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EFFECT OF VARIOUS APPLICATION TECHNIQUES OF ESSENTIAL OILS ON STORAGE OF POTATO TUBER AT DIFFERENT TEMPERATURES

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ABSTRACT

Two storage experiments were carried out at Mansoura Horticultural Research Station, Egypt, during the two successive summer seasons of 2007 and 2008. to study the effect of various application techniques (fumigation, dipping and spraying) of natural essential oils; thyme (*Thymus vulgaris*, Labiatae) and caraway (*Carum carvi*, Apiaceae) at cold storage (10°C) and ambient temperatures (35/15°C) (day/night) as well as chloropropham (CIPC) on storability, quality and processing of potato (*Solanum tuberosum* L. cv. Lady Rosetta) .

The obtained results revealed that all storage treatments differed significantly in all studied characters. Potato tubers treated with thyme or caraway oils and stored at 10°C or ambient temperature showed the lowest significant values of sprouting and weight loss percents in both seasons of the study. Application of thyme oil at cold storage or ambient temperature resulted in the highest value of dry matter as compared with other treatments, in both seasons. Cold storage had significant effect on reducing sugars and total free amino acids, in both seasons. Tubers of control treatment were of the highest significant gibberillic acid content and of lowest significant abscisic acid followed by cold storage and Chloropropham (CIPC), respectively, relative to all treatments in both seasons. All essential oils/ambient temperature or cold storage treatments gave the best quality processing of chips and French fries, i. e., color, taste and crispiness. Application of caraway or thyme oils by fumigation technique/ambient temperature achieved the highest net return in comparison with other treatments.

The study suggests that using thyme or caraway oils by fumigation technique on potato tubers at ambient temperature or cold storage as the best safe, natural, good quality, high-benefit treatments and easy to apply in practice as alternatives to chemical retardants.

Keywords*: Solanum tuberosum*, essential oils, fumigation, ambient temperature, net profit

INTRODUCTION

Significant changes in the quality of potato occur during post-harvest storage that affects its quality. The major problems that occur during potato storage are sprouting, and rotting due to disease (Vokou, 1993).

Effective sprout control is a major component of managing stored potato quality. Sprouting causes increased weight loss and associated with the conversion of starch to sugars, which is undesirable in the processing industry due to darkening of fried Products. Various methods are available to control sprouting during storage. The primary method to control sprouting in storage is with postharvest application of isopropyl N-(3-chlorophenyl) carbamate (chloropropham; CIPC). CIPC inhibits sprout development by interfering with cell division (Pringle, 2009). The replacement of synthetic pesticides such as chloropropham (CIPC) with effective potato sprout

suppressants that have negligible environmental impact is needed due to the increased concern for consumer health and safety.

One method to delay sprout development is adapting of cold temperature storage (6-10°C). These cooler temperatures can lengthen the marketing window by retarding sprout development, but potatoes may begin to sprout once placed in a warmer environment. Cold temperature storage will also result in an increase in reducing sugar content, primarily glucose. Higher concentrations of glucose cause products to fry dark resulting in unacceptable product color. Therefore, low temperature storage is not appropriate for potatoes destined for the processing market.

Oils of some herbs and spices-essential oils-have been shown to reduce sprouting in potatoes and can be applied to certify organic crops. Vaughn and Spencer (1993) who used several naturally occurring volatiles, thymol cuminaldehyde and salicylaldehyde. They were applied as volatiles or directly tubers stored at 22°C .They also found that thymol and volatiles have effectively inhibited sprouting relative to control of 98% sprouting. Bang (1995) applied essential oils, peppermint, garlic, caraway, thyme which stored on 10°C. The essential oils induced complete inhibition effect on the incidence of sprouting. Daniels *et al*. (1996) continuously bathed potato tuber to 1, 8-cineol, monoterpene of essential oil and ozone as alternatives to CIPC to control sprouting at ambient temperature .They found that 1, 8-cineol was as effective as CIPC in suppressing of sprouting. Frazier *et al*. (2004) used several naturally occurring volatiles spearmint, peppermint and clove oil by fogging to suppress potato tubers stored at 45°F for 9 months. They found that mint and clove oils have effectively inhibited sprouting relative to control.

