Recommendations for beet storage trials under controlled conditions

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ABSTRACT

At the last meeting of the IIRB Working Group "Beet Quality and Storage" (Tulln, April 2015), a proposal of recommendations for conducting beet storage trials under controlled conditions (not set in clamp) was prepared.

These recommendations are related to the origin of the samples, type and quality of their harvest, storage parameters, measurements and analysis carried out on the samples before and after storage, and the evaluation of the storage losses.

These recommendations are intended to standardize the methodology for storage trials in order to properly interpret the results and findings of such trials.

Recommandations pour des essais de conservation des betteraves en conditions controlées

RESUME

Lors de la dernière réunion du Groupe de Travail « Qualité betteravière et Conservation » de l'IIRB (Tulln, 2015), une proposition de recommandations pour la réalisation d'essais de conservation des betteraves, en conditions contrôlées, a été rédigée.

Ces recommandations se rapportent : à l'origine des échantillons, au mode et à la qualité de leur récolte, aux paramètres de conservation, aux mesures et analyses réalisées sur les échantillons avant et après conservation, au calcul des pertes de conservation.

Ces recommandations sont destinées à uniformiser les méthodologies des essais de conservation afin de pouvoir interpréter correctement les résultats et les conclusions de tels essais.

Empfehlungen für Lagerungsversuche mit Zuckerrüben unter kontrollierten Bedingungen

KURZFASSUNG

Auf dem letzten Treffen des IIRB Arbeitsgruppe "Rübenqualität und Lagerung" (Tulln, April 2015) wurde ein Vorschlag ausgearbeitet, um Empfehlungen für die Durchführung von Lagerungsversuchen mit Zuckerrüben unter kontrollierten Bedingungen (nicht in einer Feldmiete) zu geben.

Diese Empfehlungen beziehen sich auf die Herkunft der Proben, Art und Qualität der Ernte, Lagerungsparameter, Messungen und Analysen an den Proben vor und nach der Lagerung sowie die Berechnung der Lagerungsverluste.

Die Empfehlungen sollen dazu dienen, die Methode für die Anlage und Durchführung von Lagerungsversuchen mit Zuckerrüben zu standardisieren, um die Ergebnisse und Schlussfolgerungen richtig interpretieren zu können.

Introduction

Since 2007 and the establishment of a new sugar regime on European level, the beet-sugar sector and in particular the sugar companies have sought to improve the profitability of their production. One consequence was a significant lengthening of the processing campaigns in the factories. As a result, the storage time of the last harvested beets was significantly extended in many European countries. The field storage period thus increased from about less than 30 days to more than 60 days depending on the country and their climatic conditions (North-West Europe mainly).

With the aim to keep sugar losses even after long-term storage as low as possible and to maintain processing quality, numerous research institutes conducted storage experiments. Most of these experiments were designed to assess the yield loss (root weight loss, sugar content decrease, sugar weight loss, extractability decrease ...) and to validate differences in losses which are sometimes only a few percent. For that reason it is necessary to have a clearly described methodology for controlled and replicable experiments.

From the results presented by the various experts on that topic, it became soon clear that there could be a wide variety in terms of experimentation, in equipment, in the used methods, which therefore often resulted in different interpretations and conclusions of the tests.

The IIRB Working Group "Beet Quality and Storage" has therefore developed a proposal of recommendations how long-term beet storage trials under controlled conditions can be conducted.

These recommendations are related to:

- the origin of the samples,
- the way and quality of harvest operations,
- the storage conditions,
- the measurements and analyses performed on the samples before and after storage,
- the calculation of the storage losses.

The recommendations are based on a compilation of the best practices performed by the authors of this publication, and are the result from many years of experimentation with long-term storage trials, conducted in North-West Europe (Huijbregts, T. *et al*, 2013). The recommendations are intended to standardize the methodology for storage trials in order to correctly conduct, interpret and compare the results and conclusions of such experiments.

