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Shelf life of irradiated minimally processed (MP) watercress (*Nasturtium officinale*)

Vida-de-prateleira de agrião (Nasturtium officinale) minimamente processado e exposto à irradiação

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Abstract

This study was carried out to evaluate the shelf life of minimally processed (MP) watercress exposed to gamma radiation with doses of 1.0; 3.0; 4.0 kGy. Packaged irradiated and non-irradiated MP watercress was subject to sensory analysis. A panel consisting of 25-30 non-trained members, aged 20-55 years, was used. Sensory evaluation was carried out on days 0, 2, 5, 7, 9 and 12 after treatment with packages maintained at 7 °C. The members of the panel rated each sample for overall liking on a hybrid 10 hedonic scale (0 = extremely dislike; 10 = extremely like). Microbiological analyses were also conducted. Compared to the non-irradiated sample, 1 kGy irradiated watercress increased its shelf life by one day (16 days). Shelf lives of samples exposed to higher doses were reduced to 9 days (3 kGy) and 6 days (4 kGy) due to changes in appearance. The microbiological quality was good throughout the experiment.

Keywords: watercress; vegetable irradiation; acceptance test.

Resumo

Este estudo foi desenvolvido para avaliar a vida de prateleira de agrião minimamente processado exposto a doses de 1,0; 3,0 e 4,0 kGy. Amostras de agrião não irradiadas e irradiadas foram submetidas à análise sensorial. Um painel composto por 25-30 membros não treinados e idade entre 20 e 55 anos foi utilizado. A avaliação sensorial foi realizada nos tempos 0, 2, 5, 7, 9 e 12 após o tratamento com radiação, utilizando embalagens mantidas sob refrigeração (7 °C). Os provadores avaliaram cada amostra utilizando a escala hedônica híbrida de 10 cm (0 = desgostei muitíssimo; 10 = gostei muitíssimo). Em paralelo foram realizadas análises microbiológicas. A amostra de agrião irradiada com 1 kGy apresentou vida de prateleira de 16 dias, um dia a mais que a da amostra testemunha. Por outro lado, amostras expostas a doses de 3 e 4 kGy apresentaram vida de prateleira menor, com 9 dias e 6 dias, respectivamente. A qualidade microbiológica do produto permaneceu adequada durante o experimento.

Palavras-chave: agrião; irradiação de vegetais; teste de aceitação.

1 Introduction

Minimally processed fruits and vegetables (MPFV) contain no preservatives and rarely undergo treatments such as washing or heating before consumption. The inefficacy of the sanitizers used makes the decontamination of raw fruit and vegetables difficult. Research carried out in our lab has shown the presence of *Salmonella* spp. and *Listeria monocytogenes* in MP watercress and spinach, respectively[16]. Other authors[4,6,12] have already reported the presence of *L. monocytogenes*, *Salmonella* spp., *Shigella* spp., *Aeromonas hydrophila* and other pathogenic microorganisms on fresh fruit and vegetables as well as in the related MP refrigerated products. According to BEAN et al.[3], the number of documented outbreaks of human diseases associated to the consumption of raw and MP fruit and vegetables has considerably increased in recent decades. Outbreaks involving *Salmonella* and tomato, as well as *Salmonella* and cantaloupe have just been reported (Promed week 12-19 July).

Therefore, the microbiological safety of MP vegetables needs to be improved and the use of irradiation has been proposed. Besides improving the safety of this kind of food, irradiation can also extend its shelf life. The action of ionizing radiation upon microorganisms is well known, though changes in sensory attributes of vegetables and fruit should be evaluated, if industries intend to submit these products to an irradiation process.

NIEMIRA et al.[20] showed that doses up to 0.5 kGy do not significantly change the texture of four different varieties of lettuce. FOLEY et al.[10] and HAGENMAIER and BAKER[13] did not observe any changes in the appearance and texture of iceberg lettuce irradiated at 0.15-0.5 kGy. However, when exposed to 0.81 kGy, there was a change in the texture of the vegetables[13].

