A study investigating the effects of radiation sterilization on spirulina polypeptide powder

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OBJECTIVE: To determine the optimal radiation dose and observe the influence of radiation sterilization on spirulina polypeptide powder.
METHODS: The polypeptide powder of spirulina was sterilized using a ^{60}Coγ ray.
RESULTS: Radiation sterilization had significant effects on spirulina polypeptide powder, which was more effective with increasing radiation dose. Taking the sterilization rate and peptide content into account, the most effective radiation dose for sterilization was 9 kGy.
CONCLUSION: Reasonable conditions for sterilization have the effect of sterilization on spirulina polypeptide powder.

Key Words: *Polypeptide powder; Radiation; Spirulina; Sterilization*

Spirulina polypeptide is a fine powder made from spirulina, which contains various proteins and abundant nutrimental substances. It is prone to bacteria growth while undergoing production and storage. However, due to its known characteristic of moisture absorption and mutability under high temperatures, classical high-temperature and moist-heat sterilization is not suitable. In the present study, a ^{60}Coγ ray was used for the sterilization of spirulina polypeptide, the optimal radiation dose was determined, and the influence of the radiation sterilization on the spirulina polypeptide powder was observed.

METHODS

Materials

Spirulina powder was obtained from tissue fluid, which was freeze-dried after being treated using a physical method.

Radiation equipment

The 1.6×10^5 Bq ^{60}Coγ radiation equipment was placed 42.6 cm above the floor. A Fricke dosimeter and a Fammer instrument were used to measure the dose of the radiation field, and the experimental doses tested were 1 kGy, 3 kGy, 6 kGy, 9 kGy and 12 kGy, with dose rates 3 Gy/s to 6 Gy/s.

Radiation method

The spirulina powder, sealed in bags with 10 g of powder in each, were placed in the radiation field at a height of 20 cm from the floor, centering around the radiation source in a circle with some distance. When the radiation dose reached 50%, the samples were rotated to ensure uniformity of the radiation dose.

Storage method

According to the requirements for storage and testing experiments, the sterilized spirulina polypeptide powder was stored in the laboratory fume hood at room temperature and air extraction was performed for 1 h every day. Appropriate amounts of the sample were tested to detect the microbial and peptide content on the 30th, 60th, 90th, 120th and 180th day; each sample was tested three times to obtain a mean value.

Microbial content test

The microbial content was detected according to the microbial limited test.

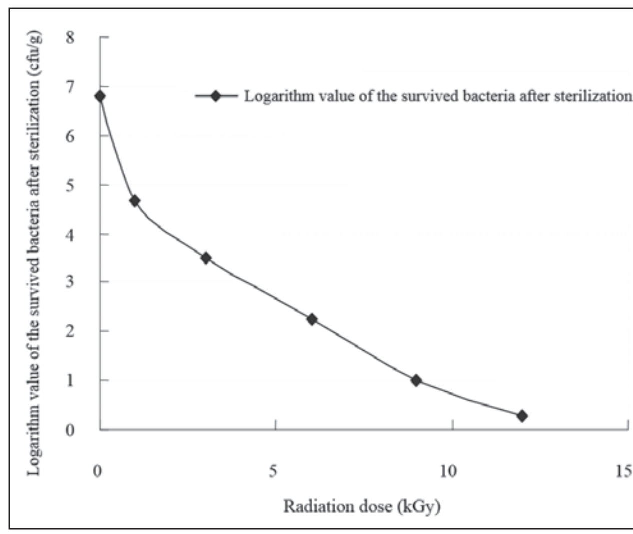

Figure 1) *Changes of the logarithm value of the surviving bacteria after sterilization using different radiation doses. cfu Colony forming units*

Peptide content test

The peptide content in the samples was determined in reference to the Lowry method.

Method of calculation

Sterilization rate (%) = (number of bacteria before sterilization – number of bacteria after sterilization) / number of bacteria before sterilization × 100%

RESULTS

Effects of sterilization using different radiation doses

The sterilization rate reached 99.10% to 100%, which indicated the remarkable effect of ^{60}Coγ radiation sterilization (Table 1). With an increasing dose of radiation, the sterilization rate increased and the logarithm value of the number of surviving bacteria after sterilization decreased (Figure 1).

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TABLE 1
Effect of sterilization on spirulina polypeptide powder using different radiation doses

Radiation dose, kGy	Bacteria, cfu/g Before sterilization	Bacteria, cfu/g After sterilization	Sterilization rate, %	Logarithm value of the number of surviving bacteria after sterilization
0.0	5.0×10^6	6.3×10^6	–	6.80
1.0	5.0×10^6	4.5×10^4	99.10	4.65
3.0	5.0×10^6	3.2×10^3	99.94	3.51
6.0	5.0×10^6	1.8×10^2	99.99	2.25
9.0	5.0×10^6	10.0	100.00	1.00
12.0	5.0×10^6	2.0	100.00	0.30

cfu Colony forming units

TABLE 2
Influence of radiation sterilization on peptide content

Radiation dose, kGy	Peptide content, % Before sterilization	Peptide content, % After sterilization
0.0	23.81	23.68
1.0	23.78	23.06
3.0	23.84	22.35
6.0	23.49	21.69
9.0	23.92	21.28
12.0	23.23	19.34

TABLE 3
Number of bacteria at different time points of storage after radiation sterilization

Radiation dose, kGy	Time, days 30	60	90	120	180
0.0	8.9×10^6	9.7×10^6	1.9×10^7	3.7×10^7	9.4×10^7
1.0	6.2×10^5	8.5×10^5	1.4×10^6	3.1×10^6	4.4×10^6
3.0	7.4×10^3	9.6×10^3	2.1×10^4	4.9×10^4	8.5×10^4
6.0	3.5×10^2	7.1×10^2	1.7×10^3	1.9×10^3	2.1×10^3
9.0	30	2.0×10^2	4.3×10^2	5.9×10^2	8.4×10^2
12.0	20	1.2×10^2	3.1×10^2	4.8×10^2	7.6×10^2

