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APPLICATION OF LOW DENSITY POLYETHYLENE FILMS: 1- THEIR MECHANICAL, PHYSICAL AND ANTIMICROBIAL PROPERTIES

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ABSTRACT

This study was carried out to evaluate low density polyethylene (LDPE) films, of 180 microns thickness, when impregnated with potassium sorbate or calcium propionate (at the concentrations of 1,2,3 and 4% w/w) which were processed by the blown film extrusion process. LDPE films were examined for their physical properties (*i.e. haze, gloss,* water vapor permeability, oxygen permeability, heat sealability and shrinkability) besides, their mechanical properties (i.e. tensile strength, elongation, slip, tear strength and burst strength). Mechanical and physical properties were *significantly affected* by the incorporation of potassium sorbate or calcium propionate up to 4% (w/w) in the films as their haze, water vapor permeability, slip and burst strength increased, while their gloss, heat sealability, shrinkability, tensile strength, elongation, *tear strength and oxygen permeability* decreased as the concentration of potassium sorbate or calcium propionate increased in the films. LDPE films were also tested against some species of microorganisms on agar plate medium, from which it was noticed that, the *inhibitory effect of the films against* the growth of *Aspergillus flavus, Fusarium oxysporium, Penicillium chrysogenum* DSM 844 in a disk test was higher than that in case of *Bacillus subtilis, E. coli* and *S. aureus* as the concentration of potassium sorbate or calcium *propionate increased up to 4%.*

Keywords: Antimicrobial packaging films, low density polyethylene, calcium propionate, potassium sorbate.

INTRODUCTION

Low density polyethylene (LDPE) is a low cost film with moderate tensile strength and clarity. It offers a good moisture protection, poor oxygen barrier and is unaffected by mineral *and essential oils (El-Sayed, 1998).*

Antimicrobial and oxygen scavenging packaging systems are two of the most promising applications of active food packaging. Some preservatives can be used as active substances incorporated into or onto polymeric packaging materials such as sorbates, benzoates, propionates and parabens. *These preservatives may* be incorporated in packaging materials where they are slowly released into the food products during storage and distribution (Floros *et al.*, 1997 and Han and Floros, 2000).

Sorbic acid and its salts (potassium and calcium sorbate) *are permitted* as preservatives in numerous processed foods. It has a conjugated system of double bonds which makes it susceptible to nucleophilic attack, and sometimes giving mutagenic products (Ferrand *et al.*, 2000).

Potassium sorbate is known to inhibit the growth of molds, yeast and bacteria. *It is more effective in inhibiting the growth of* molds than the growth of yeast and bacteria (Sofos, 1989). In a different study, application of edible corn starch film containing potassium sorbate and lactic acid inhibited the growth of *S. typhimurium* and *E. coli* 0157:H7 on poultry (Baron, 1993). Also, whey protein isolate (WPI) films (pH 5.2) containing 0.5 to 1.5% sorbic acid (SA) or P-aminobenzoic acid (PABA) were found to inhibit the growth of *L. monocytogenes*, *E. coli* 0157: H7 and *S. typhimurium* DT104 on acidified (pH 5.2) Trypticase Soy Agar containing 0.6% yeast extract and on both bologna and summer sausage slices. These films, which retained their antimicrobial activity for 21 days, also showed considerable promise in extending the shelf life of sliced bologna and summer sausages. It was found that percent elongation of the film increased as a result of contact with bologna and summer sausages, while tensile strength sharply decreased (Cagri *et al.*, 2001 and 2002).

Also, propionates were among the first monocarboxylic fatty acids to be used as antimicrobial agents in foods against molds and had little activity against yeast and bacteria (Robach, 1980 and Halek and Garg, 1989). Besides, antimicrobial chitosan films containing acetic or propionic acids reportedly inhibited the growth of *Enterobacteriaceae* and *Serratia liquefaciens* on bologna and pastrami (Ouattara *et al.*, 2000) during 168 h of storage at 5°C.