The shelf life of a food can be defined, according to ELLIS[9], as the time between the production and packaging of the product and the point at which it becomes unacceptable under defined environmental conditions. It can be determined by carrying out simultaneously chemical, physical, microbiological and sensory controls according to a predefined experimental design.

Sensory studies should be carried out to evaluate the influence of processing on the quality of irradiated minimally processed fruits and vegetables by either trained or untrained judges. Consumers' perception and attitude are important when determining the sensory quality of a product. In these cases, the visual quality of the product is evaluated as well as the texture, consistency, odour and flavour. The endpoint of the shelf life is when the overall quality has fallen below the threshold of marketability under refrigeration. This can be measured by a hedonic nine point scale that evaluates how much consumers "like" or "dislike" the product at different times of storage[17].

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**A quem a correspondência deve ser enviada*

BISHOP et al.[5] proposed a criterion to define the end point of a product, based on scores equal or less than mark 5 in a nine-point hedonic scale given by 3 members of the panel. The day after the test is administered is considered as the last day of shelf life. A score of 5 corresponds to the neutral point of the scale (like or dislike). Below 5, the food product is considered as rejected by the consumer.

In this research, the effects of gamma radiation on minimally processed watercress were evaluated through microbiological and sensory evaluation of the product as a function of storage time.

2 Materials and methods

2.1 Materials

Minimally processed watercress (*Nasturtium officinale)* samples were acquired at a minimally processed produce plant located in São Paulo city - SP, Brazil, on the day of processing. The vegetables were submitted to minimal processing that consist in selection, cutting, washing and sanitization with 200 ppm of chlorine water within 24 hours of harvesting.

2.2 Methods

Sensory evaluation of irradiated minimally processed watercress

Irradiation source

Samples were irradiated using a gamma radiation ^{60}Co source (JS 7500 MDS Nordion, Kanata, Canada) with 25.5 PBq (690 kCi). The dosimetric system used was the Harwell red perspex (United Kingdom) dosimeter. The accuracy is ± 5% and the precision ± 2%.

Polyethylene packages each containing 400 g of minimally processed watercress were exposed to 1.0, 3.0 and 4.0 kGy. These samples plus a non-irradiated control were kept at 7 ± 1 °C during the period of analysis.

Microbiological quality of irradiated minimally processed watercress

The microbiological quality of samples submitted to sensory tests was evaluated. As requested by Brazilian legislation (RDC 12 Health Department - Brazil, 2001), the Most Probable Number (MPN) of faecal coliforms[15] and the presence of *Salmonella*[1] were performed. Other tests were done such as mesophilics[18] and psychrotrophics[8], and lactic acid bacteria[14]. All these analyses were performed by the time of the sensory evaluation and according to standard procedures.

Selection of members of sensory panel

Panel members aged between 20 and 55 years were selected among undergraduate and graduate students, as well as employees and lecturers belonging to the Faculty of Pharmaceutical Sciences staff – University of Sao Paulo using a standard questionaire (Figure 1). Members were selected taking into

Recruitment of Consumers

Sensory evaluation of Foods

We are selecting people in order to become a member of a panel to test irradiated minimally processed watercress. Panelists shall evaluate the appearance, flavor, taste and texture (consistency, softness, etc) of the product and express her (his) opinion about it. The results will be confidential and you are free to give up the team whenever you wish. The dates as well as the time will be established later on and the tests will last approximately 2 months. If you are interested in volunteering, please, answer the following questions:

Name:_____ Date:_____
Telephone : _____ E-mail: _____
1. Gender: ( ) male ( ) Female
2. Age:
( ) 21-25 years
( ) 25-30 years
( ) 31-34 years
( ) 35-44 years
( ) 45-54 years
( ) over 55 years
3. Educational background:
( ) University degree
( ) High school
( ) Junior school
( ) Primary school
4. Will you be at the University until December/2003?
( ) Yes ( ) No
5. Are there any weekdays (M-F) that you will not be available on a regular basiss?
Specify_____
6. How many times do you eat minimally processed watercress?
( ) daily
( ) 2 to 5 times a week
( ) once a week
( ) occasionally (less than once a week)
( ) never tasted it
7. If you have already tasted minimally processed watercress, please point out e how much you like or dislike the product
9. like extremely
8. like very much
7. like moderately
6. like slightly
5. neither like, nor dislike
4. dislike slightly
3. dislike moderately
2. dislike very much
1. dislike extremely
8. Do you have anyhealth problem at this moment?
If yes, please specify
_____
9. Are you using any medication?
If yes, please specify
_____
10. Are you currently on a restricted diet?
If yes, please specify
_____
11. Do you smoke? ( ) Yes ( ) No