The present work aimed to study the effect of various applications of essential oils on storing of potato tuber at ambient temperature 35/15°C (day/night) as compared with those treated with essential oils and CIPC which were stored at 10°C on storability and optimizing processing related characters as well as final product quality.

MATERIALS AND METHODS

Two storage experiments were carried out at Mansoura Horticultural Research Station, Egypt, during the two successive summer seasons of 2007 and 2008. The experiments were designed to investigate the effects of various application techniques, i.e., fumigation, dipping and spraying of essential oils (thyme and caraway) plus control (distillated water) as well as Chloropropham(CIPC) with or without essential oils under two different temperature [cold storage 10°C – 90% RH and ambient temperatures 35/15°C (day/night) - 70% RH].

Plant material

Potato tubers (*Solanum tuberosum* L. cv. Lady Rosetta) of 40-80 mm in diameter were selected from Nubaria district, Behera Governorate (150-250 g) without any anti-sprouting treatment were cultivated. Essential oils of the following aromatic plants were used: *Thymus vulgaris*, Labiatae and *Carum carvi*, Apiaceae. Uniformly sized potato tubers were exposed at each treatment with natural essential oil in darkness at 35ºC and approximately 70% relative humidity (RH).

Experimental design:

A complete randomized blocks design with three replicates was used. The experiment included 11 treatments, which were as follows: (1) storing potato tubers at ambient temperature (A. T.) (35/15°C - day/night) as control, (2) cold storage at 10°C, (3) chloropropham (CIPC) at 10°C, (4) thyme oil at cold storage by fumigation technique, (5) caraway oil at cold storage by fumigation technique, (6) application thyme oil by fumigation (F) at ambient temperature, (7) application thyme oil by dipping (D) at ambient temperature, (8) application thyme oil by spraying (S) at ambient temperature, (9) application caraway oil by fumigation at ambient temperature, (10) application caraway oil by dipping at ambient temperature, and (11) application caraway oil by spraying at ambient temperature. The concentration of 2 ml/l with 2 ml Tween 80 (as emulsion materials) were used for both types of oil which equal 100, 60 and 30 ml oil/ton as for dipping, spraying and fumigation application techniques, respectively, for 6 months. CIPC was applied at 100 ppm which equal 100 ml/ton.

Essential oils extraction:

Seeds of caraway, dried herb of thyme, and 250 gm from each one were used for oil extraction by hydro-distillation for 2-3hr according to Charles and Simon (1990). The application of the essential oil treatment was based on the technique of Vaugh and Spencer (1993).

Studied characteristics:

Sprouting, weight loss and dry matter at the end of storage, i.e., six months were determined. Reducing and total phenol and total amino acids were determined according to the methods described by AOAC (1990). Gibberillic acid GA3 and abscisic acid ABA were determined according to the methods described by Okagami and Tanno (1992). Enzyme analysis peroxidase was determined using standard methods described by Yamazaki and Biette (1963). At the end of storing period, four tubers from storage treatments were taken and used for assessing suitability for processing quality, thin potato slices for crisps or 9x9 mm for French fries were prepared. Net return based on input and output of research as an average of two seasons was estimated.

Statistical analysis:

All statistical analyses were performed, using the CoStat for Windows software version 6.311. Data were analyzed by analysis of variances (ANOVA) one-way fixed factor. Duncan's multiple range test was calculated for multiple mean comparisons at a significance level of $*P < 0.05$.