In this concern, an antimicrobial film using LDPE resin after being mixed thoroughly with potassium sorbate was then extruded and its tensile properties, transparence and antimicrobial activity were measured to examine the adaptability of the prepared films as packaging materials. As found by Han and Floros, (1997) the tensile properties were not affected significantly by the incorporation of potassium sorbate up to 3% in the film. However, transparence of the film decreased as the concentration of potassium sorbate increased. The antimicrobial film reduced the growth rate and maximum growth of yeast, and extended the lag period before mold growth was apparent. Therefore, it could prevent or reduce the rate of microbial spoilagte in low viscosity liquids and on the adjacent surface area of solid food products and thus prolong their shelf life when used as a packaging material.

Therefore, this work was undertaken to study the feasibility of incorporating potassium sorbate or calcium propionate into low density polyethylene films, to measure the mechanical and physical properties of the produced films and also to determine the growth inhibiting effect of the prepared impregnated LDPE films.

MATERIALS AND METHODS

1. Microbial cultures: *Penicillium chrysorgenum* DSM 844, *Aspergillus flavus, Fusarium* oxysporium, *Staphylococcus aureus, Bacillus subtilis* and *Esherichia coli* were obtained from the Microbial Resources Center (MIRCEN), Faculty of Agriculture, Ain Shams Univ., Egypt. The cultures were maintained at 5°C on Sabouroud dextrose agar slants for fungi and nutrient agar slants for bacteria. The cultures were reactivated monthly on the suitable medium for each microorganism.

2. Media and chemicals:

Nutrient agar, Sabouroud dextrose agar and violet red bile dextrose agar were purchased from Oxoid, Hampshire, U.K. Potassium sorbate (Mw 150.22) and calcium propionate (Mw 186.22) were purchased from Sigma Chemicals Co., U.S.A.

3. Fabrication of low density polyethylene films incorporated with potassium sorbate or calcium propionate:

Fine powders of potassium sorbate or calcium propionate (60-90 microns) were hand mixed with low density polyethylene powder (Density=0.915 g/cm^3, Mw=35000, melt index =0.22 and Tm=115^{o}C, Polychemical Corporation R 41661 NOVATEC LE 542 H, Japan) in concentrations of 0%, 1%, 2%, 3% and 4% (w/w). The mixtures were then extruded by the blown film extrusion process in a single screw extruder in Zarka Plast Co., Egypt, which was 40 cm long and had a diameter of 5 cm at a screw speed of 50 rpm and the temperature was maintained in the range of 95 to 120^{o}C during the extrusion process of the films. The film produced by this system was 10 to 15 cm wide and had a thickness of 180 microns.

4. Measurement of packaging tests:

The produced films were subjected to several packaging tests and the average of triplicate values for each test was calculated.

4.1. Physical properties:

4.1.1. Thickness test: The thickness of the LDPE film was measured by a digital Micrometer (0.0005-0.001) purchased from Miluloyo Company, Japan, in the Food Technology Institute, Agricultural Research Center, Giza, Egypt.

4.1.2. Haze & gloss were measured using spherical haze and gloss meters:

4.1.3. Water vapour permeability at 75% RH/25^{o}C and 90% RH/28^{o}C, oxygen permeability (cc/m^2.24 hr) was measured in Food Development Center (Holding Company for Food Industries), Kaha City, Egypt, using Carlo Erba GC 6000 (Vega Series 2).

4.1.4. Heat sealability was measured using a sensitive tensile testing machine and shrinkable tests, were determined in Plastic Development Center, Alexandria, Egypt, according to the methods described by ASTM-D-A 1003 (1987 a) & B.S. 2782: part 5 (1980 a) ASTM-D-895 (1987 b) & B.S. 2782: parts 5 (1980 b), ASTM-D-1434 (1987 c), Briston and Katan (1985) & ASTM-F-88 (1987 d) and ASTM-D-1505-60T (1987 e) & B.S. 2782; part 5 (1980 b), respectively.

