Comparison of the Temperature Conditions in the Transport of Perishable Foodstuff

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Research Article

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Abstract: In this article, the temperatures in transport of different types of perishable foodstuffs will be compared. The comparison will be made based on the evaluation of measurement data from the remote probe and compared with the temperature measured by a thermograph installed in the vehicle. The results will be compared with a tolerance listed in the individual regulations, laws and Agreement ATP (Agreement on the International Carriage of Perishable Foodstuffs and on the Special Equipment to be Used for such Carriage), which are further described in the first part of the article.

Keywords: Agreement ATP, probe, thermograph, measurement, banana, eggs

1 Introduction

This article is about measurement of transport temperatures of perishable foods and comparison of transport requirements between transport organizations and audit institutions. Transport of perishable foodstuff is one of the most critical modes of transport. Due to the maintenance of public health, high demands must be placed on the transport as well as on the safety of the entire food transport chain. Therefore, the European Union pays great attention to safety, as is discussed for example in the White Paper on EU food safety [1]. During transport, food must stay in required conditions. Therefore, it is necessary to comply with the conditions of construction vehicles and transport units as laid down in the Agreement ATP. It is also necessary to certify vehicles carrying food as per the Agreement ATP. Transport of perishable foodstuffs has many conditions. The most important condition is to keep the temperature at a required level. Maintaining a required degree of temperature is necessary. Every kind of food needs to be transported in different temperature conditions. It is necessary to accurately determine the transported commodities and the required transport temperatures. Some temperatures are set per the Agreement ATP, but most are set according to individual producers. Compliance with these conditions is then also required from other companies that are involved in food handling. It is also necessary to control individual transports. In each EU country, according to the regulation (ES) 852/2004, it is necessary to establish a controlling body that will oversee the provide of control and safety of foods. This article deals with the analysis of the control of temperature and humidity in the selected type of transport.

2 Methods

It is necessary to have the information about temperature requirements. Transport companies have conditions about temperature and humidity requirements. CMA-CGM and Maersk Line have details prepared on required conditions [2, 3]. These conditions can be found in web portals of the transport companies. In this article, the conditions of these companies will be compared with the conditions in the Agreement ATP and the conditions of a specific transport company. This company transports fruits and vegetables. Thus, its vehicles are constructed to transport perishable foods.

2.1 Legislation

The European Union legislation covers temperature control requirements during storage and transport of perishable foods and many standards are set according to the HACCP standard [4]. Regulation EC No 852/2004 [5] on Hygiene of Foodstuffs requires manufacturers to have suitable temperatures, controlled handling, and storage facilities that can maintain food at appropriate temperatures and to enable these temperatures to be monitored, controlled, and recorded.

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The transport of perishable food products other than fruits and vegetables, and the equipment used for the carriage of these products is governed by the ATP agreement. It provides common standards for temperature-controlled transport vehicles. The transport equipment and vehicles are sea containers, reefer trailers, and reefer wagons. Annex 1 of this agreement states the types of equipment used in transport of perishable foodstuffs.


Regulation EC No 37/2005 [8] on the monitoring of temperatures in the means of transport, warehousing and storage of quick-frozen foodstuffs intended for human consumption is the most important regulation which specifies the conditions on monitoring instruments. During transport, warehousing and storage of perishable foodstuffs, vehicles shall be fitted with the right recording instruments to monitor the air temperature and humidity at frequent and regular intervals.

As the risk assessor, European Food Safety Authority (EFSA) produces scientific opinions and advice that form the basis for European policies and legislation.

ISO 22000:2005 [9] specifies requirements for a food safety management system whereby any organization in the food chain needs to demonstrate its ability to control food safety hazards in order to ensure that food is safe at the time of human consumption.

The ATP certificate is valid for six years but can be extended by another three years on the condition that an “in service” examination is carried out. There are concerns, however, that in-service testing procedures are not stringent enough and may lead to increased energy consumption.

The equipment for transport of perishable foodstuffs must have a certificate of compliance of the equipment (Figure 1). In accordance with this certificate, a compliance certification plate and the ATP mark corresponding to the class and the category of the equipment must be affixed on the transport equipment. The most common marks are

- **IR**- heavily insulated equipment
- **FNA** – Class A mechanically refrigerated equipment with normal insulation
- **FRC**- Class C mechanically refrigerated equipment with heavy insulation

The process of measurement and marking is fully described in Annex 1, Appendix 2 in ATP.

### 2.2 Temperature

Many different materials, documents and books contain tables with data about optimum temperatures for safety, storage and transport. The most important data about temperature come from a “harvester”. This company (or person) has accurate information about pre-harvest life of every commodity. In products with no harvest life it is important to know the production process. Based on this information, the right temperature is set. A high temperature can cause premature ripening or bring about a bacterial infection. A low temperature can cause total damage of products [10, 11].

