 | - | 50 | - | 41 | - |

Different letters mean significant differences at 0.05 levels

respectively when processing time by microwave is 3, 5 and 10 min, respectively for 5 cm thickness Tofu, the thickness is more, the sterilization effects is worse; it can be seen that the processing time is longer, the sterilization effects are better, the sterilization effects are the best when processing time by microwave is 10 min for 5 cm, 10 cm and 20 cm thickness Tofu, the sterilizing rate is 70.73, 58.54 and 46.34%, respectively.

CONCLUSION

Good effects were obtained by microwave sterilizing microbes in fresh Tofu. The sterilization effects are best (the sterilizing rate is higher than 70%) for Fungi, bacteria, actinomycetes and mold when processing time is 10 min by microwave sterilizing different thickness Tofu, which is in line with expectation. Among which the sterilization effects for Fungi and actinomycetes in 10 cm thickness Tofu is better than those in 5 cm and 20 cm thickness Tofu, the sterilization effects for bacteria and mold in 5 cm thickness Tofu is better than those in 10 cm and 20 cm thickness Tofu. It can be found that the difference of sterilization effects is not obvious when processing time is 3 min and 5 min; the difference of sterilization effects is obvious when processing time is 5 min and 10 min, which may be caused by microwave energy accumulating. There have sterilization effects for pathogenic microbes in different thickness Tofu, which show that microwave sterilizing thickness at least 20 cm.

The results show that microwave sterilization effects are good on most pathogens microbes in Tofu and the microwave sterilization effects are obvious for fresh Tofu with thickness of 20 cm, the method of

microwave sterilization is an efficient, environmental, no pollution and no residual method.

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