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INFLUENCE OF UV RADIATION ON THE MICROBIOLOGICAL QUALITY OF ALOE PULP

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Key words: aloe, pulp, UV radiation, microflora, storage

The aim of performed researches was an evaluation of the influence of UV radiation usage on the population of microorganisms settling the aloe pulp. The research materials were leaves of a three-year aloe. The aloe pulp in two forms (with skin and without skin) was prepared according to the patent application P346068. Part of prepared pulp was subjected to analyses before being exposed to the UV radiation process, while the other part was divided and treated with UV radiation with a range of 240–280 nm for 10 and 20 min. Microbiological analyses were performed on raw pulp before irradiation, in pulp exposed to irradiation (1 day after irradiation) and 30 days of storage. In the researched material the total counts of mesophile bacteria, total counts of *Staphylococcus aureus* and total counts of yeasts and fungi were determined. The study demonstrated an increase in the numbers of coagulase positive and coagulase negative *Staphylococcus aureus* after 30 days of storage of a preserved homogenate at ±4°C. After a 30-day storage period of preserved homogenate with skin and without skin there was observed an increase of mesophilic microflora population from values of 3.11 and 2.47 log cfu/g to 7.48 log cfu/g in both cases. The number of yeasts living in the aloe pulp with skin and without skin, after being subjected to the process of preservation and storage for the period of 30 days, increased from about 1.5 to 5 logarithmic cycles. During the 30-day storage period of UV preserved aloes pulp it was observed that there was a significant overgrowth of researched homogenate by the population of shred fungi.

INTRODUCTION

In the last few years it has been observed that the consumers' awareness on food products – in relation to choice of food products – has been constantly growing. That is mainly connected with the process of production, as well as food storage conditions. Consumers are willingly reaching for products with reccommended nutritious value, as well as good quality. Products chosen by consumers often contain natural plant supplements, *e.g.* small parts of plants. All products received in the process of preserving fruit and vegetables, serving as additives to dairy preserves, received by traditional methods of fermentation (pasteurization, sterilization), were of good microbiological quality but of diminished nutritive and sensory quality, *i.e.* changed colour, taste and low vitamins value [Guerrero-Beltrn, 2004; Kowalska, 2006]. Nowadays, the industrial food producers are seeking alternative methods of preservation, *e.g.* high or reduced pressure, ultraviolet radiation, pulsed electric field which can be used instead of the earlier-mentioned thermal food processings. These technologies have been designed to produce safe food maintaining its nutritional and sensory qualities and most of the fresh attributes and its storage stability [Lado & Yousef, 2002; Janowicz, 2006].

The aim of the performed researches was to evaluate the influence of UV radiation used on the population of microorganisms living in the aloe pulp.

MATERIAL AND METHODS

The research materials were three-year-old aloe leaves (*Aloe arboresces*). A sample of 2000 g of leaves was rinsed in sterile distilled water, then dried and divided into two parts. The aloe pulp in two forms (with skin as well as without skin) was prepared according to the patent application P346068 [Steinka, 2003]. The first part of leaves with skin was subjected to homogenization process in the special device by Eldom, Poland. Aseptic conditions were kept during the homogenization process. One part of the prepared pulp was exposed to particular investigation before being treated with the UV radiation. The other part was being divided, spilled in thin layer and exposed to UV radiation with a range of 240–280 nm for 10 and 20 min. Having completed the process, all samples were put into sterile PE/PA bags. The bags were hermetically closed with a vacuum packing machine made by Severin and stored in cooling conditions (±4°C).

Microbiological analyses were performed in raw pulp before irradiation, in pulp exposed to irradiation (1 day after irradiation) and 30 days of storage. The researched material was determined for the total count of mesophilic bacteria on the nutrient agar medium (Merck), total count of *Staphylococcus aureus* on the Baird-Parker RPF medium (bioMerieux) and the count of yeasts and moulds on the agar YGC medium with a chloramphenicol (Merck). The incubation of mesophilic bacteria, *Staphylococcus aureus* and yeasts and moulds was carried at a temperature of 30°C for 72 h, 37°C for 48 h and at the 25°C for 120 h.