RESULTS AND DISCUSSION

Sprouting, weight loss and dry matter:

All essential oils treatments (ambient temperature or cold storage) and CIPC greatly suppressed the incidence of sprouting behavior, and weight loss of tubers cv. Lady Rosetta compared with control (Table 1 and Figs. 1 & 2). Application of thyme and caraway oils by dipping or fumigation at ambient temperature have significantly inhibited sprouting percentage and reduced weight loss as well as attaining higher tuber dry matter content in both seasons.

Table 1: Sprouting behavior characters as well as dry matter and reducing sugars of potato tubers as affected by various application techniques of essential oils at different temperatures during 2007 and 2008 seasons.

Treatments	Sprouting (%)		Weight loss (%)		Dray matter (%)		Reducing sugars (%)	
	2007	2008	2007	2008	2007	2008	2007	2008
1. Control (A. T.)	100.0 a	80.0 a	25.12 a	26.18 a	22.50 ef	23.70 cd	2.05 c	3.18 d
2. Cold storage 10 °C	70.58 b	62.0 b	9.50 b	8.00 b	23.60 a-d	22.80 e	4.29 a	4.52 a
3. CIPC 10 °C	0.00 g	0.00 c	1.51 i	1.26 g	21.65 f	24.55 ab	4.07 ab	4.13 b
4. Thyme x Cold storage	0.00 g	0.00 c	2.19 h	1.45 g	24.56 a	24.95 ab	3.81 ab	3.93 b
5. Caraway x Cold storage	0.00 g	0.00 c	2.88 g	2.95 ef	23.33 b-e	24.38 bc	3.41 b	3.48 c
6. Thyme x F. (A. T.)	4.68 e	4.33 c	2.25 gh	2.11 fg	22.66 de	23.6 d	1.25 d	1.56 f
7. Thyme x D. (A. T.)	0.00 g	0.00 c	2.56 gh	2.80 ef	24.00 ab	25.30 a	1.39 cd	1.68 ef
8. Thyme x S. (A. T.)	2.89 f	2.00 c	3.41 f	4.65 d	23.8 abc	24.68 ab	1.24 d	1.54 f
9. Caraway x F. (A. T.)	0.00 g	0.00 c	4.33 e	3.45 e	23.6 a-d	24.89 ab	1.29 d	1.52 f
10. Caraway x D. (A. T.)	10.0 c	6.98 c	6.75 d	5.73 c	22.9 cde	23.66 d	1.76 cd	1.83 e
11. Caraway x S. (A. T.)	6.92 d	5.98 c	8.03 c	6.25 c	22.8 cde	24.55 ab	1.45 cd	1.51 f

Means followed by the same letter (s) within each column do not significantly differ using Duncan's Multiple Range Test at the level of 5%.

F.: Fumigation; D.: Dipping; S.: Spraying; A.T.: ambient temperature 35/15 °C day/night.

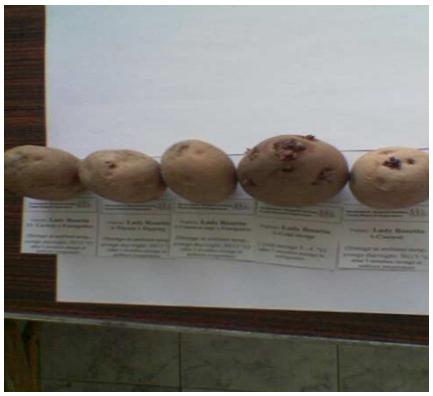

Fig. 1: Effect of essential oils application at different temperature on potato sprouting cv. Lady Rosetta; from left to right, 1: caraway x fumigation (35/15°C), 2: Thyme x fumigation (35/15°C), 3: caraway x spraying (35/15°C); note: no sprouts were observed at the end of storage; 4: cold storage (10°C) and 5: control without essential oil application at ambient temperature (35/15°C). Photos were taken after 6 months of storage.