4.2. Mechanical properties:

Tensile strength & elongation and slip (coefficient of friction) were measured using a universal testing machine while the tear strength and burst strength, were measured using a Burst-resistance instrument, all determined according to the methods of ASTM-D-882-83 (1987 f) & B.S. 2782-301E(1980 c), ASTM-D-1984-63 (1987 g), ASTM-D-1922-61T (1987 h) and B.S. 1133 (1980 d) respectively.

4.3. Disk-diffusion test of antimicrobial activity for LDPE films:

The studied treated films were tested for their inhibiting effect against some microorganisms such as: *Penicillium chrysogenum* DSM 844, *Aspergillus flavus, Fusarium oxysporium, Staphylococcus aureus, Bacillus subtilis* and *Escherichia coli.* Subcultures of each fungal or bacterial strain were spread on the agar surface of the petri plate as described by Koch (1981) and disc shaped films, impregnated with or without the studied used preservatives (1x1 cm) were then placed on the surface of each agar plate as described by Lee *et al.*, (1998). The inoculated agar plates were then incubated at 25°C and 37°C for fungi and bacteria strains respectively, for 3 days. The clear zone formed around the film on the media was recorded as an indication of the inhibitory effect of the studied impregnating preservative against the studied fungi or bacteria.

4.4.Statistical analysis

The obtained data was statistically analyzed by using analysis of variance and least significant differences (LSD) as described by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Physical properties of LDPE films:

The *physical properties of the studied LDPE films, treated with either* potassium sorbate or calcium propionate, were evaluated and the obtained results are shown in (Table, 1), from which it could be noticed that, the haze values of such films significantly increased ($P<0.05$) as the concentration of either potassium sorbate or calcium propionate increased from 1 to 4%.

Moreover, it could be also observed that the LDPE films with potassium sorbate attained higher haze values (46.5% to 60.0%) than those of the LDPE films containing calcium propionate (40.0% to 52.0%) at the different concentrations used. Meanwhile, the haze value for the control (i.e. the untreated film) film increased only by 22%. These results are in agreement with those obtained by Han and Floros (1997) who found that, the transmittance of LDPE films was reduced on increasing its content of potassium sorbate concentration up to 3% after which the treated films lost their transmittance. Therefore, the incorporation of potassium sorbate or calcium propionate in the treated films rendreed the LDPE more opaque and reduced their transparency, *which would affect their suitability as packaging* materials especially for foods or items where the apperance of the commodity is of some importance to the consumer.

Gloss is an important factor in packaging films where it is a measure of the ability of the film to reflect incident light spectrally. A high gloss will, therefore, reflect a sharp image of any light source and will thus give rise to pleasing sparkles on the film (Briston and Katan, 1985).

Data (Table 1) reveals that increasing the concentrations of either potassium sorbate or calcium propionate in the treated LDPE films (at concentrations ranging from 1% to 4%) resulted in a significant affect ($P<0.05$) on their measured gloss which decreased materially with every increase of the added preservative. Therefore, the incorporated potassium sorbate or calcium propionate made the LDPE films more opaque and caused them to lose their transparency and their gloss.

Table (1): Physical properties of low density polyethylene (LDPE) films (180 microns) *impregnated with different* concentrations of potassium sorbate or calcium propionate.