Terms of Agreement:
I have understood the purpose of the test described in this form, and the information given by me here is true and I authorize the use of this information in the selection of the judges.

São Paulo, _____/_____/_____

Signature and ID number.

Figure 1. Recruitment questionnaire for the shelf life sensory study of irradiated minimally processed watercress.

consideration their ability to participate, health conditions and acceptance of the product.

Sensory acceptance test

Acceptance was assessed using a 10 hybrid hedonic scale (0 = extremely dislike; 10 = extremely like)[21] (Figure 2). The overall acceptance of samples was tested on days 0, 2, 5, 9 and 12 after treatment, according to the methodology proposed by ASTM[2]. Irradiated and non-irradiated minimally processed watercress samples were given to members of the sensory panel.

Sensory envaluation of irradiated minimally processed watercress

Name:_____ Date: ____/_____/ 2003.

You are receiving a coded irradiated minimally processed watercress sample. Season it with salt. Evaluate its appearance, odour, flavour, taste and texture (i.e. the sensation of chewing leaves and stalks) by marking from zero to ten on the scale below (using the gaps between dots as well), according to how much you liked it or disliked the sample.

Sample nº:_____

0___•___•___•___•___5___•___•___•___•___10

disliked extremely neither liked, nor disliked liked extremely

Comments:_____

Figure 2. Model of ballot used on the acceptance test of irradiated watercress samples.

The irradiated and non-irradiated watercress samples (10 g) were served on disposable white plates coded with a 3 digit number. Forks, salt, and water - to minimize the remaining flavour between samples - were also offered to the panelists. Samples were evaluated under a white light in individual booths in the Sensory Analysis Lab.

The panel members tested four different samples of minimally processed watercress on each day of sensory evaluation: one control (not exposed to irradiation), a sample exposed to 1.0 kGy, a sample exposed to 3.0 kGy and one sample exposed to 4.0 kGy.

Statistical analysis

Data were submitted to Regression analysis – SAS software (Release 6.11, SAS Institute, Inc., Cary, NC.)

3 Results and discussion

Table 1 shows the microbiological results during the shelf life study. The three doses to which the MP watercress samples were exposed (1, 3 and 4 kGy) reduced the mesophilic population by 3-5 $\log_{10}$ whereas the psychrotrophics and *Enterobacteriaceae* populations were reduced by 2-4 $\log_{10}$ and 1-3 $\log_{10}$, respectively. Lactic acid bacteria population was reduced by 1-4 $\log_{10}$. Faecal coliforms and *Salmonella* spp. were not detected throughout the experiment. The microbiological conditions of samples remained acceptable based on standard market tolerance for microbial counts throughout the shelf life study.

Table 1. Population (log CFU.g^{-1}) of mesophiles, psychrotrophic, *Enterobacteriaceae*, and lactic acid bactéria in irradiated minimally processed watercress (*Nasturtium officinale*) during shelf life at 7 ± 1 °C.

Microorganisms	Time* (days)	Doses			
		Control (0 kGy)	1 kGy	3 kGy	4 kGy
Mesophiles	0	4.15	1	1	1
	2	4.7	1	1	1
	5	4.59	1	1	1
	7	3.6	1	1	1
	9	3.2	1	1	1
	12	5.65	2.45	1	1
Psychrotrophic	0	4.89	2	2	2
	2	5.54	2	2	2
	5	6.25	2	2	2
	7	6.41	2	2	2
	9	6.04	3.87	2	2
	12	6.75	2	2	2
Enterobacteriaceae	0	2.11	1	1	1
	2	1	1	1	1
	5	1	1	1	1
	7	4.23	1	1	1
	9	3	1	1	1
	12	3	1	1	1
Lactic acid bacteria	0	3.2	1	1	1
	2	2.79	1	1	1
	5	3.45	1	1	1
	7	2.63	1	1	1
	9	2.43	1	1	1
	12	5.04	1	1	1

