Positive impact of plastic packaging on CO_2-emissions

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Content

1 Introduction

Xtend ® modified atmosphere / modified humidity (MA/MH) packaging, developed by Stepac LA Ltd., prolongs the keepability of fresh produce (1). The packaging is designed to provide a produce specific modified atmosphere and modified humidity to prevent quality loss. The benefits of longer cold storage time and shelf life are self evident and include expanding marketability and reducing waste, Nevertheless, there are other benefits associated with the use of Xtend ® packaging that are not so obvious. Prolonging cold storage life often makes it possible to shift from the more common air freight towards other means of transport. The packaging also makes it possible to ship perishable produce without ice (2). Both of these benefits have impact on CO_2-emissions and on transport costs. In this study, financed by Stepac, the impact of two cases on CO_2-emissions are quantified. The first case describes shifting transport of fresh produce from air to sea freight via the use of Xtend ®. The second case compares CO_2-emissions when using Xtend ® iceless packaging as opposed to when using ice during transport of broccoli across the USA.

2 Calculation method

For calculation and comparison of emissions by different means of transport, the 7 step approach by STREAM (3) was used. STREAM focuses on all relevant emissions during the most frequent means of transport. Data for road transport were obtained from Van Essen *et al.* (4). Emphasis was on vehicle emissions but those created during fuel production were also taken into account. The focus was on the differences in emissions by the different types of transport. Emissions during production of the product and the packaging were not taken into account, because these emissions are similar for each transport method and do not affect the emissions caused by the shift in transport.

In the second case in which iceless packaging was compared to ice, production of ice and waxed cartons were not be taken into account since data was unavailable. For the purpose of this study, it was assumed that emissions caused by the packaging material used in the iceless system are not higher than emissions caused by the packaging material used in the ice-packed system.
Only CO_2emissions were considered in this study. CO_2 is one of the emissions that affect climate change. For each shift in transport the CO_2-emissions were calculated as follows: For each vehicle the fuel consumption (MJ/km) was multiplied by the refining emissions of the fuel (g/MJ). The product of both was added to the emissions of the vehicle (g/km). This is then divided by the average used capacity (metric ton) to find the total emissions of the vehicle (g/ton*km) In order to keep the results comparable we assumed that the same volume (one metric ton) was being transported by each modality. The CO_2-emissions between two points in the world were then calculated by multiplying the length of the route by the total CO_2-emissions per vehicle (Equation 1).

Equation 1

$$E_{CO_2} = E_{vehicle} * l_{route}$$

3 Routes

3.1 Case one – air versus sea transport

To calculate the impact on CO_2-emissions of transporting fresh produce by sea freight as opposed to air freight 5 different routes are selected (Table 1). For each route there is an air and a sea variant. The last route (route 5) is a combination of sea and air freight.

Table 1: Routes

Route	Produce	Keepability	From	Via	To	By
1	White Asparagus	40 days in Xtend ®	Peru	-	The Netherlands	Sea freight
	White Asparagus	7 days	Peru	USA (Miami)	The Netherlands	Air freight
2	Mango (ready to eat)	21 days in Xtend ®	Israel	-	The United Kingdom	Sea freight
	Mango (ready to eat)	7 days	Israel	-	The United Kingdom	Air freight
3	Green Onions	21 days in Xtend ®	Egypt	-	The United Kingdom	Sea freight
	Green Onions	7 days	Egypt	-	The United Kingdom	Air freight
4	Cherries	45 days in Xtend ®	Chile	-	The United Kingdom	Sea freight
	Cherries	10 days	Chile	-	The United Kingdom	Air freight
5	Green Asparagus	28 days in Xtend ®	Peru	Jamaica	The United Kingdom	Sea – Air freight combination
	Green Asparagus	7 days	Peru	-	The United Kingdom	Air freight

For sea freight, typically 40ft. reefer containers are used on large (>6000 TEU) container vessels, so this is the modality that was chosen for this study. For air freight, products can be transported by passenger aircraft (belly-hold cargo) or dedicated cargo aircraft. If a passenger aircraft is used, emissions must be divided between passengers and cargo. To avoid added uncertainty caused by an estimation of the average amount of passengers (and their combined weight) on any of the above routes, emissions were calculated for dedicated cargo aircraft only.

Energy consumption for aircraft, and the emissions they create, is greatest during take off. This affects the overall average emissions per kilometer. For this reason, in the STREAM method of calculation, emissions are given for 3 separate distances; short range (2,778 km), medium range (6,482 km) and long range (12,038 km).

In Equation 1 the length of the route (l_{route}) determines the total CO_2-emissions. The distance of each route is the shortest possible connection between the ports of origin and destination. In practice, the distance travelled may vary because of weather and/or other pick-up points. The distances of each route used in this study are given in Table 2 (5&6).