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Inoculation were performed in accordance to the Polish Standard [PN-90/A-75052/04].

RESULTS AND DISCUSSION

As a result of conducted investigations the increase in count of microorganisms populations settling in aloe pulp during the storage has been observed. The average degree of contamination of the homogenized fresh aloe pulp with skin by coagulase positive and coagulase negative *Staphylococcus aureus*, the mesophilic microflora and also yeasts and moulds showed adequatly: 1.78 log cfu/g, 4.16 log cfu/g, 3.11 log cfu/g, 2.60 log cfu/g and 3.93 log cfu/g. The average degree of contamination of the fresh aloe pulp homogenized without skin of the same micro-organisms showed relatively: 1.30 log cfu/g, 3.64 log cfu /g, 2.47 log cfu/g, 2.14 log cfu/g as well as 4.09 log cfu/g.

Test results showed that the time of UV radiation had an influence on the growth of micro-organisms settling in aloe pulp.

After a day of storage of the aloe pulp that was being preserved for 20 min the count of coagulase-positive *S. aureus* reduced in both: the aloe pulp with skin and without skin and amounted to about 0.5 and 1.3 log cycle (Table 1). In the aloe pulp preserved for 10 min no changes have been observed. Performed researches revealed that there is an increase of the number of coagulase-positive *S. aureus* in aloe pulp after 30 days of storage at 4°C preserved with UV radiation. The study revealed that in the aloe pulp with skin, stored for 30 days, the count of coagulase-positive *S. aureus* was higher by about 0.5 log cycles cycle than in aloe pulp without skin (Table 1). A probable cause of the presence of coagulase-positive *S. aureus* in the investigated material was the method of gaining leaves and their storage in the horticultural farm. The reduction of the count of coagulase-negative *S. aureus* was observed after 1 day of storage of aloe pulp with and without skin. The experimental results showed that the count of coagulase-negative *S. aureus* settled in aloe pulp with skin subjected to UV radiation for 10 and 20 min was reduced respectively from 4.16 log cfu/g up to: 4.01 log cfu/g, 2.54 log cfu/g. The population of coagulase-negative *S. aureus* settled in the aloe pulp with skin and without skin, exposed to UV radiation for 10 and 20 min decreased from 3.64 log cfu/g to: 2.38 log cfu/g and 2.34 log cfu/g (Table 2). An increase in the count of coagulase-negative *S. aureus* by approx. 1.7 log cycles (from 2.54 to 4.29 log cfu/g) and by approx. 1 log cycle (from 2.38 to 3.71 log cfu/g and from 2.34 to 3.48 log cfu/g) was noted in the homogenate with skin and without skin stored for the next 30 days (Table 2).

Performed researches indicate a significant growth of the count of mesophylic bacteria settling in the preserved aloe pulp during 30-days storage at 4°C (Table 3). After 1 day of storage the initial value was significantly exceeded in aloe pulp with skin preserved by UV radiation for 10 min (from 3.11 log cfu/g to 3.91 log cfu/g), and in aloe pulp without skin preserved for 20 min (by approx. 0.4 log cycle) (Table 3). In the aloe pulp without skin preserved by UV radiation for 10 min the reduction from the initial count included within the range of error (Table 4). The result of the performed researches showed that there was an increase of the count of mesophilic bacteria above 4.6 log cycles in aloe pulp preserved by UV radiation after another 30 days of storage at 4°C. The real value in each case exceeded 7.48 log cfu/g (Table 3).

The amount of yeasts settled in the aloe pulp with skin and without skin, subjected to preservation and storage for the period of 30 days, increased from approx. 2.5 log cfu/g in each case to 1.5-5 log cycles (Table 5). More favourable environment for yeasts growth was the homogenate with skin. In medicine examples of stimulating the growth of yeasts under UV radiation are well-known, which can also occur in the investigated material.