With refrigerated foods, temperature control is essential, not only to maintain the microbiological safety and quality of foods but also to minimize any changes in the biochemical and physical properties of the food. The temperatures of storage of refrigerated foods may vary greatly and fluctuate during manufacturing, distribution, retail and in the home. Consequently, during the life of a refrigerated food, considerable opportunities exist for temperature abuse. Thus, the greater the temperature abuse, the greater the potential for microbial growth.

Codex Alimentarius [12, 13] is the most important standard for food safety worldwide. This standard sets general conditions for transport and storage safety of foods. These standards also do not provide specific transportation temperatures for transported commodities. This type of standard sets general conditions for producers.
2.2.1 Measurement of food quality

Measurement of food quality is essential; quality indicators are not constant and the quality of food changes over time. The most important quality-related changes are

- Chemical reactions, mainly due to either oxidation or Maillard reactions;
- Microbial reactions: microorganisms can grow in foods. In case of fermentation this is desired; however, in other cases microbial growth will lead to spoilage and, in case of pathogens, to unsafe food;
- Biochemical reactions: many foods contain endogenous enzymes that can potentially catalyze reactions leading to quality loss (enzymatic browning, lipolysis, proteolysis, and more);
- Physical reactions: many foods are heterogeneous and contain particles. These particles are unstable, in principle at least, and phenomena such as coalescence, aggregation, and sedimentation usually lead to quality loss. Also, changes in texture can be considered as physical reactions, though the underlying mechanism may be of a chemical nature.

New methods of testing for food quality continue to be developed alongside improvements to traditional methods of analysis. The tools used, particularly those for analytical measurement, continue to become more sensitive, more specific and faster, and the industries using these tools must keep up with these changes. All of these advancements set new standards and protocols on how the quality of foods and their ingredients are defined and monitored.

As food quality changes are often a function of physics-based phenomena, these changes can be well characterized through the use of mathematical modeling. Modeling approaches such as kinetic modeling, response surface modeling, and multivariate statistical modeling can all be used. This section covers the measurement of quality attributes for dairy products, meat and meat-based products, fruits and vegetables, seafood, and cereals and grains. This section also covers the modeling of quality for these product groups [14–16].

2.2.2 Measurement of food temperature

If we want to compare and set the right temperature range for different types of food, we must compare temperature conditions from more sources. I choose for comparison four different sources (transport companies CMA-CGM, MAERSK, Agreement ATP and information from a specific transport organization) [17, 18]. These groups of organizations have prescribed detailed transport conditions. These companies have their own suppliers of these commodities so I can compare conditions accurately.

I performed the measurement in a transport organization which transports perishable foodstuffs. I used the equipment from my department. For measuring I used the equipment from Testo (one base and four probes). Probes were applied to the transport space of semi-trailer. Semi-trailer has FRC specification. This specification is made according to the Agreement ATP Class C. Mechanically refrigerated equipment fit with a refrigerating appliance so that Ti may be chosen between $+12^\circ$C and $-20^\circ$C inclusively.

It is the probe Testo Saveris H2D and T2D. Probes have a range of temperature from $-20 \div +50 \,^\circ$C. Technical parameters of this equipment are on the webpage www.testo.com.

2.2.3 Transport temperature condition

For comparison I choose one kind of transport relation. I choose this relation because in this transport different types of food are carried. This transport was made from Slovakia to Hungary. It was the transport of bananas from Slovakia to Hungary and the import of eggs from Hungary to Slovakia. Table 1, shows the comparison of transport conditions for this kind of foods.

In Table 1, it can see the differences among the conditions of each transport organization. Generally, this poses a problem because each organization has its own supplier and this supplier has different conditions. But for my output these conditions suffice. The most important data for my comparison are data from a transport organization because the measurements are conducted in its vehicles.

The problem is with the transport temperature of eggs because there is no information about temperature in transport conditions of this company. For this research I use conditions from document CMR[19].

2.3 Measurement on specific transport

This measurement was conducted from the warehouse in Madunice (Slovakia) to the warehouse in Üllo (Hungary). During the transport between Madunice to Üllo bananas were transported. The return route was between Üllo and Vel’ký Krtiš. On the route between Vel’ký Krtiš and Beckov eggs were transported. During the final route between Beckov and Madunice the vehicle was empty.

On Figures 2 to 4 we can see the temperature measurements in a semi-trailer during this transport. The first column is the row of whole measurement, the second column
Table 1: Comparison of transport temperature (°C).