Table 2: Distances

Air				Sea		
Route	Distance	Transit time		Route	Distance	Transit Time
1	10,521 km	1 day		1	11,466 km	25 days
2	3,608 km	1 day		2	6,193 km	7 days
3	3,511 km	1 day		3	5,678 km	10 days
4	11,664 km	1 day		4	13,722 km	25 days
5	11,334 km	2 days		5	11,109 km	14 days

The routes were calculated to reflect reality as best possible. Route 1 is different from other routes, because in the air freight scenario, Miami (United States) is used as a hub. Therefore the total distance is the sum of the distance between Lima and Miami (4,215 km) and Miami and London (7,119 km). The sea leg of route 5 is also unique compared to the other routes, because it is a sea-air combination with Kingston (Jamaica) as the hub. The total distance of transport is the sum of the distance by sea between Callao and Kingston (3,582 km) and the distance by air between Kingston and London (7,527 km). The transit times given in Table 1 are well within the storage limits of Xtend® packages.

3.2 Case two – iceless packing versus packed in ice

Case two compares CO_2-emissions when using Xtend ® MA/MH carton liners (iceless) as opposed to when using ice in waxed cartons during road transport of broccoli across the USA. The iceless system does not affect the transport modality as in case one, but does affect freight capacity. More product can be transported in a single haulage when adopting iceless Xtend® packing. When shipping in ice and waxed cartons, 20 pallets with 64 cartons can be loaded into an eighteen ton truck because of weight limitations. With the Xtend® iceless system 28 pallets can be loaded per truck. A common route for broccoli is from a production area in California (Salinas) to a consumption area in New York (New York) by truck. The length of the route is 4,830 kilometer (7).

4 Results

4.1 Case one – air versus sea transport

By lengthening the storage life of perishable produce with Xtend®, deep-sea ocean freight becomes an option for transporting certain goods around the world. It is not only cost effective, but it also reduces CO_2-emissions released into the atmosphere and thus has a less negative environmental impact. This study calculated that during air freight (routes 1 to 4), an average of 3,919 kilogram CO_2 per ton product is emitted. Of those 3,919 kilograms, 721 kilogram CO_2 is released during the production of the kerosene used to fuel the aircraft. For the same routes (1 to 4) only an average of 229 kilogram CO_2 per ton product is emitted during transport of products if sea freight is used. This calculation includes the 21 kilogram CO_2 emitted to produce the fuel oil. This is a reduction in CO_2-emissions of 94.2%. Even route 5, the sea/air combination, results in a 32.9% reduction of CO_2-emissions due to the shift from air only to combined air and sea freight. The CO_2-emissions for each route and the percentage reduction in CO_2-emissions by shifting to sea freight are presented in Table 3.

Table 3: Emissions

Air Freight			Sea Freight		
Route	CO_2-emission		Route	CO_2-emission	Reduction
1	5,821 kg/ton		1	283 kg/ton	95.1%
2	1,893 kg/ton		2	153 kg/ton	91.9%
3	1,842 kg/ton		3	140 kg/ton	92.4%
4	6,121 kg/ton		4	339 kg/ton	94.5%
5[1]	5,831 kg/ton		5	3,915 kg/ton	32.9%

4.2 Case two – iceless packing versus packed in ice

By eliminating the need for ice during the transportation of broccoli, Xtend® MA/MH carton liners facilitate an increase in freight capacity, amounting to 40% more broccoli in each truck load. This is not only cost effective, but also reduces CO_2-emissions. When ice is used, 359 kg CO_2/ton is emitted, whereas the iceless system emits 215 kg CO_2/ton. This is a reduction of 40% CO_2-emissions per ton of broccoli. In practice, this means the iceless system makes two in five transports from Salinas to New York redundant, saving on CO_2-emissions and costs (diesel, labor, etc.).

[1] *Combination of air and sea freight*

5 Conclusions

Using Xtend® MA/MH packaging, cold storage time and shelf life of fresh produce are prolonged and sea freight often becomes a feasible alternative to air freight. This study proves that by shifting from air to sea freight, CO_2-emissions are significantly reduced. Even when a combination of sea and air freight is employed a reduction of CO_2-emissions is realized. In addition, when shifting from ice packing to an iceless system, freight capacity increases in road transport, which in turn, results in a reduction of CO_2-emisions.

The CO_2-emissions associated with manufacturing the packaging material or producing ice and waxed cartons were not included in this study. The average savings of 94% in CO_2 emissions when shifting to sea transport can surely compensate for the emissions associated with producing the packaging materials. On that note, emissions associated with production of Xtend® should be lower or equal to the amount of CO_2 emitted during the production of other packaging materials (slurry ice, waxed cartons) used for transport with ice.

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