Characteristics / Concentrations	Haze % 90°		Gloss % 45°		Water vapor permeability ($g/m^2/48$ hrs) 75% R.H. 25°C		Water vapor permeability ($g/m^2/48$ hrs) 90% R.H. 28°C		Heat sealability ($Kg/cm^2/sec.$)		Shrinkability % Longitudinal direction		Shrinkability % Cross direction	
	K.S	Ca.P	K.S	Ca.P	K.S	Ca.P	K.S	Ca.P	K.S	Ca. P	K.S	Ca.P	K.S	Ca.P
1%	46.5	40.0	42.5	36.5	0.25	0.35	0.40	0.50	160	155	2.70	2.80	3.60	3.80
2%	52.0	44.0	37.4	33.2	0.30	0.40	0.55	0.65	155	150	2.20	2.40	3.10	3.30
3%	58.0	48.0	32.5	27.5	0.40	0.50	0.65	0.75	150	145	1.90	2.00	2.60	2.80
4%	60.0	52.0	26.8	24.5	0.55	0.60	0.80	0.90	144	141	1.50	1.80	2.20	2.40
0% (control)	25		64		0.20		0.30		165		3.0		4.0	
L.S.D.for concentrations	3.3175		1.7782		0.0389		0.0419		2.3770		0.1673		0.1565	
L.S.D.for substances	4.0395		4.3182		0.0878		0.1202		4.7886		0.3212		0.4528	
L.S.D for interaction	7.4481		8.4398		0.0971		0.1377		5.8103		0.3596		0.4674	

K.S= potassium sorbate, Ca.P = Calcium propionate

Both K.S. & Ca.P. *were used to impregnate the same film.*

Oxygen permeability was 1063, 965 and 707 cc/m^2. 24 hr at 22-25°C for control LDPE film, LDPE film with 4% calcium propionate and LDPE film with 4% potassium sorbate, respectively.

This effect may result in a serious disadvantage in applying LDPE films in see-through packaging when the LDPE films containing potassium sorbate or calcium propionate is to be applied as plastic packaging materials.

Table (1) also reveals that, water vapor permeability increased significantly as the concentration of either potassium sorbate or calcium propionate increased in the treated LDPE films (up to 4%) in comparison to the control film. Maximal water vapor permeability values (0.8 and 0.9 $g/m^2/48$ hrs at 90% RH / 28°C) were noticed with incorporation of 4% potassium sorbate or calcium propionate in LDPE films, respectively, while, the untreated LDPE film attained only 0.30 $g/m^2/48$ hrs at 90% RH/28°C. This effect could have a significant effect when such treated films are used for packaging any food item sensitive to water absorption or water loss.

On the other hand, the highest oxygen permeability was detected with the control untreated LDPE film (being 1063 $cc/m^2/24$ hr at 22-25°C). Meanwhile, O_2-permeability for LDPE films containing 4% potassium sorbate or calcium propionate was 707 and 965 hr at 22-25°C, respectively. From these results, it could be concluded that LDPE films impregnated with either potassium sorbate or calcium propionate combine both the properties of low oxygen permeability and high water vapor permeability. Therefore, incorporation of either potassium sorbate or calcium propionate could materially affect the shelf life of the food item because of the significant effect of either salt on both oxygen and vapor permeability during prolonged shelf standing in spite of the antimicrobial effect of both salts when impregnated in such films. Hotchkiss (1988) reported similar conclusions with respect to quality of packaging films and shelf life of packaged food items. In comparison to O_2-permeability and water vapor permeability values for LDPE films containing 1% up to 4% potassium sorbate or calcium propionate exhibited lower O_2-permeability values and higher water vapor permeability than untreated LDPE film. Therefore, these films could be considered as suitable packaging materials, which maintain the moisture content at a natural level and reduce both surface desiccation which causes discoloration and fat oxidation of the packaged food.

