DEVELOPMENT OF PACKAGING MACHINE FOR FRUITS AND VEGETABLES

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ABSTRACT

Moisture loss of fresh fruits and vegetables is a main cause of deterioration. It resulted not only in the direct quantitative loss, but also in change in appearance, texture and nutrition. To reduce the loss of moisture content during the distribution in the market, fresh products are packaged using plastic films. But, most of the fresh products are packaged manually in Korea.

In order to minimize the labor requirement, the packaging machine for fruits and vegetables was developed and tested. Prototype was composed of film feeding unit, bag former, products feeding conveyor, film feeding roller, center sealer, end sealer and discharge conveyor. Green peppers, carrots and perilla leaves were tested with prototype. Prototype could pack 1780, 1390, 1780 bags per hour at the feeding speed of 0.08m/s respectively and 2250, 1810, 2640bags per hour at the feeding speed of 0.10m/s respectively. And packaging speed of green peppers and carrots was improved by 3.7 and 3.4 times compared with manual packaging. The packaging condition with the prototype was good and the products had almost no damages.

Key Word : Fruits and Vegetables, Packaging, Retail packaging, Packaging machine, Plastic Film

INTRODUCTION

Due to the conspicuous trend toward nuclear family, appearance quality is most important; to receivers and market distributors, they are also keenly interested in firmness and long storage life. Consumers consider good quality fruits and vegetables to be those that look good, are firm, and offer good flavor and nutritive value. Although consumers buy on the basis of appearance and depend upon good edible quality, assurance of safety of the products is extremely important to the consumers.

Moisture loss of fresh fruits and vegetables is the main cause of deterioration. It resulted not only in the direct quantitative loss, but also in change in appearance, texture and nutrition. To reduce the loss of moisture content during the distribution in the market, fresh products are packaged using plastic film.

Many plastic films are available for packaging, but relatively few have been used to wrap fresh products, and fewer have gas permeability that makes them suitable to use for MAP. Because O_2 content in a MA package is typically reduced from an ambient 21 percent to 2 to 5 percent, there is a danger that CO_2 will increase from ambient 0.03 percent, to 16 to 19 percent in the package. This is because there is normally a one-to-one correspondence between O_2 consumed and CO_2 produced. Because such high levels of CO_2 would be injurious to most fruits and vegetables, an ideal film must let more CO_2 exit than it lets O_2 enter. The CO_2 permeability should be about 3 to 5 times the oxygen permeability, depending upon the desired atmosphere.

Most materials used for consumer unit packaging are plastic films composed of two or more types of film material combined into a single film. Low-density polyethylene (LDPE) is the main film used in packaging fresh products. However, most of the fresh products are packaged manually using plastic film in Korea.

Advantages of retail packaging in the production site are increased productivity, improved quality of products, reduced cost, and so on. But retail packaging is hardly worked in habitat, because packaging machines for fresh product are insufficient and packaging labor is not enough in habitat.

The object of this study, in order to minimize the labor and maximize the efficiency of fresh fruits and vegetables handling process, is the development and test of a packaging machine for fruits and vegetables.

MATERIALS AND METHODS

Design condition of packaging machine for fresh products

Fresh products have irregular shape although the same degree, easily get an injury and continuously ripe after harvest. Thus, packaging materials for fresh products must have control of H_2O, O_2 and CO_2, also have to maintain freshness. And packaging machines have got to have the characteristics which are able to work continuously without changing operate-method and mechanical parts, not to injure to the fresh products.

Prototype manufacture

As shown in Fig. 1., the prototype developed in this study was composed of a film feeding unit, a bag former, a products feeding conveyor, a film feeding roller, a center sealer, an end sealer, a discharge conveyor and a controller with PLC(Programmable Logic Controller). The process of packaging consisted of film feeding, bag forming, center sealing and end sealing with cutting. The products were laid over the film at the feeding conveyor for feeding the products.