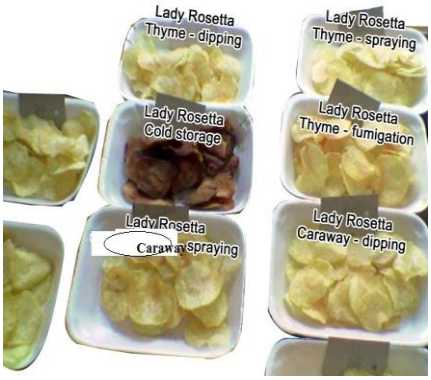

Fig. 2: Samples of potato chips: from top to bottom and left to right, 1. thyme x dipping, 2. thyme x spraying, 3. cold storage, 4. thyme x fumigation, 5. caraway x spraying and 6. caraway x dipping.

The essential oil and basic components were found to act as an uncoupling agent in mitochondria at low concentration (Pauly *et al*., 1981), thereby, inhibit mitochondrial respiration (Lorber and Miller, 1980), membrane disturbances (Lorber and Muller, 1980), which may be suppressing to the sprouting. Similar finding was obtained by Sonli *et al*. (2010) who reported that ground seed treatments of caraway treatments were the most effective treatments for reducing number of sprouts on potato tubers and preventing weight losses of tubers.

Biochemical characters:

All storage treatments (essential oils and CIPC) gave lower values of reducing sugars and amino acids during both seasons as compared to the cold storage at 10°C and the control (Table 1&2). The lowest values of reducing sugars and amino acids content were found in tubers treated with CIPC, thyme or caraway at 10°C, and thyme and caraway oils by dipping and fumigation (ambient temperature), respectively, (without significant difference between the two treatments).

This greatly confirmed the potency of such treatments in preservation and maintenance of the stored tubers reserves, keeping the internal biochemical enzymatic activities in minimum level and in more stable case thereby prolonged their dormancy case. Also, proved that these treatments were highly effective in protection of their tubers against the were known degradable effects of higher temperature / oxidative stressful storage conditions and accordance to the findings of Davies (1990) who indicated that those essential oils and/or their basic constituents (monoterpenes and antioxidants) trended to slow down the activity of carbohydrates and protein breakdown associated enzymatic systems as well as respiration and energy metabolism enzyme.

Table 2: Amino acids, Phytohormones and peroxidase enzyme of potato tubers as affected by various application techniques of essential oils at different temperatures during 2007 and 2008 seasons.

Treatments	Total free amino acids (%)		GA3 (mg/100 g F. W.)		ABA (mg/100 g F. W.)		Peroxidase activity (%)	
	2007	2008	2007	2008	2007	2008	2007	2008
1. Control (A. T.)	0.307 ab	0.301 ab	48.52 a	46.26 a	0.892 hi	0.94 h	56.77 g	55.51 g
2. Cold storage 10 °C	0.352 a	0.348 a	14.81 b	13.57 b	9.74 h	8.48 g	80.67 e	79.06 c
3. CIPC 10 °C	0.084 bc	0.047 c	13.75 c	12.71 c	8.65 i	10.03 f	87.67 c	86.65 c
4. Thyme x Cold storage	0.030 c	0.029 c	1.62 g	12.68 c	23.54 c	22.36 c	97.33 a	96.29 a
5. Caraway x Cold storage	0.08 bc	0.049 c	1.87 fg	12.19 c	10.94 g	11.46 e	80.68 e	80.26 e
6. Thyme x F. (A. T.)	0.152 abc	0.153abc	1.98 fg	11.04 d	15.12 d	14.10 d	77.55 f	76.77 f
7. Thyme x D. (A. T.)	0.106 bc	0.108 bc	2.26 f	10.92 d	24.55 b	23.59 b	97.68 a	96.46 a
8. Thyme x S. (A. T.)	0.084 bc	0.059 c	11.40 e	2.20 e	12.48 e	11.52 e	80.67 e	80.5 e
9. Caraway x F. (A. T.)	0.146 abc	0.157abc	12.2 d	1.91 e	25.45 a	24.79 a	95.81 b	94.63 b
10. Caraway x D. (A. T.)	0.186 abc	0.187abc	13.27 c	1.88 e	11.89 f	11.41e	81.75 e	79.33 e
11. Caraway x S. (A. T.)	0.147 abc	0.151abc	11.08 e	1.47 e	12.13ef	11.34 e	84.50 d	83.62 d

Means followed by the same letter (s) within each column do not significantly differ using Duncan's Multiple Range Test at the level of 5%.