More specific experiments, such as those made with a respirometry room (CO_2 measurement), or performed in a beet pile in the field (uncontrolled conditions) or with samples from beet clamps after harvesting (uncontrolled conditions) are not part of these recommendations. They are not included in the description.

Recommendations (for standard trials)

1. Origin of the samples

1.1. Sampling of beets	**From a field trial conducted especially for that purpose with specific small plots (10 to 50 m²) and field replicates.** Not from a beet clamp. Not taken at random in the field, or on a long distance from the field, or from the conveyor belt of the harvesting machine.
1.2. Needed amount of beets	**Minimum 50 to 120 beets coming from one plot for one replicate**. From these beets, 20 to 50 (beets or kg beets) are used as reference (before storage) and another 20 to 50 (beets or kg beets) for storage.
1.3. Choice of beets	**Only healthy and representative beets with small root tip breakage (1-2 cm ∅) and correctly topped**. Overtopped/broken beets, beets with rotten parts are discarded. In case of experiments where overtopped beets, root breakage and wounded beets are included, these must be scored (see below). Level of topping and root breakage must ideally be specified.
1.4. Soil tare	**As low as possible** (especially when the evaluation of losses is made on the beet gross weight). No washing of the beets before storage (because this results in higher losses), no brushing. Big lumps of soil should be removed manually.
1.5. Number of replicates	**The more the better**, to get a stable value! Example: 4 replicates of 50 kg or 6 replicates of 20 kg. To be specified.

2. Harvesting method

2.1. Manual harvesting	Not necessary, or only for very specific trials. Example: simulation of the effect of harvest injuries and harvest quality. Beets are then manually harvested with a minimum of damage for the control treatment. To be specified.
2.2. Mechanical harvesting	**Ideally made with a plot harvester;** too much damage of the beets should be avoided. To be specified.
2.3. Beet topping	**Beets are normally topped;** according to local practice (topping level differs between countries). Depending on the trial objective. Average level of topping is to be specified and scored (see below).
2.4. Methodology for topping	**Topping should be the same for all treatments**. Not necessary to be defined, when beets are topped by the plot harvesting machine. A manual correction and re-topping of beets can be made for the elimination of the green material. Specify, if the beets are re-topped before brei analysis.
2.5. Root tip breakage	**As low as possible**. Depending of the trial objective. Level of root tip breakage should be specified and scored (see below).
2.6. Methodology for root tip breakage	Not necessary to be defined because beets were harvested by plot harvesting machine, correctly settled and used. Specify the methodology for specific trials (example: soil tare cleaning turbine/table to simulate harvesting injuries).

3. Storage place (controlled conditions)

3.1. Place of storage	**Closed place (climate container, barn) with constant or controlled temperature (frost-free).**
3.2. Kind of container for the beets	Closed box or net sacks, but anaerobic conditions must be avoided to prevent fermentation! Slow gas exchange must be provided, but not too much ventiliation (results in drying out of the beets). Therefore, never make storage experiments in open box or net sacks in an open environment. To be specified.
3.3. Storage temperature	**Temperature has to be controlled and registered.** Ideally between 5-**15°C**. Storage losses depend mainly on the temperature sum (thermal time). Therefore, temperature and length of storage period have to be adapted knowing that formation of storage moulds and rots becomes usually visible after a thermal time of ±300°C degree days **Thermal time = Sum of the daily average temperature, in base = 0. Daily average temperature = (T_{min} + T_{max})/2.** NB: Day of harvesting and last day of storage are included.
3.4. Storage humidity	**Ideally near the maximum** (>95% at the beet surface), to avoid drying out of the beets To be mentioned/registered if possible.
3.5. Ventilation	No or as minimum as possible.

