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EFFECT OF SOME CHEMICAL TREATMENTS ON THE CHANGE OF TECHNOLOGICAL CHARACTERISTICS OF SUGAR BEET ROOTS DURING STORAGE

[23]

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ABSTRACT

This work was carried out to reduce the deterioration and to extend the shelf life of sugar beet roots after harvest and before processing. Roots were divided to six groups (100 roots for each group), subjected to different treatment (i.e $Ca(OH)_2$, SO_2, NaOH, $C_3H_6O_2$ and $Na_2S_2O_5$) at different concentrations and stored for 15 days in open air. The technological characteristics of sugar beet roots were studied. The least percentage of weight loss and highest juice purity, quality and sucrose recovery were obtained by treating the roots with 500ppm $Na_2S_2O_5$ (solution).The highest value of hardness was obtained from roots treated by a solution of 5% $Ca(OH)_2$ while the least value for sucrose loss in wastes was obtained by the use of 2500ppm SO_2 . Thus, it is necessary to manufacture sugar beet directly after harvest to reduce sugar loss and obtain best physical and technological characteristics. On the other hand, when, roots are in surplus, it should be treated by sodium metabisulfite solution (500ppm)to reduce the loss of sugar and minimize deterioration and fit the technological properties required along manufacture process.

Key word: Sugar beet, Roots, Storage condition, Chemical treatment, physical, Technological characteristics.

INTRODUCTION

Sugar beet is becoming a growing source of sugar production. It represents about 22 %of Egypt total sugar production in1999/2000, compared to 20% percent in 1998/1999. Sugar production from beet in Egypt increased from 374400 to 456000 ton in 1999 and 2000, respectively (**Thomas, 2000**).

The importance of sugar beet to agriculture is not only confined to sugar production, but also to produce secondary production (**Badawy, 1992**).

In most beet growing areas, harvest periods are short and in consequence sugar beet storage is necessary. The problems of storage are quality deterioration of roots and decrease of sucrose due to respiration and activation of some en-

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zymes, resulting in a decrease of physical and technological characteristics of sugar beet roots.

McCready and Goodwin (1966) reported that beets in factory lose sugar as a result of at least three different ways. The first is spoilage by microorganisms which use up sugar in respiration and produce enzymes which convert sucrose to invert sugar. The second substantial source of sugar loss occurs through direct respiration of stored sugar beet roots. The sugar loss by direct respiration was estimated as up to 0.5 pound of sugar per ton beets per day. The third source of sugar loss is the biochemical transformation of sucrose into invert sugar, and other carbohydrates that occurred directly in the roots. Inverted sugars inhibit crystallization and cause difficulties in beet sugar processing. Among the three processes causing sugar loss in beets, biochemical transformation that have received the least attention.

Goodban and McCready (1965) mentioned that potential advantage of beet liming are mostly a consequence of the reactions of calcium hydroxide with the pectic substances that hold the cells together and make up as much as 30% of the water insoluble portion of the beet. **Camirand *et al* (1981)** found that the addition of lime to sugar beet tissue at lower temperature causes demethylation of the pectin in the cell walls of the beet tissue, allowing Ca^{2+} to crosslink the pectin as a stable insoluble matrix. This permits alkaline diffusion with less disintergration of the pulp, high deacetylation rates and pectin degradation above 37°C can limit process to lower temperature.

Pratt and Schaeffer (1999) used the propionic acid to preserve sugar beets. They treated the whole beets and chopped beets by submerging them in solution of propionic acid for 2 minutes then allowed them to remain in open air up to 13 days. The % sugar in the beet, sliced or whole, was higher after 6 days compared to that when the beet was first harvest. The increase in % sugar in all samples during the first six days was the results of dehydration as decreasing water content in the beet was evident. A marked decrease in % sugar began after 6 days in each of the untreated beet samples reaching a low of 8.55%. The %sugar in the treated samples was higher than the starting point throughout the entire test, reaching 20.16%.

Mousa (1990) studied the total sugar loss, percentage of weight loss and change of purity of two sugar beet varieties during storage under different storage conditions (i.e in open air with vegetative shoots, in open air without vegetative shoots, cooling at 10°C and relative humidity of 85% and freezing at −10°C). He found that the loss of sugar by freezing was lesser than other storage conditions, the juice purity of the two varieties decreased under different storage conditions.