The examination revealed that there is a reduction of moulds count after 1 day of storage of aloe pulp. In the case of aloe pulp with skin subjected to UV radiation for 10 and 20 min the count of moulds decreased from 3.93 log cfu/g to 3.55 log cfu/g and 3.62 log cfu/g. However, in the pulp without skin the reduction was greater and amounted to

TABLE 2. Changes of the count of coagulase-negative *Staphylococcus aureus* during the storage of aloe preserved under ultraviolet light.

Storage time	Count of bacteria (log cfu/g)			
	AS		BS	
	230-280 nm			
	10 min	20 min	10 min	20 min
Control	4.16		3.64	
1 day	4.01	2.54	2.38	2.34
30 days	3.55	4.29	3.71	3.48

AS –aloe pulp with skin; BS –aloe pulp without skin

TABLE 1. Changes of the count of coagulase-positive *Staphylococcus aureus* during the storage of aloe preserved under ultraviolet light.

Storage time	Count of bacteria (log cfu/g)			
	AS		BS	
	230-280 nm			
	10 min	20 min	10 min	20 min
Control	1.78		1.30	
1 day	1.78	1.30	1.30	nb in 1 g
30 days	1.60	2.64	1.70	1.70

AS –aloe pulp with skin; BS –aloe pulp without skin, nb – not present

TABLE 3. Changes of the count of mesophilic bacteria during the storage of aloe preserved under ultraviolet light.

Storage time	Count of bacteria (log cfu/g)			
	AS		BS	
	230-280 nm			
	10 min	20 min	10 min	20 min
Control	3.11		2.47	
1 day	3.91	2.67	2.50	2.91
30 days	> 7.48	> 7.48	> 7.48	> 7.48

AS –aloe pulp with skin; BS –aloe pulp without skin

TABLE 4. Estimation of variability of microorganisms population in the aloe pulp.

Type of variability (factors)		Analysed features									
		mesophilic bacteria		coagulase-positive *S. aureus*		coagulase-negative *S. aureus*		yeasts		moulds	
		$\bar{x}$	Ex	$\bar{x}$	Ex	$\bar{x}$	Ex	$\bar{x}$	Ex	$\bar{x}$	Ex
Form	AS	4.63	± 0.92	1.81	± 0.18	3.79	± 0.27	3.15	± 0.32	4.04	± 0.25
	BS	4.22	± 1.03	1.22	± 0.26	3.20	± 0.27	3.62	± 0.86	3.70	± 0.40
Exposure time to UV light	10 min	4.49	± 0.97	1.58	± 0.09	3.58	± 0.26	3.26	± 0.51	3.76	± 0.28
	20 min	4.35	± 0.99	1.45	± 0.35	3.41	± 0.33	3.51	± 0.78	3.98	± 0.39

Ex – error of the estimation mean, $\bar{x}$ – average value, AS –aloe pulp with skin; BS – aloe pulp without skin

TABLE 5. Changes of the count of yeasts during the storage of aloe preserved under ultraviolet light.

Storage time	Count of bacteria (log cfu/g)			
	AS		BS	
	230-280 nm			
	10 min	20 min	10 min	20 min
Control	2.60		2.14	
1 day	2.78	2.60	2.43	2.53
30 days	4.30	4.00	5.32	7.16

AS –aloe pulp with skin; BS –aloe pulp without skin

1.5 log cycle (Table 6). After another storage period a significant overgrowth of the moulds population was observed in examined homogenate (Table 6).