F.: Fumigation; D.: Dipping; S.: Spraying; A.T.: ambient temperature 35/15 °C day/night.

Phytohormones, gibberellins, abscisic acid, and activity of peroxides:

Tubers of the control treatment were of the highest gibberillic acid and of lowest abscisic acid followed by cold storage and CIPC stored at cold storage, respectively, relative to all treatments in both seasons, Table 2. The data also clear that, tuber treated with thyme by dipping or caraway by fumigation at ambient temperature was of lowest gibberillic acid and highest abscisic acid in both seasons. Also, among storage treatments, thyme of dipping has considerably increased the activity of peroxides followed by caraway of fumigation at both seasons.

In this respect, the balanced hormonal case of low gibberillic acid content and high abscisic acid content is tightly associated with the prolongation of tuber dormancy and minimum internal biochemical changes during storage (Herrman *et al*., 1996). These results might also be explained on the finding of Oosterhaven, 1993, who stated that, carvon the basic constituents of caraway oil found to be completely inhibited 3 hydroxy-3-methyl glutraly coenzyme A reductase (HMGR) the key enzyme of mevalonate pathway in potato tubers at low concentration. The mevalonate is known as the main pathway of gibberellins biosynthesis. This in turn might lead to stimulation of abscisic acid biosynthesis, since the two hormones are known to be synthesized from the same precursor and pathway (Oosterhaven, 1993).

On the other hand, understanding of ambient high temperature storage condition as a stressful factor, induce more serious internal oxidative stress, generation of elevated level of degradable and toxic reactive oxygen species (ROS) (O^{-}_{2},OH^{-} and H_2O_2) (Rojas *et al*., 2000).

Processing quality of potato chips and French fries:

All essential oil treatments at ambient temperature or cold storage and CIPC treatment gave the highest chips and French fries quality characters, i.e., color, crispiness and taste (with no considerable differences between them), in comparison with cold storage and the control treatments (Table 3).

The present results could be expected based on the similar beneficial effect of these treatments on dry matter, storability, sprouting behavior (Table 1), tubers reserves especially reducing sugars and amino acids (Table 2).

The same treatments greatly controlled and prevented the accumulation of sugars, optimized the stored tubers content of reducing sugars and amino acids after storage at ambient temperature. Thus, it could explain the worst processing quality (darkened chips of bad taste and crispiness) of storage treatments based on the occurrence of Millard reaction during frying process due to the extremely accumulated reducing sugars and amino acids (Brierley *et al.*, 1996). The same processing quality parameters were correlated with starch and dry matter content (Table 1; Fig. 2; Hesen, 1981) and with amino acids content (Table 2) in both seasons. These results are in harmony with those previously obtained by El-Awady (2006). With the same basis, this could explain the best processing quality of essential oils produced chips, the considerable control (optimization) of reducing sugars and amino acids of their tubers thereby , the prevention of Millard reaction occurrence during frying processes and in turn best color, crispiness and taste.

Table 3: Quality processing of potato tubers as affected by various application techniques of essential oils at different temperature during 2007 and 2008 seasons.

