



The effect of cleaning and de-hulling on the trichothecene content in oats and barley

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1. INTRODUCTION

The aim of the project was to improve the competitiveness of the grain processing industry by securing domestic supply of grain that is of high quality and meets user needs.

The aim was also to increase the grain chain's awareness of the effect of sorting and de-hulling on the mycotoxin levels in cereals and to promote the use of sorting in the pre-cleaning of the raw material.

2. MATERIALS AND METHODS

A total of 75 unsorted grain samples were collected for this study from the 2007 crop.

Raisio plc submitted 10 oats and 20 malting barley samples from Southwest Finland and 10 oat samples from Southern Ostrobothnia.

Raisio plc's mill Melia (Nokia) submitted 7 silo samples of oats, 7 sorted and de-hulled samples and 7 samples of ground hull.

2. MATERIALS AND METHODS ...

The Kasken tila farm (Kiiikoinen) submitted 31 oats and 4 malting barley samples from the group of farmers in Satakunta.

Fusarium toxin (DON, DAS, 3-AcDON, 15-AcDON, F-X, NIV, T-2 and HT-2 toxin) levels were determined for all samples.



2.1 Pilot-scale sorting and de-hulling

The effect of sorting was studied with selected oat samples from Satakunta with DON concentrations of 1 000 – 10 000 µg/kg.

Pilot-scale sorting was carried out at the Kasken tila farm with a Petkus 531 sorter.

The process aimed at removing as much light grain and impurities as possible by using high air volume. The amount of process waste was approximately 2 % of the weight and 10 % of the volume.

2.2 Industrial sorting and de-hulling

In February 2008, Raisio plc submitted oat samples taken from the 2007 crop at the Nokia mill.

The unsorted samples examined had been taken prior to de-hulling and after the de-hulling process on six different processing days.

The samples submitted by Raisio plc showed lower mycotoxin levels than the samples from Satakunta.

3. RESULTS AND DISCUSSION

Table 3. DON concentrations in unsorted samples provided by farmers and their distribution by concentration range.