According to the studied bibliography the microorganisms show different resistance level to ultraviolet radiation. It depends on many factors, *i.e.* the number of cells, environmental conditions and stage of microorganisms development. The strongest effect is observed in aerobic conditions, however addition of *e.g.* cysteine to environment reduces the effectiveness of UV radiation [Müller, 1983: Kunicki-Goldfinger, 2006]. The literature data relating to the influence of UV radiation on the microorganisms are not homogeneous. Stevens *et al.* [1998] and also Erkan *et al.* [2001] affirmed in their investigations that the UV-C is capable of inhibiting microbial growth and beneficial effect on reducing brown rot of peaches [Stevens *et al.,* 1998] and delaying senescence of products like tissue slices of zucchini squash [Erkan *et al.,* 2001]. The tendency of changes of the number of yeasts observed after UV radiation could be described by polynomial second order equation, which confirms the curvilinear character of changes quoted by Stevens *et al.* [1998]. Lamikanra *et al.* [2005] investigating the influence of superficial UV radiation on the fresh – cut cantaloupe melon's quality came to the conclusion that the population of yeasts, moulds and mesophilic bacteria was reduced [Lamikanra *et al.* 2005]. However, some of bacteria and yeasts possess potent repair mechanism – photoreactivation, therefore they may restore DNA integrity [Lado & Yousef, 2002; Allende *et al*., 2003]. In the above examinations the use of UV radiation caused a reduction of moulds after one day of storage. The next stage – storage of preserved aloe pulp – caused the regrowth of the studied microorganisms. These results can be compared with the investigations led by Marquenie *et al*.[2002] on strawberries inoculated with conidia's of *Botrytis cinerea*. As a results of UV radiation treatment for about 254 nm population of moulds reduced [Marquenie *et al.,* 2002].

TABLE 6. Changes of the count of moulds during the storage of aloe preserved under ultraviolet light.

Storage time	Count of bacteria (log cfu/g)			
	AS		BS	
	230-280 nm			
	10 min	20 min	10 min	20 min
Control	3.93		4.09	
1 day	3.55	3.62	2.53	2.40
30 days	4.00	5.23	4.48	4.60

AS –aloe pulp with skin; BS –aloe pulp without skin

CONCLUSIONS

1. Preservation with ultra-violet radiation does not eliminate the studied microflora from aloe tissue.

2. It is not possible to keep the aloe pulp irradiated with UV rays for more than 30 days, because intensive growth of moulds and yeasts was observed in the investigated plant tissue.

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WPŁYW PROMIENIOWANIA UV NA JAKOŚĆ MIKROBIOLOGICZNĄ MIAZGI ALOESOWEJ

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Celem podjętych badań była ocena wpływu stosowania promieniowania ultrafioletowego na populacje mikroorganizmów zasiedlających miazgę aloesową. Materiał badawczy stanowiły liście trzyletniego aloesu. Miazgę aloesu w dwóch formach (ze skórą oraz bez skóry) przygotowywano według zgłoszenia patentowego P346068. Część przygotowanej miazgi pozostawiano do badań przed procesem promieniowania UV, natomiast pozostałą dzielono, a następnie poddawano działaniu promieni UV o zakresie 240 – 280 nm przez 10 i 20 min. Analizy mikrobiologiczne wykonywano w surowej miazdze przed naświetlaniem, w miazdze poddanej naświetlaniu (1 dzień po naświetlaniu) oraz po 30 dniach przechowywania. W badanym materiale oznaczano ogólną liczbę bakterii mezofilnych tlenowych, liczbę gronkowców oraz liczbę grzybów. W wyniku przeprowadzonych badań wykazano wzrost liczby koagulazo-dodatnich i koagulazo–ujemnych *Staphylococcus aureus* po 30 dniach przechowywania utrwalonego homogenatu w warunkach chłodniczych. Po 30 dniowym okresie przechowywania utrwalonego homogenatu ze skórą oraz bez skóry stwierdzono wzrost populacji mikroflory mezofilnej z wartości 3,11 i 2,47 log cfu/g do 7,48 log cfu/g w obu przypadkach. Liczba drożdży zasiedlających miazgę aloesu ze skórą, jak i bez skóry poddaną utrwalaniu i przechowywaniu przez okres 30 dni, uległa zwiększeniu od około 1,5 do 5 cykli logarytmicznych. Podczas 30 dniowego okresu przechowywania utrwalonej UV miazgi aloesowej zaobserwowano znaczny przerost badanego homogenatu populacją grzybów strzępkowych.