Treatments	Chips						French fries					
	Color		Taste		Crispness		Color		Taste		Crispness	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
1. Control (A. T.)	3.00 e	3.33 c	3.00 d	3.33 bc	4.33 abc	4.33 abc	3.33 de	3.00 d	3.33cd	4.00bcd	4.67ab	4.67 ab
2. Cold storage 10 ºC	3.33 de	3.33 c	4.33 abc	4.33 ab	4.33 abc	4.67 ab	3.67cde	3.33cd	4.00 abc	4.33abc	4.67ab	4.67 ab
3. CIPC 10 ºC	4.67 ab	4.67 ab	5.00 a	4.67 a	5.00 a	5.00 a	4.67 ab	4.67 ab	5.00 a	4.67 ab	5.00 a	4.33abc
4. Thyme x Cold storage	4.67 ab	4.67 ab	5.00 a	4.67 a	5.00 a	5.00a	4.67 ab	4.67 ab	5.00 a	4.67 ab	5.00 a	4.33abc
5. Caraway x Cold storage	4.67 ab	4.67 ab	5.00 a	4.67 a	5.00 a	5.00 a	4.67 ab	4.67 ab	4.67ab	4.67 ab	5.00 a	5.00 a
6. Thyme x F. (A. T.)	4.67 ab	4.67 ab	4.64 ab	4.67 a	5.00 a	5.00 a	4.67 ab	4.67 ab	4.67 ab	4.67 ab	5.00 a	5.00 a
7. Thyme x D. (A. T.)	5.00 a	5.00 a	5.00 a	4.67 a	5.00 a	5.00 a	5.00 a	5.00 a	4.67 ab	5.00 a	5.00 a	5.00 a
8. Thyme x S. (A. T.)	4.67 ab	4.67 ab	4.67 ab	4.67 a	5.00 a	5.00 a	4.67 ab	4.67 ab	5.00 a	5.00 a	5.00 a	5.00 a
9. Caraway x F. (A. T.)	5.00 a	5.00 a	5.00 a	4.67 a	5.00 a	5.00 a	5.00 a	5.00 a	4.67 ab	5.00 a	5.00 a	5.00 a
10. Caraway x D. (A. T.)	4.00 bcd	4.67 ab	4.67 ab	4.67 a	4.67 ab	4.67 a	4.00 bcd	4.00abc	4.33abc	4.33abc	4.67 ab	5.00 a
11. Caraway x S. (A. T.)	4.33 abc	4.67 ab	4.67 ab	4.67 a	4.67 ab	4.67 a	4.00bcd	4.33abc	3.67bcd	4.33abc	4.67 ab	4.67ab

Means followed by the same letter (s) within each column do not significantly differ using Duncan's Multiple Range Test at the level of 5%.

F.: Fumigation; D.: Dipping; S.: Spraying; A.T.: ambient temperature 35/15 ºC day/night.

The results in hand have evidently confirmed the association between the storability characters and the internal biochemical status of potato tubers at the end of storage and their subsequent chips quality character after frying.

Economic evaluation:

Net profit of final products was estimated as a relationship between gross return and total treatment cost (Table 4). The results showed that the highest net return (L. E. 3994/ton) was obtained from application of caraway oil treatment when applied as fumigation technique at ambient temperature (35/15°C-day/night) in comparison with other treatments. Thus, this treatment proved to be highly economical for potato storing. It could be concluded that using Thyme or Caraway oils by fumigation technique on potatp tubers at ambient temperature (35/15°C - day/night day/night) or at cold storage (10°C**)** as the best safe , natural, good quality and high-benefit treatments.

Table 4: Estimate of additional net return of treatments.

Treatments	Gross return* (L. E. Ton^{-1})	Treatment cost** (L. E. Ton^{-1})	Total cost*** (L. E. Ton^{-1})	Net return (L. E. Ton^{-1})	Benefit/cost**** ratio	order
1. Control (A. T.)	1000.00	0.00	1000.00	0.00	0.00	11
2. Cold storage 10 ^{o}C	3000.00	150.00	1150.00	1850.00	1.61	10
3. CIPC 10 ^{o}C	3000.00	200.00	1200.00	1800.00	1.50	9
4. Thyme x Cold storage	5000.00	159.00	1159.00	3841.00	1.59	8
5. Caraway x Cold storage	5000.00	156.00	1156.00	3844.00	1.60	7
6. Thyme x F. (A. T.)	5000.00	9.00	1009.00	3991.00	3.96	2
7. Thyme x D. (A. T.)	5000.00	18.00	1018.00	3982.00	3.91	4
8. Thyme x S. (A. T.)	5000.00	30.00	1030.00	3970.00	3.85	6
9. Caraway x F. (A. T.)	5000.00	6.00	1006.00	3994.00	3.97	1
10. Caraway x D. (A. T.)	5000.00	12.00	1012.00	3988.00	3.94	3
11. Caraway x S. (A. T.)	5000.00	20.00	1020.00	3980.00	3.90	5