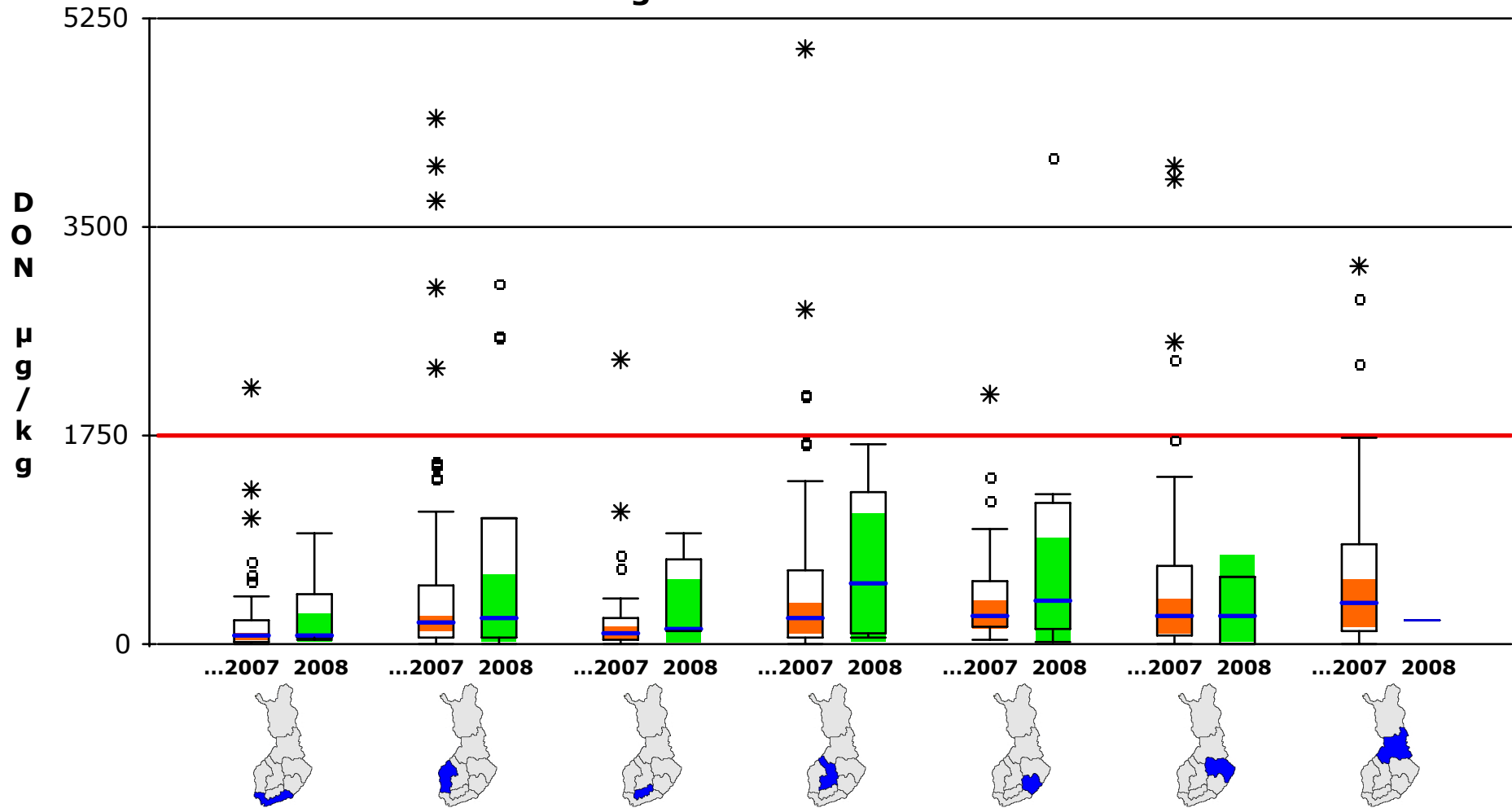
| Samples | Number of samples and fluctuation range for DON concentrations | | | | Total (median) |
|-----------------------------------|--|------------------|------------------|-------------------|-------------------|
| | < 200 µg/kg | 200-1250 µg/kg | 1250-1750 µg/kg | > 1750 µg/kg | |
| Oats (Satakunta) | 3 (85-110) | 16 (210-1200) | 6 (1300-1700) | 6 (1900-10000) | 31 (1100) |
| Oats (Raisio plc) | 14 (<25-130) | 6 (210-740) | - | - | 20 (120) |
| Malting barley (Satakunta) | 1 (140) | 3 (210-360) | - | - | 4 (235) |
| Malting barley (Raisio plc) | 17 (<25-180) | 3 (320-850) | - | - | 20 (120) |
| Total | 35 (<25-180) | 28 (210-1200) | 6 (1300-1700) | 6 (1900-10000) | 75 (240) |

3. RESULTS AND DISCUSSION ...

Table 4. Total concentrations of T-2 and HT-2 toxins in unsorted samples provided by farmers and their distribution by concentration range.

| Samples | Number of samples and fluctuation range for the sum concentrations of T-2 + HT-2 toxins | | | | Total (median) |
|-----------------------------|---|----------------|----------------|----------------|----------------|
| | < 25 µg/kg | 25-200 µg/kg | 200-500 µg/kg | > 500 µg/kg | |
| Oats (Satakunta) | 12 | 16 (29-150) | 2 (218-326) | 1 (520) | 31 (80) |
| Oats (Raisio plc) | 4 | 11 (26-191) | 3 (244-272) | 2 (580-780) | 20 (111) |
| Malting barley (Satakunta) | 2 | 2 (30-39) | - | - | 4 (35) |
| Malting barley (Raisio plc) | 13 | 7 (31-173) | - | - | 20 (46) |
| Total | 31 | 36 (26-191) | 5 (218-272) | 3 (520-780) | 75 (68) |