<table>
<thead>
<tr>
<th></th>
<th>CMA-CGM</th>
<th>MAERSK</th>
<th>ATP</th>
<th>Transport Organisation (+CMR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bananas</td>
<td>+13.3 ± 13.9</td>
<td>+13.3 ± 13.5</td>
<td>x</td>
<td>+14</td>
</tr>
<tr>
<td>Eggs</td>
<td>+1.1</td>
<td>-2</td>
<td>x</td>
<td>+18</td>
</tr>
<tr>
<td>Apples (granny smith)</td>
<td>0 ± 6</td>
<td>-1 ± 4</td>
<td>x</td>
<td>+4</td>
</tr>
</tbody>
</table>

Figure 2: Transport temperatures of bananas. Transport between Madunice to Üllo.

is the date of measurement, the third is the time of measurement, and the fourth is the temperature of the first probe. This probe is H2D, which was placed in the middle of the semi-trailer and can store data about temperature and humidity. In Figure 2, we can see the process of temperature changes before and during the transport of bananas. This transport started on 4.5.2016 at approximately 20:00. Information from this probe was used for the comparison of temperatures. This probe was chosen because it was in the middle of the semi-trailer. In fact, when we look at the report, we can see that temperatures are similar. The space in the semi-trailer was pre-cooled. This fact we can see on the report at approximately 19:40. In Figure 3 we can see the process of temperature changes during the transport of bananas and eggs. Figure 4 is the process of temperature changes of eggs and the range of the vehicle to station. After the completion of transport, the temperature is not controlled anymore. This fact is presented below the blue line.

3 Results

After the analysis of transport temperatures, we can compare these temperatures with the recommended temperatures.

During the transport of food, it is necessary to maintain the right temperatures. Before transport (on Figure 2, this is presented above the red line) the transport space must be pre-cooled. The first transport in this case was the transport of bananas [20]. On the second figure we can see that the temperature was reduced approximately half hour before loading. This situation is sufficient. The goods were unloaded approximately on 5.5.2016 at approximately 2:00. The transport temperature during this route
was in a range of allowable limit. In this time, the process of pre-cooling began for another commodity.

Another transport was the transport of eggs. This transport was conducted from Vel’ký Krtíš. The distance between Úllo and Vel’ký Krtíš is 125 km (approximately 1 h 45 minutes driving by car). During this transport the space was pre-cooled. Loading of eggs started on 5.5.2016 at approximately 5:00 and unloading on 5.5.2016 at approximately 12:00. In this period the space of the trailer cooled down. The temperature in the space of the trailer was sufficient. The maximum temperature was 11.8 °C which is under the line of the maximum transport temperature for eggs.

After the analysis of the transport temperature in this transport we can confirm that the temperature conditions for transport were in compliance.

### Figure 3: Transport temperatures of bananas and eggs. Transport between Madunice to Úllo and between Úllo to Vel’ký Krtíš.

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Temperature</th>
<th>Humidity</th>
<th>Bed Temperature</th>
<th>Humidity</th>
<th>Load Temperature</th>
<th>Humidity</th>
<th>End Temperature</th>
<th>Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5.2016</td>
<td>5:00</td>
<td>11.6</td>
<td>80</td>
<td>11.6</td>
<td>80</td>
<td>11.6</td>
<td>80</td>
<td>11.6</td>
<td>80</td>
</tr>
</tbody>
</table>

### Figure 4: Transport temperatures of eggs. Transport between Vel’ký Krtíš to Beckov and Beckov to Madunice.

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Temperature</th>
<th>Humidity</th>
<th>Bed Temperature</th>
<th>Humidity</th>
<th>Load Temperature</th>
<th>Humidity</th>
<th>End Temperature</th>
<th>Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5.2016</td>
<td>5:00</td>
<td>11.6</td>
<td>80</td>
<td>11.6</td>
<td>80</td>
<td>11.6</td>
<td>80</td>
<td>11.6</td>
<td>80</td>
</tr>
</tbody>
</table>
4 Discussion

The measurements were performed over a longer period of time. In that time the vehicle performed many transports. The transport from Madunice to Üllo to Vel’ký Krtíš and Madunice was chosen because only one commodity was loaded in the semi-trailer. Therefore, it was more accurate to compare transport temperatures. During transport, there is a problem with keeping the temperature in vehicles even if they are in the cargo space loaded with a number of commodities. In these cases, it is necessary to plan the storage of goods in the vehicle during transport. In every transport it is necessary to know how the cargo was loaded into the vehicle [21]. Refrigerated vehicles have many specifications. One of them is that on the roof there are regulation vents. Through these vents the air flows to the entire space of the trailer. Near the vents the temperature is closest to the equivalent of the temperature set on a thermograph. The agreement ATP provides little information on transport conditions. It would be appropriate to carry out an analysis of the required transport temperatures in individual commodities. To remedy the problems associated with the transport of temperature setting it would be appropriate to construct a table in which discrete temperatures are indicated. It would also facilitate the work of the drivers and make for less complaints associated with setting of transport temperatures.

5 Conclusion

In this transport case, the temperature of the semi-trailer was sufficient. When transporting bananas, it is of particular importance that the required temperature be maintained. Banana, as a commodity, is sensitive to temperature and humidity changes due to early ripening. Bananas are transported from shipping ports as all vehicle shipments. This system facilitates the development of criteria for the delivery of goods. Additionally, this enables direct delivery of such shipments to retail chains. When distributing to smaller customers it is necessary to consolidate the shipment in such a way that the correct temperature can be set for each commodity. After making further measurements it will be possible to determine the temperature setting in the cooling chain. In July, measurements in international transport vehicles were performed. During this transport many different kinds of goods were transported. After this measurement a more accurate comparison will be possible.

References

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