Heat sealability of packaging film is one of the most important properties when considering its use in wrapping or bag making equipment. Besides, the integrity of the seal is also of tremendous importance to the ultimate package (Briston and Katan, 1985). According to the results in (Table 1), the heat sealability values of LDPE films containing the incorporated antimicrobial agents, i.e. potassium sorbate or calcium propionate, were found to be reduced significantly as the concentration of either salt increased in comparison with the control LDPE film. Yet the antimicrobial films continued to have some good sealing properties. The values of heat sealability were found to range between 141 and 160 $Kg/cm^2/sec.$, in the LDPE films containing 1 to 4% potassium sorbate, respectively. Besides, it was found to range between 141 and 155 $Kg/cm^2/sec.$ in the LDPE films containing calcium propionate using the same 1 to 4% salt concentration. While, the relevant figures in case of the control film was found to be 165 $Kg/cm^2/sec.$. Therefore, the antimicrobial LDPE films containing either potassium propionate or calcium propionate (in the concentrations of 1 to 4%), were found to have good sealing properties which could be advantageous for these films.

The same data in (Table,1) indicates that shrinkability ratios (longitudinal and cross directional) of LDPE films, incorporated with potassium sorbate or calcium propionate, were also significantly reduced when compared with those of the control untreated film. This effect leads to formation of air pockets surrounding packaged frozen poultry, causing freezer burn, therefore these films could not be used for frozen poultry packaging as previously reported by Robertson (1992).

Besides, mechanical properties, i.e. tensile strength, elongation, slip, tear strength and burst strength of LDPE films as affected by different concentrations of potassium sorbate or calcium propionate (0,1,2,3 and 4%) are listed in (Table, 2).

Tensile strength is the amount of force necessary to break a strip of the tested material and elongation at break is the percent increase in length of the sample at the instant of break. Obtained results in (Table 2) reveal that, the tensile strength (Kg/cm^2) and elongation (%) properties of the studied LDPE films were significantly affected as the concentrations of either potassium sorbate or calcium propionate in the film was increased up to 4% as compared with the control LDPE film. The tensile strength of the studied antimicrobial polymers is assumed to be related to the volume of their amorphous regions with respect to concentration of the incorporated small active agents such as potassium sorbate (Han and Floros, 1997). Moreover, the force needed to pull the LDPE films with potassium sorbate was higher than that needed for LDPE films with calcium propionate at the different concentrations applied (i.e. 1 to 4%). On the other hand, the obtained results (Table 2) indicate that, the antimicrobial films containing potassium sorbate had the higher increase in length at the instant of break compared to the other LDPE film containing calcium propionate at the same different concentrations applied (1 to 4%). Therefore, incorporation of potassium sorbate or calcium propionate produced films that were weaker and less elastic (or less flexible) than the control untreated film.

The slip (which equals 1/coefficient of friction) is a measure of the ease with which the surface of one material will slide over another, thus films which move easily over various surfaces have a low coefficient of friction or slip (*Robertson, 1992*).

Data in the same (Table 2) reveals a significant increase in slip values of LDPE films containing potassium sorbate or calcium propionate on increasing their concentrations. On the other hand, the lowest value of slip was observed for the control LDPE film which showed only 2.8 Kg/cm^2, which increased to 3.7 Kg/cm^2 and 3.5 Kg/cm^2 in LDPE films incorporated with either potassium sorbate or calcium propionate at the 4% concentration respectively. These results agree with the findings of Robertson (1992) who reported that, the frictional properties of a film are important, both during its passage through printing and packaging machines, and after being made up into a bag, sack or overwrap. In practice it is usual to speak of a film's slip properties rather than coefficients of friction, one being the reciprocal of the other.

Table (2): Mechanical properties of low density polyethylene (LDPE) films (180 microns) impregnated with different concentrations of potassium sorbate or calcium propionate.