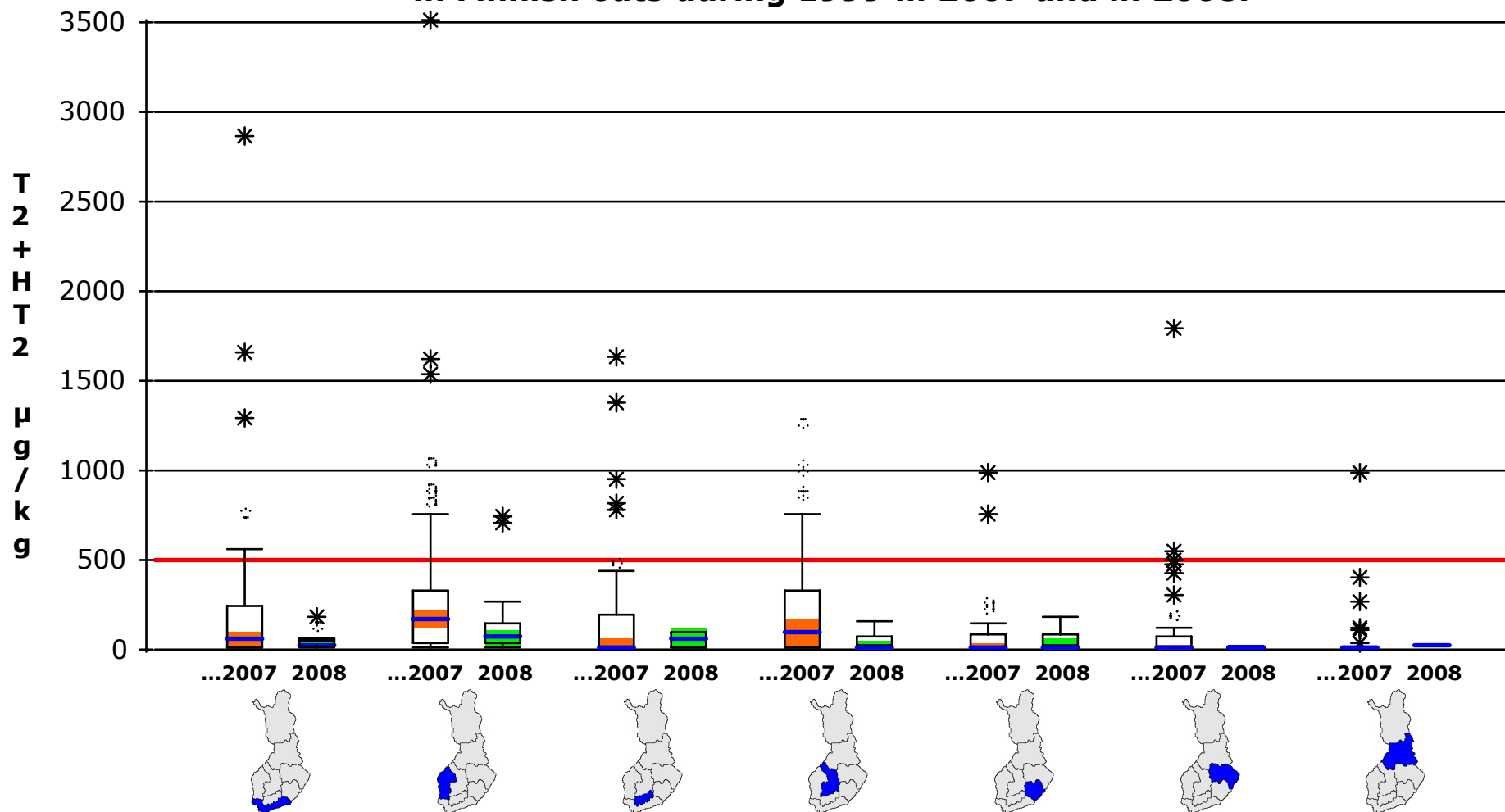
Regional comparison of DON contents in Finnish oats during 1999 ... 2007 and in 2008.



Research areas and years

(Boxplot figures ... 2007 include all the research data during 1999 ... 2007)

Regional comparison of the sum of T-2 + HT-2 contents in Finnish oats during 1999 ... 2007 and in 2008.



Research areas and years

(Boxplot figures ... 2007 include all the research data during 1999 ... 2007)

3. RESULTS AND DISCUSSION ...

Drying the harvested crop carefully guarantees high-quality grain raw material.

In addition, pre-purification, such as sorting and de-hulling, helps reduce the levels of *Fusarium* toxins significantly in both oats and barley.