Abou Shady (1994) reported that storage of sugar beet roots under different conditions (i.e in open air, in open air with covering and in normal store room) led to a higher increase in the change in daily weight, roots stored with cover recorded the lowest weight loss. Sugar recovery and juice purity increased in all storage conditions.

Nezam El-Din (1996) sliced sugar beet roots and dried them after treating with sodium hydroxide, ascorbic acid and sulfur dioxide. He found that the treatment by sulfur dioxide fumes had the pronounced effect on the slices of beet roots. The color and chemical changes were very low compared with the fresh beet roots.

This work was carried out to extend shelf life of sugar beet roots by applying chemical treatments to increase juice purity, sugar recovery and quality when roots are in surplus.

MATERIAL AND METHODS

Materials

Source of sugar beet roots

Sugar beet roots (*Beta vulgaris L.*) cultivar Pleno were obtained from the fields of Delta Sugar Company, Kafr El-Sheikh Governorate , Egypt.

Preparation of samples

Sugar beet roots were divided into six groups (100 roots of each group), stored for 15 days in open air after treated by the following treatments:

- The first group without treatment (control)
- The second group was treated by dipping in calcium hydroxide solution for 10 minutes at concentration of 1%, 5% and 10%.
- The third group was treated with sulfur dioxide at 500, 1000 and 2500ppm (sulfur dioxide was obtained by burning sulfur in sealed cabinet).
- The fourth group was treated by dipping in sodium hydroxide solution of 0.1, 0.5, and 1N for 10 minutes.
- The fifth group was treated by dipping in propionic acid solution of 1, 2 and 4% for 10 minutes.
- The sixth group was treated by dipping in sodium metabisulfite at 500, 1000 and 2500 ppm as SO_2 for 10 minutes.

During storage periods temperature ranged from 18°C to 31°C and relative humidity ranged from 55% to 85.5%. Analysis was carried out at 0, 3, 6, 9, 12 and 15 days after harvest.

Methods

Chemical analyses

Moisture, ash, total nitrogen, reducing sugars, total sugars and total soluble solids were determined according to the procedure in **A.O.A.C. (1990)**.

Sucrose percentage was determined as described by **Le Docte (1977)** using saccharometer. Alpha amino nitrogen, sodium and potassium were determined according to **Brown and Lilliand (1964)** using Auto-Analyzer (type Zig Verema Automation) by Delta Sugar Company. The results calculated as milliequivalents/100gm beet.

Technological characteristics

Sugar recovery (SR), sucrose loss in wastes, juice purity, and quality were determined according to the procedure of Delta Sugar Company described by **Sapronova *et al* (1979)**. The following equations were used:

Sugar recovery = (pol − 0.29) − 0.343 (K+Na) - α N (0.0939)

Sucrose losses in wastes = (K+Na) 0.343 + (α N . 0.0939) + 0.29

$$Juice\ purity = \frac{Sucrose\,\%.100}{T.S.S.\,\%}$$

$$Quality = \frac{SR.100}{Pol}$$

Where: pol = sucrose %
K = potassium
Na = sodium
α N = α -amino- nitrogen
SR = sugar recovery
T.S.S = total soluble solids

Hardness (Kg/mm^2): determined using taster precision (model Dillon Advanced, Force Gauge, AFG- 500), as recommended by **Bourne and Comstock (1986)**.

RESULTS AND DISCUSSION

Chemical composition of fresh sugar beet roots

Data in Table (1) shows chemical composition of fresh sugar beet roots.

Table 1. Chemical composition of fresh sugar beet roots

Compound	Percentage
Moisture	79.00
Sucrose	16.50
Reducing sugar	0.73
Ash	0.52
Total nitrogen	0.25
Fiber	1.33
Fat	0.22
Other	0.68

The results of moisture, reducing sugars and ash are in agreement with those of **Ibrahim (1970), Mousa (1990) and Nezam El-Din (1996)**. While results of sucrose are similar with results recorded by **Abou Shady (1994).**

Effect of chemical treatments on technological characteristics of sugar beet roots during storage

Hardness (Kg/mm^2)

Data in Table (2) show the effect of chemical treatments and storage periods of sugar beet roots on the hardness. Sodium hydroxide (1.0N) was the superior solution to keep root hardness at the highest level (16.65Kg/mm^2). Considering calcium hydroxide solution, data in Table (2) show that also calcium hydroxide solution with concentration of 10% was the effective one (13.95 Kg/mm^2). However the concentration of 5% solution could be recommended because it is more safety and economical in the application, and because the small difference of texture hardness by the use of 10% concentration (0.48Kg/mm^2). It was observed undesirable black color after treating the roots with sodium hydroxide solution especially with the concentration of 1.0N and 0.5N.