Characteristics / Concentrations	Tensile strength (Kg/cm^2)		Elongation (%)		Slip (Kg/cm^2)		Tear Strength (Kg/min)		Burst strength (Kg/cm^2)	
	K.S.	Ca.P	K.S	Ca.P	K.S	Ca.P	K.S	Ca.P	K.S	Ca.P
1%	157	155	210	208	3.20	2.95	0.46	0.42	4.8	5.0
2%	156	153	209	207	3.40	3.10	0.42	0.40	5.2	5.4
3%	154	152	208	206	3.50	3.20	0.38	0.36	5.5	5.8
4%	151	150	205	203	3.70	3.50	0.34	0.30	5.8	6.1
0% (control)	158		212		3.0		0.44		4.80	
L.S.D. for concentration	1.0368		1.5559		0.1336		0.222		0.1584	
L.S.D. for substances	1.7795		1.7795		0.1832		0.430		0.3333	
L.S.D. for interaction	2.0571		2.1484		0.1970		0.0414		0.3388	

K.S=potassium sorbate, Ca.P = Calcium propionate.
Slip = 1/coefficient of friction.

The characteristic of good slip is indicated by a relatively low coefficient of friction. High slip is normally required for a number of reasons: i.e. it eases the passage of the film through packaging equipment, and facilitates the movement of finished packages over various surfaces as they are ejected from packaging machines. However, there are also occasions when low slip is a definite requirement. For example, woven plastic sacks and plastic wraps around frozen carcasses are often required to be stacked to heights of several meters, any tendency towards slip under these conditions can be a real danger.

Furthermore, tear strength is an important property of packaging films and a knowledge of both resistance to tear initiation and tear propagation is often helpful (Robertson, 1992).

Furthermore, the same results in (Table, 2) reveal that, the tear strength for LDPE films treated with the two studied antimicrobial agents significantly decreased as their concentrations increased, being (0.46, 0.42, 0.38 & 0.34) and 0.42, 0.40, 0.36 & 0.30) Kg/min for LDPE films containing 1,2,3 & 4% of potassium sorbate or calcium propionate respectively. Meanwhile, the tear strength of the control LDPE film was found to be 0.44 Kg/min only.

In addition, the burst strength of any material or film is assumed to be the pressure measured at the moment of failure of the film and is essentially a measure of the capacity of the film to absorb energy (Briston and Katan, 1985). From the obtained data (Table 2) it was observed that, the control LDPE film had the lowest value of burst strength (4.7 Kg/cm^2), while, the burst strength for the other studied antimicrobial treated LDPE films ranged from 4.8 Kg/cm^2 to 6.1 Kg/cm^2, from which , it could be concluded that the burst strength of LDPE films incorporated with potassium sorbate or calcium propionate significantly increased as the concentrations of the studied antimicrobial agents increased, where it reached 5.8 Kg/cm^2 and 6.1 Kg/cm^2 at the highest applied concentration of 4% potassium sorbate or calcium propionate, respectively.

Antimicrobial properties of LDPE films containing potassium sorbate or calcium propionate:

Results (Table 3) show that LDPE films containing different concentrations of potassium sorbate or calcium propionate (up to 4%) showed a positive antimicrobial activity against the growth of *Aspergillus flavus, Fusarium oxysporium* and *Penicillium chrysogenium*. As recorded in (Table, 3) exhibition of antimicrobial activity against gram positive bacteria, i.e., *S. aureus* and gram negative bacteria, i.e., *E. coli* was observed at concentrations ranging between 2 and 4% of potassium sorbate or calcium propionate in the films. Similar results were obtained by Han and Floros (1997) and El-Akel *et al.* (2001) who found that the antimicrobial LDPE films (containing 1% potassium sorbate) reduced the growth rate and maximum growth rate of yeast and extended the log period before mold growth was apparent which could be due to the release of potassium sorbate from antimicrobial LDPE films into the microbial media. Also, Lee *et al.* (1998) found that, the antimicrobial LDPE films (containing grape fruit seed extract) showed inhibitory activities against *E. coli* and *S. aureus* in the disk test.

Table (3): Antimicrobial activity of low density polyethylene (LDPE) films (180 microns) impregnated with different concentration of potassium sorbate or calcium propionate.