3. RESULTS AND DISCUSSION ...

Sorting reduced DON and 3-AcDON concentrations in cereals to 1/2 or 1/3.

T-2 and HT-2 concentrations were reduced to 2/3.

Sorting had the greatest effect on the levels of T-2 and HT-2 toxins.

The results indicate that sorting has the greatest effect on the toxins produced as a result of a *Fusarium* infection very early in the season.

3. RESULTS AND DISCUSSION ...

Together with sorting, de-hulling reduced the concentrations of DON and 3-AcDON in oat samples by 67-91 % compared with unprocessed samples.

After de-hulling, no concentrations (below the LOQ) of T-2 and HT-2 were detected in the cereal samples.



4. CONCLUSIONS ...

In summary, the pre-cleaning of cereals, sorting and de-hulling, significantly improved the safety, hygiene and technical quality of the grain raw material.



4. CONCLUSIONS ...

As a result of pilot-scale sorting, the oat raw material lost 2 % of its weight, which means around 10 % in volume.

As for barley, sorting decreased the weight and volume by around 2 %.

This helps reduce the costs of grain transports and storage.



Risk assessment

| Cultivation field | | | Risk factors for <i>Fusarium fungi</i> | | | | farmer's observations of risk factors for <i>Fusarium fungi</i> |
|---|---|-----------------------|--|----------------|----------------|---------------|---|
| | | | no risk | low risk | high risk | critical risk | |
| Location | cropping zone 1 | irrespective of grain | green | | | | |
| | cropping zone 2 | irrespective of grain | | yellow | | | |
| | cropping zone 3 | irrespective of grain | | | orange | | |
| | cropping zone 4 | irrespective of grain | | | | orange | |
| Soil | soil type | clay | green | | | | |
| | | sand | | yellow | | | |
| | | mould | | | orange | | |
| | | mud or muddy clay | | | | orange | |
| | peat | | | | | red | |
| | pH of soil is under 6,0 | irrespective of grain | | yellow | | | |
| Preceding crop in rotation | 2 years growth of same plant in the same area | oats | | | orange | | |
| | | wheat and barley | green | | | | |
| | 3 years growth of same plant in the same area | oats | | | orange | | |
| | | wheat and barley | | yellow | | | |
| 4 years growth of same plant in the same area | oats | | | orange | | | |
| | wheat and barley | | | orange | | | |
| Sowing and tilling methods | sowing method of growing period | zero-till | | | not verifiable | | |
| | | sowing after tilling | | | not verifiable | | |
| | tilling method of previous autumn | autumn ploughing | | | not verifiable | | |
| | | low tilling | | | not verifiable | | |
| | zero-till | | | not verifiable | | | |
| Cultivation process | | | | | | | |
| Cultivation technique | traditional cultivation | oats | | | orange | | |
| | | wheat and barley | | yellow | | | |
| | organically-grown | irrespective of grain | green | | | | |
| Cultivated plant | correlate with grain | oats | | | orange | | |
| | | wheat and barley | | yellow | | | |
| | | malting barley | | | orange | | |
| | | rye and winter wheat | green | | | | |
| correlate with variety | oats | | | orange | | | |
| | wheat and barley | | yellow | | | | |
| Quality of seed | no quality guarantee | irrespective of grain | | | orange | | |
| | quality guarantee | irrespective of grain | green | | | | |
| | no seed dressing | irrespective of grain | | yellow | | | |
| Rate of fertilization nitrogen | in accordance with cultivation guide of grain | | green | | | | |
| | out of line with cultivation guide of grain | | | yellow | | | |
| Plant protection | herbicides | oats | green | | | | |
| | | wheat and barley | | | | | |
| | herbicides and plant disease | oats | | yellow | | | |
| | | wheat and barley | green | | | | |
| herbicides and plant regulators | oats | | | not verifiable | | | |
| | wheat and barley | | | not verifiable | | | |
| Weather conditions during growing season | | | | | | | |
| Weather conditions at start of growing season | start of growing season | rainy | green | | | | |
| | | dry | | yellow | | | |
| Weather conditions during flowering season | flowering season | rainy | | | orange | | |
| | | dry | green | | | | |
| Weather conditions during harvesting | harvesting season | late | | | orange | | |
| | | rainy | | | orange | | |
| | | temperature variation | | | orange | | |
| Harvesting and drying | | | | | | | |
| Flattening % | under 5 % | irrespective of grain | green | | | | |
| | 5 - 25 % | oats | | yellow | | | |
| | | wheat and barley | green | | | | |
| over 25 % | irrespective of grain | | | orange | | | |
| Drying | warm air drying, humidity % | under 25 % | green | | | | |
| | | over 25 % | | yellow | | | |
| | non-immediate drying, humidity % | under 14 % | | | | | |
| | over 15 % | | | | red | | |
| Sorting of grain | unsorted | irrespective of grain | | | orange | | |
| Storage of grain | storage space | inadequate | | yellow | | | |