When calcium hydroxide was added directly to the fresh beet tissue at 40°C or lower, deesterification of the pectin predominates over degradation; calcium crosslinks carboxyl group to form a firm insoluble calcium pectate **(Goodban and McCready, 1965)**. Data in table (2) show that after three days of storage period hardness values of all treated roots were increased, then they gradually decreased.

Table 2. Effect of chemical treatments on the changes of hardness (Kg/mm^2) during storage

Treatment	Con.	Hardness(Kg/mm^2) after storage period of:					
		0day	3days	6days	9days	12days	15days
Control		20.74	16.36	12.82	9.51	9.02	8.44
$Ca(OH)_2$	1%	20.74	22.1	16.45	12.47	12.41	11.83
	5%	20.74	27.56	21.5	15.67	14.48	13.47
	10%	20.74	24.8	15.1	14.91	14.47	13.95
SO_2	500ppm	20.74	20.65	14.9	12.1	11.2	10.06
	1000ppm	20.74	28.45	17.00	12.37	12.9	12.53
	2500ppm	20.74	26.16	15.7	13.61	12.27	12.15
NaOH	0.1N	20.74	20.72	13.17	13.17	12.22	11.34
	0.5N	20.74	32.2	20.8	13.8	13.35	12.15
	1.0N	20.74	30.8	25.9	18.00	17.32	16.65
$C_3H_6O_2$	1%	20.74	19.1	14.2	12.17	11.67	10.92
	2%	20.74	32.4	21.45	13.72	12.35	11.35
	4%	20.74	30.3	19.95	19.09	12.55	12.07
$Na_2S_2O_5$	500ppm	20.74	18.45	14.1	13.51	11.56	11.28
	1000ppm	20.74	28.46	16.45	12.36	11.95	11.26
	2500ppm	20.74	25.29	14.45	13.01	12.35	11.62

Percentage of weight loss (%)

The effect of different chemical treatments on the change in percentage of weight loss has been studied. Table (3) illustrates the change in percentage of weight loss after treatment with different chemical treatments and during storage periods. At the end of storage periods (15days), The use of 500 ppm $Na_2O_2S_5$ as a dipping solution protect the roots against weight loss so that it recorded the least percentage of weight loss (32.47%). Solution of 0.1N, 0.5N NaOH, 2500 ppm SO_2 or 1000 ppm SO_2 have intermediate effect on weight loss. The roots which were treated with 1% $Ca(OH)_2$ had the highest percentage of weight loss. The same table shows that the weight loss percentage of all samples at the end of storage period was slight and ranged from 32.47% to 40.2%. The loss of weight during storage may be due to respiration process and metabolic changes occurred in beet roots tissues.

Table 3. Effect of chemical treatments on the percentage of weight loss during storage

Treatment	Con.	Percentage of weight loss (%) after storage period of:					
		0day	3days	6days	9days	12days	15days
Control		Zero	11.84	18.76	26.5	33.4	39.7
$Ca(OH)2$	1%	Zero	12.5	19.18	26.61	33.72	40.2
	5%	Zero	11.99	19.18	26.19	32.53	38.65
	10%	Zero	11.61	19.32	26.88	32.82	38.71
SO_2	500 ppm	Zero	9.92	16.75	25.12	32.14	38.43
	1000ppm	Zero	8.38	17.6	25.59	30.86	36.04
	2500ppm	Zero	5.37	13.15	21.32	28.42	35.12
NaOH	0.1N	Zero	7.53	14.46	22.04	28.41	34.57
	0.5N	Zero	5.7	11.15	18.64	27.52	34.83
	1.0N	Zero	6.99	12.8	21.67	29.35	36.24
$C_3H_6O_2$	1 %	Zero	10.53	15.53	24.18	31.08	37.45
	2 %	Zero	10.95	16.62	23.44	30.84	38.86
	4 %	Zero	10.76	17.99	24.45	32.95	39.06
$Na_2S_2O_5$	500ppm	Zero	7.51	12.91	18.6	25.48	32.47
	1000ppm	Zero	13.82	20.27	27.89	33.98	39.12
	2500ppm	Zero	13.3	19.42	26.33	32.18	37.6