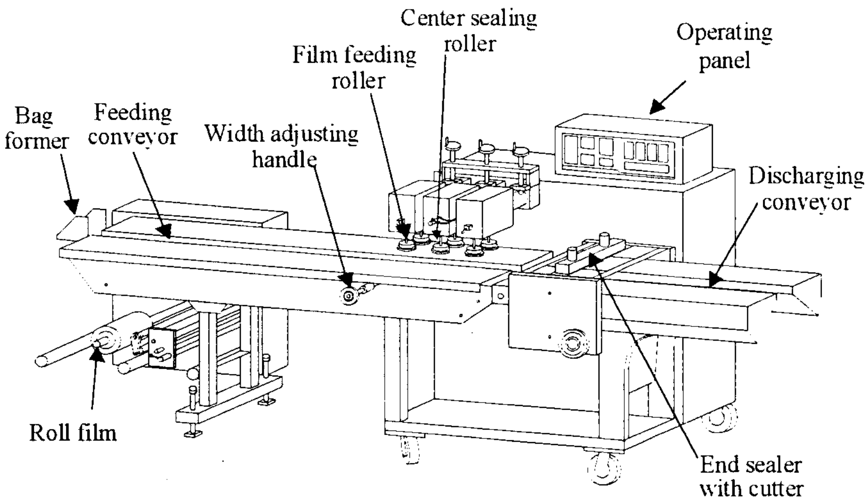

Fig. 1. Schematic diagram of prototype

In order to reduce transfer of heat from the center sealing roller to the fresh products, the center sealing roller was placed above the conveyor. And, to package long products, enough distance was put between the center sealing unit and the end sealer.

To cut side-sealed-film(after center sealing) according to product length, the product detecting-sensor was located between the center sealer and the end sealer.

The end sealer was manufactured by an oval jaw motion, assured a long dwell time and hermetic seals with low-density polyethylene films as well as with laminates and co-extruded films. And, the type of end sealer with cutter developed in this study was impulse sealing. The concept of impulse sealing is as follow; the first the sealing bars close, then within 50 ms the nichrome wire heat up, causing the packaging material to melt. The nichrome wire essentially melts the material in half under pressure causing the material to separate around the cold wire. The heat is then turned off and the material cools under pressure, while the seal bars are still closed. Once the material has resolidified, the bars open and the seal is complete. This causes the seal and cut in one process and eliminates the need for a knife cut.

The intermittent long-dwell sealing head was driven by an electromagnetic clutch and controlled by the output signal of a barrier photo sensor.

Prototype could control working speed in compliance with worker's skill, control sealing temperature precisely according to the films and count packaged-product. Specification of the prototype is shown in Table 1.

Table 1. Specification of prototype

Items	Specification
Prototype size	4,000(L) × 1,230(W) × 1,530(H) mm
Film width	100 ~ 350 mm
Feeding conveyor size	2,240(L) × 220(W) × 820(H) mm
Film feeding roller	Ø120 mm
Center sealing roller	250W(Diameter : ø120, Sealing width : 3 mm)
End sealer & cutter	250~500W, Length : 240mm, Thickness : 0.9 mm
Discharge conveyor size	830(L) × 220(W) × 820(H) mm
Packaging size	100~800(L) × 50~150(W) × 10~90(H) mm
Driving motor	0.75kW(220V/3Ph)

Test materials

The test products used in this study were green peppers, washed carrots and perilla leaves. Physical characteristics were shown in Table 2. Packaging material was low-density polyethylene (LDPE) film, 300mm width, 0.05mm thickness.

Table 2. Physical characteristics of products tested in this study

Produces	Weight(g)	Length(mm)	Diameter(mm)		Remark
			Long	Short	
Green pepper	8~14	98~129	16~17	-	-
Washed carrot	116~463	135~285	38~66	15~43	-
Perilla leaves	45~83	97~132	-	-	Weight of dozen leaves

Test method

Working performance was tested according to parameter conveyor speed at 0.08, 0.10, 0.13m/sec and test material respectively. The packaging performance was tested for ten minutes and was converted into the packaging amount per hour. Packaging conditions indicated as "Good" and "Bad". The "Good" defined in this study meant perfect sealing and smart-face of sealing and cutting. And the "Bad"s were the others of "Good" ones. In order to compare freshness of packaged green pepper and carrot with that of non-packaged green peppers and carrots, the weight of the products that were in a cold storage room was measured for 25days. The cold storage room was Temp. 4~6℃, RH 90%.

RESULTS AND DISCUSSION

Working performance of variable feeding speed

As shown in Table 3 , prototype could package 1780bags of green pepper, 1390bags of carrot, and 1780baga of perilla leaves per hour. At that time, the feeding speed was 0.08m/s. And prototype could package 2250bags of green pepper, 1810bags of carrot and 2640 bags of perilla leaves per hour at the feeding speed of 0.10m/s respectively. The packaging condition with the prototype was good and the products had almost no damage.

Prototype could not package every product at the feeding speed of 1.13m/s. Because the end-sealing was not good, formed-bag was not cut and damage occurred on the fresh products.