***Gross return of final products was estimated according to the quality of potato tuber at the end of storage (healthy tuber, free in virtual and physiological defects and good quality for processing products) and ranging from £.Є 1000: 5000/ton.**

****Treatment cost was calculated according to the following prices: Refrigerator storage cost £.Є 150.00/ton; CIPC £.Є 500.00/l.; thyme oil £.Є 300.00/l., and caraway oil £.Є 200.00/l.**

*****Total costs were price of potato tubers per ton before storing which equal nearly £.Є 1000, plus treatment cost.**

******Benefit/cost ratio was divided by net return in total costs.**

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تأثير طرق إضافات مختلفة من الزيوت العطرية على تخزين درنات البطاطس فى درجات الحرارة المختلفة

أمل أبو الفتوح العوضى، عبدالبديع صالح عزت والسيد نادر محمد البنا
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اجريت تجربتان تخزينيتان بمحطة بحوث البساتين بالمنصورة- محافظة الدقهلية في موسمين متتاليين للعروة الصيفى ٢٠٠٧و ٢٠٠٨ لدراسة تأثير طرق إضافات مختلفة (التبخير، الغمس والرش) من الزيوت العطرية الطبيعية (الزعتر والكراوية) على صنف بطاطس ليدى روزيتا (صنف تصنيعي) المخزنة على ١٠ درجة مئوية ودرجة حرارة الغرفة بالاضافة الى معاملة الكلوروبروفام (CIPC) على القدرة التخزينية والجودة للدرنات المخزنة، ورفع كفاءة وجودة منتج الشبسي النهائي.

وكانت أهم النتائج المتحصل عليها كما يلي:

- أعطت الدرنات التى عوملت بزيت الكراوية و الزعتر والمخزنة على ١٠ درجة مئوية أو درجة حرارة الغرفة بطريقة التدخين أقل القيم المعنوية فى نسب التزريع، الفقد فى الوزن ونسبة التالف في كلا الموسمين.
- تفوقت المعاملة باستخدام زيت الزعتر بطريقة النقع معنويا فى محتوى درناتها من المادة الجافة سواء في التخزين البارد أو على درجة حرارة الغرفة بالمقارنة بالمعاملات الأخرى فى كلا الموسمين.
- أعطت معاملة الكنترول أعلى القيم المعنوية فى محتوى الدرنات من الجبريللين وزيادة نشاط انزيم البيروكسيديزوأقل القيم المعنوية فى محتواها من الأبسيسيك اسد يليها التخزين البارد والكلوروبروفام على التوالى فى كلا الموسمين.
- أعطت جميع المعاملات باستخدام الزيوت والتخزين على البارد أو درجة حرارة الغرفة أفضل القيم المعنوية فى تحسين جودة الشبسى أو الأصابع المحمرة فى اللون والطعم والقرمشة.

تقترح هذه الدراسة استعمال زيت الزعتر أو الكراوية بطريقة التدخين للدرنات المخزنة على درجة حرارة الغرفة لمدة ٥ أشهر لأغراض التصنيع والأستهلاك الطازج كأفضل المعاملات الطبيعية الأمنة وقليلة التكاليف وسهل تطبيقها عمليا كبدائل للمواد الكيميائية.

قام بتحكيم البحث

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