Juice purity (%)

From Table (4) it could be noticed that juice purity was affected by all treatments applied on sugar beet roots with different degree. The highest purity juice was reached when roots were dipped in 500ppm $Na_2S_2O_5$ solution. Roots treated with 1.0N NaOH resulted juice with the least purity. Although this treatment recorded the highest value for hardness, it gave the lowest value of juice purity. The same table show that the roots which treated with 500 ppm $Na_2S_2O_5$ solution was decreased in purity at the third day of storage but after that it began to increase and recorded the highest value of juice purity at the end of storage period. On the other side the roots treated with 4% propionic acid was gradually increased in purity value up to the maximum after 12 days of storage. Generally juice purity (%) had increased in samples by the use of most treatments than control samples. This is due to high loss of moisture in open air and increase of total soluble solids and consequently sucrose percentage. This results was supported by results obtained by **Abou-Shady (1994).**

Table 4. Effect of chemical treatments on the changes of juice purity during storage

Treatment	Con.	Juice purity(%) after storage period of:					
		0day	3days	6days	9days	12days	15days
Control		84.18	81.6	82.88	74.63	68.29	65.62
$Ca(OH)_2$	1%	84.18	78.22	87.03	90.35	84.21	79.15
	5%	84.18	82.95	82.17	86.38	86.04	82.65
	10%	84.18	87.99	86.82	80.60	84.11	82.54
SO_2	500ppm	84.18	84.88	82.39	83.15	83.06	85.49
	1000ppm	84.18	89.64	81.50	84.53	86.66	78.11
	2500ppm	84.18	84.59	82.82	76.53	79.00	84.61
NaOH	0.1N	84.18	81.86	85.61	81.83	83.21	84.40
	0.5N	84.18	84.09	85.90	88.04	86.53	88.65
	1.0N	84:18	83.45	80.47	79.31	78.78	76.70
$C_3H_6O_2$	1%	84.18	87.21	84.08	87.91	83.84	81.66
	2%	84.18	83.41	81.01	83.06	86.40	83.73
	4%	84.18	87.43	89.38	89.68	89.79	88.07
$Na_2S_2O_5$	500pm	84.18	79.79	81.52	83.96	85.09	88.90
	1000ppm	84.18	81.60	84.40	86.22	86.73	87.15
	2500ppm	84.18	82.5	84.87	82.52	80.87	85.56

Quality (%)

Table (5) shows that high values of quality were achieved by the treatment of beet roots with $Na_2S_2O_5$ at 500 ppm, NaOH at 0.1N, SO_2 at 2500ppm, $C_3H_6O_2$ at 2% and $Ca(OH)_2$ at 1%. The recorded values were 83.65, 82.6, 81.82, 81.61 and 78.42%, respectively. These values show that the quality of all treated samples were increased than that the zero time. Whereas, the quality of the control decreased from 78.47 to 68.04% at the end of storage period. This is due to the high values of α-amino nitrogen, sodium and potassium in control sample (data not showed). **Carter, (1986)** reported that high sucrose concentration and root quality were generally associated with low to moderate N and low Na concentration, high K:Na ratio and low water concentration in the roots. These three at high levels have an adverse effect on percentage of sucrose and apparent purity (**Merle *et al* 1964**).