Our results are compatible with those by GOULARTE and OTHERS[11] who observed that doses of 0.7, 0.9 and 1.1 kGy reduced in 2-3 $\log_{10}$ the population of mesophiles presented on minimally processed cut iceberg lettuce. After having been stored at 5 °C for 3 days, the population was 1-2 $\log_{10}$. The same reduction was observed for the populations of *Enterobacteriaceae* and *Pseudomonas*.

Sensory attributes can change when vegetables are exposed to radiation. Colour and flavour were improved when carrots were irradiated whereas the texture worsened when compared to chlorine treatment 7. According to YU et al.[22], changes in texture are associated with the degradation of pectic substances due to irradiation.

All watercress samples, regardless of dose, were accepted by members of the panel on days 0, 2, and 5 (Table 2). Watercress exposed to 4 kGy was rejected on day 6 and samples irradiated with 3 kGy were refused on day 9 (Figure 3). Non-irradiated and irradiated with 1 kGy samples were accepted until day 12 (Table 2).

NIEMIRA et al.[20] showed that doses up to 0.5 kGy did not soften lettuce leaves of four varieties (Boston, Iceberg, Green

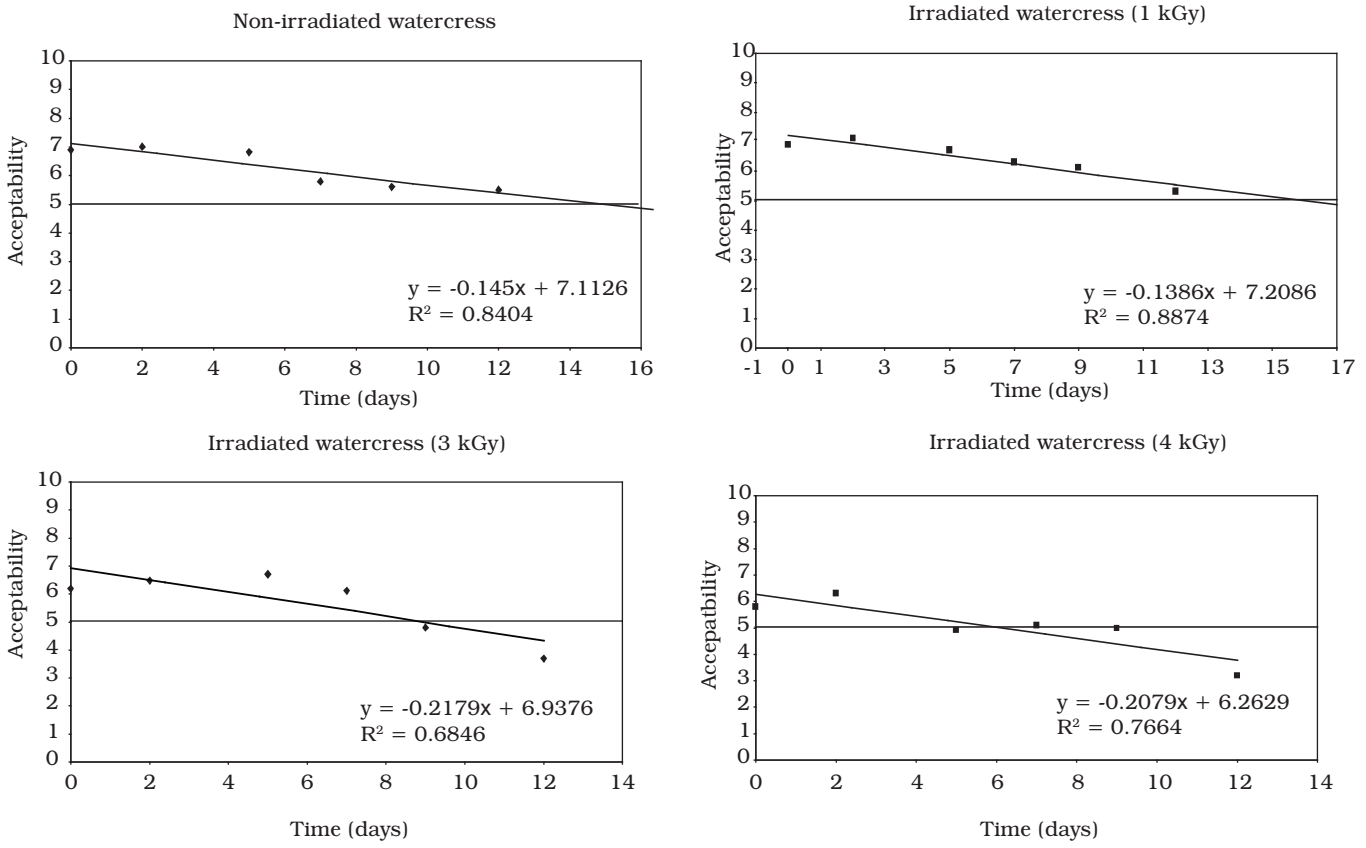

Figure 3. Shelf life curves of non-irradiated and irradiated minimally processed watercress showing the decrease of acceptability over time at 7 °C.

Table 2. Acceptance mean scores of the non-irradiated and irradiated watercress samples during storage at 7 °C.

kGy	Time* (days)					
	0	2	5	7	9	12
0	6.9[a]	7.0[a]	6.8[a]	5.8[a]	5.6[a]	5.5[a]
1	6.9[a]	7.1[a]	6.7[a]	6.3[a]	6.1[a]	5.3[a]
3	6.2[a]	6.5[a]	6.7[a]	6.1[a]	4.8[b]	3.7[b]
4	5.8[a]	6.3[a]	4.9[b]	5.1[a]	5.0[a]	3.2[b]

*Hedonic scale of 1 (completely unacceptable) to 9 (completely acceptable). Rejection cutoff was 5. [ab]Mean scores in a column (day) with the same letter do not differ significantly ($p > 0.05$), according to the Tukey means comparison test.