Test organisms	Control LDPE film	LDPE films with potassium sorbate				LDPE films with calcium propionate			
		1%	2%	3%	4%	1%	2%	3%	4%
Penicillium chrysogenum DSM 844	-	+	+	++	++	+	+	+	++
Aspergillus flavus	-	+	+	++	++	+	+	+	++
Fusarium oxysporium	-	+	+	++	++	+	+	+	++
Staphylococcus aureus	-	-	-	++	++	-	-	+	++
Bacillus subtilis	-	-	-	++	++	-	-	+	++
Esherichia coli	-	-	-	++	++	-	-	+	++

-, no reaction +, clear zone of 1.0-2.0 mm
++, clear zone of 2.0-3.0 mm.

Also, data in (Table, 3) clearly indicates that the clear zones around the films on the plate medium, inoculated with the tested microorganisms, were wide for LDPE films with 4% potassium sorbate or calcium propionate than those with 1% to 3% concentrations only. Moreover, incorporation of potassium sorbate only at 3% into LDPE films showed a more inhibitory effect against the tested microorganisms than LDPE films with 3% calcium propionate only.

Finally from the above-mentioned results and discussions it could be concluded that the incorporation of potassium sorbate or calcium propionate into LDPE films up to 4% (of each or both) improved some of their mechanical and physical properties, i.e. decreasing shrinkability, oxygen permeability as well as increasing their slip and burst strength. Besides, LDPE films containing potassium sorbate or calcium propionate showing some inhibitory activities against some microorganisms, is promising for the use of such impregnated films to preserve and prolong the shelf-life of such food items when used as packaging films.

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أغلفة البولى اثيلين منخفض الكثافة المضادة للكائنات الحية الدقيقة:
١ – خواصها الطبيعية والميكانيكية والمضادة للكائنات الحية الدقيقة

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فى هذه الدراسة تم انتاج وتقييم اغلفه البولى اثيلين منخفض الكثافة بسمك ١٨٠ ميكرون والمحتـــوى على مواد مضاده للكائنات الحية الدقيقة مثل سوربات البوتاسيوم وبروبيونات الكالسيوم بتركـــيزات ١، ٢، ٣، ٤% (وزن/ وزن) وتم تصنيعها بواسطة النفخ بالبثق الحرارى ثم اختبار الخواص الطبيعية لـــهذه الأغلفـة مثل درجة التغبش، درجة اللمعان، درجة النفاذية لبخار الماء والأوكسجين ودرجة اللحام، درجـــة الانكمـــاش والخواص الميكانيكية مثل المقاومة للشد والاستطاله، المقاومة للانزلاق ، قوة التمزق والانفجـــار. أظـــهرت النتائج أن التغيرات فى الخواص الطبيعية والميكانيكية كانت معنويه بزيادة تركيز كل من سوربات البوتاسيوم أو بروبيونات الكالسيوم فى إغلفة البولى اثيلين حتى تركيز ٤% حيث تزيد كل من درجة التغبـــش والفانيـــة لبخار الماء ودرجة الانزلاق وقوة الانفجار وتقل كل من درجة اللمعان ودرجة اللحـــام ودرجـــة الانكمـــاش والمقاومة للشد والاستطاله وقوة التمزق والنفاذية للأوكسجين بزيادة تركيز المادة الحافظة فى أغلفـــه البولـــى اثيلين منخفض الكثافة.

وتم دراسة التأثير المثبط لهذه الأغلفه على بعض سلالات الفطر مثل :
spergillus flavus, Penicillium chrysogenum DSM 844, *Fusarium* oxysporium
وسلالات البكتريا مثل *E. coli, Bacillus subtilis, S. aureus* وكان التاثير المثبط لهذه الأغلفة علـــى سلالات الفطر أعلى من تأثيرها المثبط على سلالات البكتريا حيث يزداد التاثير المثبط بزيادة تركيز كل مـــن سوربات البوتاسيوم أو بروبيونات الكالسيوم حتى ٤% لكل منهما على حده.