Sugar recovery (%)

The effect of different chemical treatments on the percentage of sucrose

Table 5. Effect of chemical treatments on the changes in quality during storage

Treatment	Con.	Quality(%)after storage period of:					
		0day	3days	6days	9days	12days	15days
Control		78.47	77.78	76.88	73.78	70.01	68.04
$Ca(OH)_2$	1%	78.47	79.13	80.85	81.06	79.86	78.42
	5%	78.47	79.47	79.87	80.76	79.74	78.03
	10%	78.47	79.48	78.89	76.96	78.87	78.00
SO_2	500ppm	78.47	79.78	79.76	79.45	79.27	80.18
	1000ppm	78.47	78.81	80.00	80.80	82.02	79.05
	2500ppm	78.47	78.98	79.00	79.51	80.17	81.82
Na OH	0.1N	78.47	79.09	80.29	80.85	81.83	82.60
	0.5N	78.47	79.19	80.37	81.33	81.97	82.50
	1.0N	78.47	78.22	77.29	77.30	77.31	75.97
$C_3H_6O_2$	1%	78.47	80.37	80.76	81.79	81.64	81.51
	2%	78.47	78.44	80.47	81.81	82.24	81.61
	4%	78.47	78.44	78.63	79.18	80.32	79.89
$Na_2S_2O_5$	500ppm	78.47	79.24	81.03	81.7	82.49	83.65
	1000ppm	78.47	79.29	79.92	80.11	80.34	80.44
	2500ppm	78.47	77.52	77.97	78.32	78.38	79.99

recovery from roots sugar at different storage periods was illustrated in table (6). Sugar recovery of control sample was decreased from 61.66% at the start of storage to 28.12% at the end of storage. The sugar recovery of all samples treated with different chemicals was also decreased, but less than the control sample. The decrease of sugar recovery is due to increase of amino nitrogen, potassium and sodium content during storage (data not show). The presence of N, K and Na disturbed the crystallization process and therefore more sugar retained in molasses. This finding is in agreement with those of **Rorabaugh and Norman (1956)**. The highest sugar recovery of 55.03% was recorded by the use of 500 ppm sodium metabisulfite. Where as, the lowest value of 39.73% was recorded by the use of 1% $Ca(OH)_2$.

Sucrose loss in wastes (%)

Percentage of sucrose loss in wastes of sugar beet roots as influenced by chemical treatments and storage period was presented in Table (7). The loss of sucrose in wastes increased during storage of control samples as well as of samples treated with different chemicals. This loss was higher in the control than the

Table 6. Effect of chemical treatments on the changes in sucrose recovery during storage (dry weight).

Treatment	Con.	Sucrose recovery (%)after storage period of:					
		0day	3days	6days	9days	12days	15days
Control		61.66	54.83	53.70	42.01	32.63	28.12
$Ca(OH)_2$	1%	61.66	57.08	53.90	51.70	44.39	39.73
	5%	61.66	56.43	52.78	52.54	46.73	43.53
	10%	61.66	58.71	55.77	50.86	49.34	46.38
SO_2	500ppm	61.66	56.43	54.56	53.01	50.49	49.37
	1000ppm	61.66	58.37	56.99	56.53	56.89	47.02
	2500ppm	61.66	56.69	48.96	48.20	48.17	48.91
Na OH	0.1N	61.66	55.02	53.66	50.03	50.48	50.06
	0.5	61.66	57.82	54.04	50.68	50.93	50.04
	1.0N	61.66	54.40	48.77	45.11	43.16	41.81
$C_3H_6O_2$	1%	61.66	57.30	55.21	53.43	51.16	49.51
	2%	61.66	56.84	57.36	55.59	53.97	50.02
	4%	61.66	55.93	49.42	48.24	47.82	46.02
$Na_2S_2O_5$	500ppm	61.66	56.93	56.75	56.44	55.87	55.03
	1000ppm	61.66	55.85	52.66	49.97	48.42	47.03
	2500ppm	61.66	51.99	48.80	45.64	44.24	45.47

Table 7. Effect of chemical treatments on the changes in sucrose loss in wastes during storage