Data presented as colony forming units/g

TABLE 4
Influence of the time of storage after radiation sterilization on peptide content

Radiation dose, kGy	Peptide content, % 30 days	60 days	90 days	120 days	180 days
0.0	22.98	21.35	20.29	17.85	15.21
1.0	21.69	20.74	19.67	17.04	15.16
3.0	21.03	19.21	18.63	16.23	15.02
6.0	20.19	19.03	18.45	17.19	14.34
9.0	20.10	18.98	18.31	17.05	14.33
12.0	18.93	17.82	16.93	16.22	13.93

Influence of ^{60}Coγ radiation at different doses on the peptide content in spirulina polypeptide powder

After exposing the samples to different ^{60}Coγ radiation doses, the peptide content decreased, but it was not significantly different from before radiation (Table 2). With an increase in radiation dose, the peptide content decreased (Figure 2).

Changes in the number of surviving bacteria after radiation sterilization and storage

After the radiation sterilization, the number of bacteria increased after a period of time in storage. The number of bacteria decreased with increasing radiation dose (Table 3 and Figure 3).

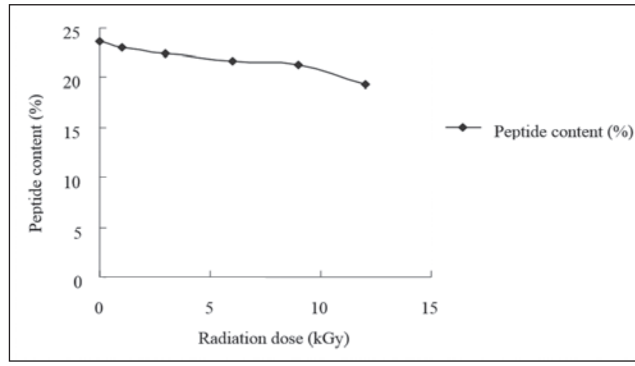

Figure 2) *Influence of radiation sterilization on the peptide content*

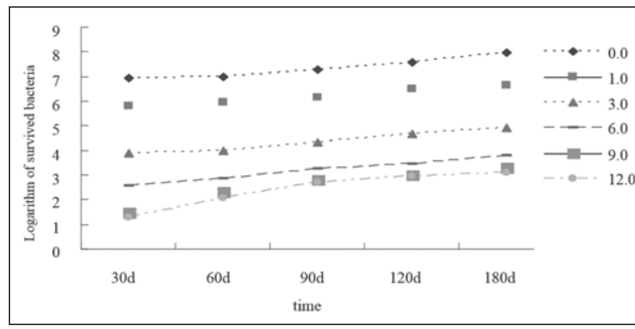

Figure 3) *Logarithm value of the number of surviving bacteria after radiation sterilization. d Days*

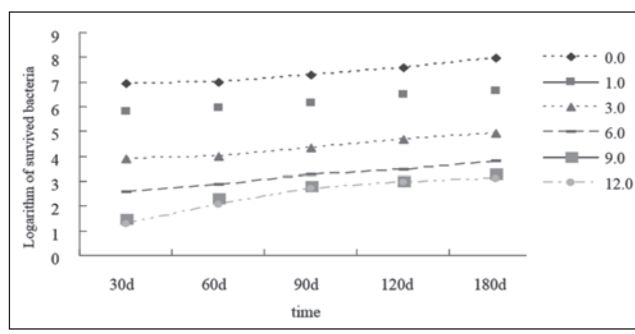

Figure 4) *Peptide content after radiation sterilization at different time points. d Days*

Changes in peptide content in spirulina polypeptide powder after radiation sterilization and storage

After radiation, with an increasing amount of time spent in storage, the peptide content of the samples decreased (Table 4 and Figure 4).

DISCUSSION

Research shows that spirulina polypeptide products have abundant physioactive substances, such as amino acids and polypeptides (1), which produce effects that include eliminating tiredness, accelerating metabolism, enhancing immunity and delaying skin aging (2-4). Spirulina polypeptide powder is prone to bacterial growth while undergoing the production and storage of spirulina products; therefore, it is important to sterilize and keep active substances from destroying it.

The radiation produced by radioactive ^{60}Coγ can kill bacteria directly or indirectly and, in addition, it provides the following advantages: it can sterilize products thoroughly, without producing pollution and residual toxicity, in addition to not inducing radioactivity; sterilization can be performed at room temperature, namely cold sterilization, which will not affect the components of traditional Chinese medicine; the product can be sterilized after packaging without secondary pollution; it can be stored for prolonged periods of time if the packaging is bacteria-proof; it is suitable for continuous production of either large or small amounts; and it is energy saving, with low costs associated with its use (5).

We used the $^{60}CO\gamma$ ray for the sterilization of spirulina powder and the results reveal that the effect is remarkable. As the radiation dose increased, the effects of sterilization increased. When the radiation dose was 9 kGy and 12 kGy, the sterilization rate can reach 100%, and the peptide content of the spirulina powder does not change significantly compared with before the radiation sterilization. With the increase of the radiation dose, the peptide content decreases, especially when the dose is 12 kGy. Storage time also affects bacterial number and peptide content of the spirulina powder to some extent. The results of the present study demonstrate that peptide content decreases with an increase in the number of days in storage; and the larger the dose of radiation, the longer the shelf life is. Taking the sterilization rate and peptide content into account, the most effective dose of radiation sterilization was 9 kGy.

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