4. Analysis of beet samples before storage / at storage time Day = 0 (reference samples)

4.1. Topping level	Yes, should be determined, at least of the stored beets. Average level of topping is to be specified and scored using the IIRB topping scale with 6 topping levels (or more) (Figure 1). Specify the average topping level (or the gravity index). Specify if the beets have been re-topped before brei analysis.
4.2. Root tip breakage	Yes, should be determined, at least of the stored beets. Average level of root tip breakage is to be specified and scored using the IIRB root breakage scale with 5 levels. Specify the average root breakage diameter (or the gravity index) (diameter 0-2 cm = 1, 2-4 cm = 2, 4-6 cm = 3; 6-8 cm = 4; >8 cm = 5).
4.3. Surface injuries	If possible, should be determined, of the stored beets. Describe the methodology and specify the results.
4.4. Breakage resistance	Not necessary
4.5. Root weight	**Yes, essential!** Gross root weight of the stored beets (before storage) of each replicate.
4.6. Dirt tare	Yes. Of the beets used as reference. To be specified if important.
4.7. Top weight	Not necessary

4.8. Sugar content	**Yes, essential!** Of the beets used as reference.
4.9. Beet quality	Yes (K, Na, alpha amino N) (glucose if possible). Determination of the extractability coefficient. **Specify the used formula (with or without glucose).**
4.10. Further determinations	Dry matter content (important to calculate the loss of water from the weight loss). Marc content, glucose, fructose, raffinose, betaine, glutamine, etc. if possible. These parameters may provide a lot of more specific indications.

5. Analysis of beet samples after storage or at storage time Day = X (stored samples)

5.1. Leaf regrowth/sprouting	Interesting to be mentioned. To specify with a slight scale (example: 0 to 3: 0 = no, 1 = light, 2 = medium, 3 = high). Give a gravity index.
5.2. Moulds and rots on beet surface	Interesting to be mentioned. To specify with an internal scale (example: 1 to 8: see Figure 2.) Give a gravity index.
5.3. Rotten parts in beet tissue	Interesting to be mentioned To specify if done by scoring the rotten parts before washing. If it is made by cutting and weighing the rotten parts, a representative brei can not be obtained anymore.
5.4. Identification of moulds and rots	Not necessary, but could be interesting To be mentioned if made.
5.5. Root weight	**Yes, essential!** Gross weight of the stored beets. Allows evaluation of the weight losses
5.6. Dirt tare	No relevant (if loss calculation is based on gross weight loss).
5.7. Top weight	No relevant.
5.8. Sugar content	**Yes, essential!** Allows evaluation of the sugar content losses and sugar weight losses.
5.9. Beet quality	Yes (K, Na, alpha amino N) (glucose, if possible). Allows evaluation of the extractability losses. **Specify the used formula (with or without glucose).**
5.10. Further determinations	Dry matter content (important to calculate the loss of water from the weight loss). Marc content, glucose, fructose, raffinose, betaine, glutamine, etc. if possible. These parameters may provide a lot of more specific indications.

6. Calculation of storage losses

6.1. Root weight losses	Yes, essential! **Calculated from the difference of gross root weight (slight dirt tare included) (or on net weight) of the stored beets before and after storage.** Calculation on gross weight or net weight must be precised. Mainly expressed in %, where 100% is the root weight before storage (reference).
6.2. Sugar content losses	Yes, essential **Calculated from the difference of sugar content between the beets used as reference and the stored beets after storage.** Mainly expressed in %, where 100% is the sugar content before storage (reference).
6.3. Sugar weight losses	**Yes, essential!!** **Calculated from the difference of sugar weight of the stored beets** **before storage (root weight of the stored beets before storage and sugar content of the reference beets) and after storage (root weight and sugar content of the stored beets after storage)** Mainly expressed in %, where 100% is the amount of sugar weight before storage (reference). Can also be expressed in: - g sugar/t beet/day (then specify the average storage temperature), - t of beet adapted at 16% sugar content - €/ha (very specific to each national payment system).
6.4. Extractability losses	Yes **Calculated from the difference of extractibility between the reference and the stored beets.** Expressed in %. **Specify the used formula (with or without glucose).**
6.5. Invert sugar accumulation	**Strongly recommended** if possible. Gives very important information! Expressed in glucose content (mmol/100 g beet or mmol/kg beet) or in invert sugar content (mmol/kg beet) in stored beets