Treatment	Con.	Sucrose loss in wastes(%)after storage period of:					
		0day	3days	6days	9days	12days	15days
Control		3.55	3.85	4.31	4.59	4.86	5.03
$Ca(OH)_2$	1%	3.55	3.67	3.79	3.90	3.98	4.05
	5%	3.55	3.74	3.80	3.90	4.09	4.44
	10%	3.55	3.68	3.89	4.27	4.48	4.63
SO_2	500ppm	3.55	3.68	3.83	4.05	4.21	4.31
	1000ppm	3.55	3.70	3.78	3.93	4.08	4.30
	2500ppm	3.55	3.63	3.69	3.84	3.95	3.99
Na OH	0.1N	3.55	3.67	3.75	3.83	3.89	4.00
	0.5N	3.55	3.63	3.70	3.77	3.87	4.03
	1.0N	3.55	3.67	3.88	3.96	4.12	4.46
$C_3H_6O_2$	1%	3.55	3.67	3.75	3.84	3.96	4.07
	2%	3.55	3.68	3.75	3.70	3.95	4.14
	4%	3.55	3.75	3.86	3.94	4.05	4.34
$Na_2S_2O_5$	500ppm	3.55	3.65	3.74	3.86	3.94	4.03
	1000ppm	3.55	3.67	3.77	3.85	3.92	4.04
	2500ppm	3.55	3.70	3.83	3.89	3.97	4.15

other samples. The best treatment, which gave the lowest sucrose loss value, was 2500 ppm of SO_2 gas. While the least one was10% $Ca(OH)_2$. These findings are in agreement with data reported by **Abou Shady (1994)**. The increase of sucrose percentage in wastes of all chemical treatments may due to the increase of α-amino nitrogen, sodium and potassium and water loss of beet roots during storage. Enzymatic activity, by which sucrose transformed into invert sugar which can inhibit crystallization of sucrose increased sucrose loss in wastes.

Generally, it is recommended to process sugar beet roots immediately after harvest to reduce sugar losses and preserve physical and technological characteristics and to reduce invertase activity which analyze the sucrose to glucose and fructose. If manufacturing is difficult immediately after harvest, the roots should be treated by dipping in sodium metabisulfite (500ppm) for 10 minutes. This can reduce the loss of sugar and preserved the physical and technological characteristics.

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مجلة اتحاد الجامعات العربية للدراسات والبحوث الزراعية ، جامعة عين شمس ، القاهرة ، ١١(١) ، ٣٠٣ - ٣١٤ ، ٢٠٠٣

تأثير بعض المعاملات الكيمائية على التغيرات التي تحدث في الصفات التكنولوجية لجذور بنجر السكر أثناء التخزين

[٢٣]

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١- قسم علوم وتكنولوجيا الأغذية - كلية الزراعة - جامعة عين شمس - القاهرة - مصر

٢- وحدة التصنيع الزراعي - مركز بحوث الصحراء - القاهرة - مصر

تمت هذه الدراسة لتقليل التغيرات الكيمائية ولاطالة فترة الصلاحية لجذور بنجر السكر عقب الحصاد وقبل التصنيع. تم تقسيم الجذور إلى ٦ مجموعات (١٠٠ جذر لكل مجموعة) ثم معاملة المجامع ببعض المعاملات الكيمائية المختلفة (مثل هيدروكسيد الكالسيوم , هيدروكسيد الصوديوم, غاز ثاني أكسيد الكبريت, حمض البروبيونيك, ميتاباى سلفيت الصوديوم بتركيزات مختلفة) والتخزين في الجو العادي لمدة ١٥ يوم.

وتم دراسة التركيب الكيماوي لجذور البنجر والتغيرات آلتي تحدث أثناء فترة التخزين وقد أظهرت النتائج آن معاملة الجذور بمحلول ميتاباى سلفيت الصوديوم بتركيز ٥٠٠ جزء في المليون كانت افضل المعاملات من حيث المحافظة على الوزن من الفقد ونقاوة العصير والجودة والسكر

المسترجع بينما سجلت المعاملة بمحلول ٥% هيدروكسيد الكالسيوم أعلى قيم للصلابة أما بالنسبة للسكر المفقود في المولاس سجلت المعاملة بثاني أكسيد الكبريت ٢٥٠٠ جزء في المليون اقل قيم للفقد.

لذا فانه من الضروري تصنيع بنجر السكر مباشرة بعد الحصاد لتقليل فقد السكر والحصول على صفات تكنولوجية جيدة و في حالة تعذر ذلك يجب معاملة الجذور بالغمر في محلول ميتاباى سلفيت الصوديوم ٥٠٠ جزء في المليون لمدة ١٠ دقائق لتقليل الفقد في السكر أثناء التخزين و المحافظة على الصفات التكنولوجية الجيدة أثناء إتمام عملية التصنيع.

تحكيم: أ.د على صالح ضبش
أ.د حمدى عبد اللطيف