Table 3. Linear Regression analysis of sensory acceptance as a function of time for non irradiated and irradiated watercress.

kGy	slope	intercept	r	SS[a]	MS[b]	p[c]
0	-0.139	7.09	-0.91	51.710	51.710	0.003
1	-0.145	7.25	-0.94	55.907	55.907	0.002
3	-0.213	6.94	-0.83	121.87	121.87	0.000
4	-0.207	6.28	-0.88	114.41	114.41	0.000

[a]squared sums; [b]mean squared sums; and [c]probability level.

Leaf and Red Leaf). FOLEY and OTHERS[10] and HAGENMAIER and BAKER[13] did not observe changes in visual characteristics nor in the texture of iceberg lettuce exposed to doses between 0.15-0.5 kGy. NIEMIRA et al.[19] noted no impact on the endive's texture or color when exposed to 0.8 kGy.

The shelf life of minimally processed watercress irradiated with 1 kGy and stored at 7 ± 1 °C increased by one and half days when compared to the non irradiated sample. The shelf lives of samples exposed to 3.0 and 4.0 kGy were shortened by 8 and 5 days, respectively (Table 2, Figure 3). The linear regression analysis of sensory acceptance as a function of time for non irradiated and irradiated watercress corroborates these findings (Table 3). The end point of the shelf life was determined by the appearance of stalks and leaves that became yellowish during the period of study.

4 Conclusion

Minimally processed watercress was sensorially accepted by the panelists when exposed to doses of 1, 3 and 4 kGy on day zero. The highest doses 3 and 4 kGy resulted in a reduction of their shelf life when compared to non-irradiated samples, especially because of changes on texture and appearance. On the other hand, the dose of 1 kGy besides improving the microbiological quality of watercress also increased its shelf life by one and half days when compared to the non-irradiated one samples.

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