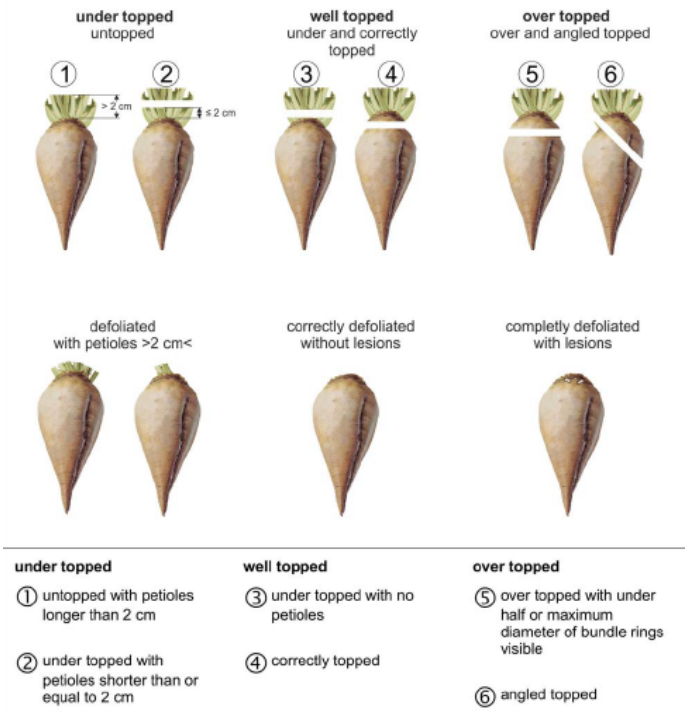

Figure 1. Assessment classes for topping and defoliation quality proposed by the Agricultural Engineering Working Group of the IIRB (Schulze Lammers et al., 2015)

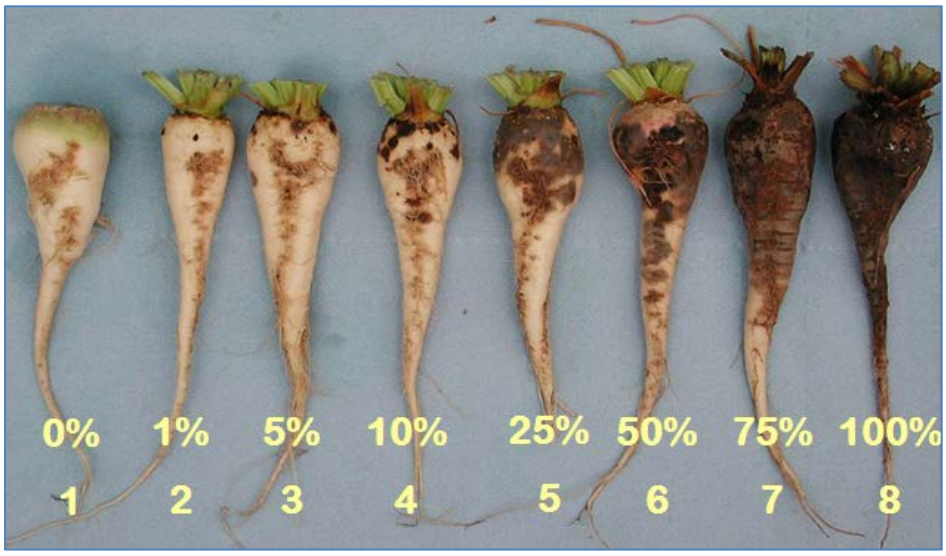

Figure 2. Proposed scoring scheme for the infestation with moulds and rots after storage. The original scoring scheme has been developed for Rhizoctonia, but it can also be used for other disorders at the beet surface (C. Hoffmann, personal communication).

Bibliography

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