The packaging speed of green peppers and carrots was improved by 3.7 and 3.4 times compared with the manual packaging done in Korea.

Table 3. Working performance according to variable speed of feeding conveyor

Speed (m/s)	Produce	Packaging Condition	Damage Ratio(%)	Working Performance (bags/hr)	Remark
0.08	Green pepper	Good	-	1,780	
	Carrot	Good	-	1,390	
	Perilla leaves	Good	-	1,780	
0.10	Green pepper	Good	-	2,250	Green pepper feeding was needed two workers.
	Carrot	Good	-	1,810	
	Perilla leaves	Good	-	2,640	
0.13	Green pepper	Bad	15	2,770	Sealing and cutting was bad
	Carrot	Bad	12	2,260	
	Perilla leaves	Bad	-	-	

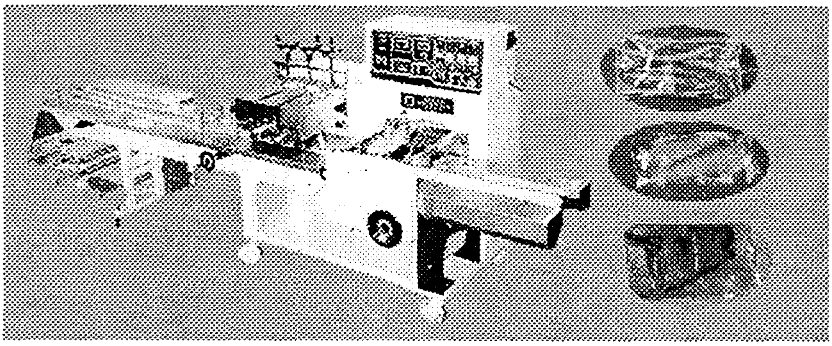

Fig. 2. Photo of prototype and packaged products by prototype

Weight loss during storage

The result of the storage test was shown in Fig. 3. and Fig. 4. After 25-days storage, the weight-loss-ratio of products packaged with prototype was 99.2, 98.9% of the initial weight, while the weight-loss-ratio of non-packaged products was 87.0, 94.0% of the initial weight.

These results showed that the packaging of plastic film on fresh products could significantly prevent weight loss of fruits and vegetables.

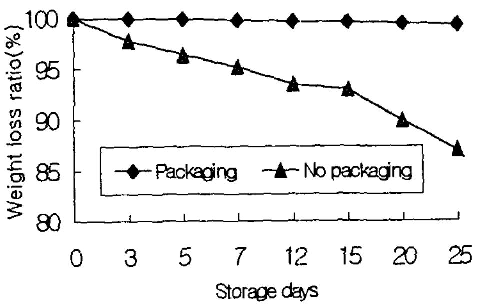

Fig. 3. Weight loss rate of during storage for green pepper

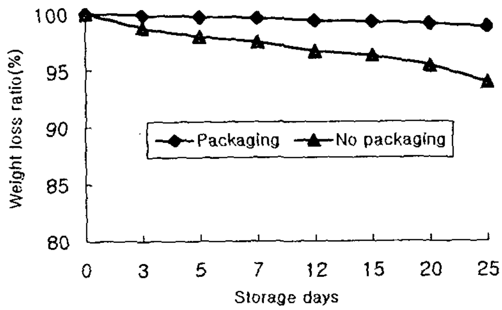

Fig. 4 Weight loss rate of during storage for carrot

CONCLUSIONS

A modified atmosphere is one of the most advantageous ways of keeping perishable products fresh. The basic features of this process are hermetic seals, high barrier film and gas injection to modify the oxygen content inside the packs.

In order to minimize the labor requirement, the packaging machine for fruits and vegetables was developed and tested.

The results are summarized as follows:

1. The prototype developed in this experiment was composed of film feeding unit, bag former, products feeding conveyor, film feeding roller, center sealer, end sealer and discharge conveyor.
2. Prototype could pack 1780, 1390, 1780bags per hour at the feeding speed of 0.08m/s respectively, and 2250, 1810, 2640bags per hour at the feeding speed of 0.10m/s respectively. And the packaging condition with the prototype was good and products had almost no damage.
3. The packaging speed of green peppers and carrots improved by 3.7 and 3.4 times compared with the manual packaging done in Korea.
4. The result of the storage test on products packaged with prototype showed that the packaging of plastic film on fresh products could significantly prevent weight loss of fruits and vegetables.

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