Risk assessment ...

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|---|---|-----------------------|---------------------------------|----------|-----------|---------------|--|
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| Location | cropping zone 1 | irrespective of grain | | | | | |
| | cropping zone 2 | irrespective of grain | | | | | |
| | cropping zone 3 | irrespective of grain | | | | | |
| | cropping zone 4 | irrespective of grain | | | | | |
| Soil | soil type | clay | | | | | |
| | | sand | | | | | |
| | | mould | | | | | |
| | | mud or muddy clay | | | | | |
| | peat | | | | | | |
| | pH of soil is under 6,0 | irrespective of grain | | | | | |
| Preceding crop in rotation | 2 years growth of same plant in the same area | oats | | | | | |
| | | wheat and barley | | | | | |
| | 3 years growth of same plant in the same area | oats | | | | | |
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| 4 years growth of same plant in the same area | oats | | | | | | |
| | wheat and barley | | | | | | |
| Sowing and tilling methods | sowing method of growing period | zero-till | not verifiable | | | | |
| | | sowing after tilling | | | | | |
| | tilling method of previous autumn | autumn ploughing | not verifiable | | | | |
| | | low tilling | | | | | |
| | | zero-till | | | | | |

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|---------------------------------------|---|-----------------------|---------------------------------|----------|----------------|---------------|--|
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| Cultivation process | | | | | | | |
| Cultivation technique | traditional cultivation | oats | | | | high risk | |
| | | wheat and barley | | low risk | | | |
| | organically-grown | irrespective of grain | low risk | | | | |
| Cultivated plant | correlate with grain | oats | | | | high risk | |
| | | wheat and barley | | low risk | | | |
| | | malting barley | | low risk | | | |
| | | rye and winter wheat | low risk | | | | |
| | correlate with variety | oats | | | | high risk | |
| | | wheat and barley | | low risk | | | |
| Quality of seed | no quality guarantee | irrespective of grain | | | | high risk | |
| | quality guarantee | irrespective of grain | low risk | | | | |
| | no seed dressing | irrespective of grain | | low risk | | | |
| Rate of fertilization nitrogen | in accordance with cultivation guide of grain | | low risk | | | | |
| | out of line with cultivation guide of grain | | | low risk | | | |
| Plant protection | herbicides | oats | low risk | | | | |
| | | wheat and barley | low risk | | | | |
| | herbicides and plant disease | oats | | low risk | | | |
| | | wheat and barley | low risk | | | | |
| | herbicides and plant regulators | oats | | | | | |
| | wheat and barley | | | | not verifiable | | |

Risk assessment ...

| | | | Risk factors for Fusarium fungi | | | | |
|--|----------------------------------|-----------------------|---------------------------------|----------|-----------|---------------|--|
| | | | no risk | low risk | high risk | critical risk | farmer's observations of risk factors for Fusarium fungi |
| Weather conditions during growing season | | | | | | | |
| Weather conditions at start of growing season | start of growing season | rainy | ■ | | | | |
| | | dry | | ■ | | | |
| Weather conditions during flowering season | flowering season | rainy | | | ■ | | |
| | | dry | ■ | | | | |
| Weather conditions during harvesting | harvesting season | late | | | ■ | | |
| | | rainy | | | ■ | | |
| | temperature variation | large | | | ■ | | |
| Harvesting and drying | | | | | | | |
| Flattening % | under 5 % | irrespective of grain | ■ | | | | |
| | 5 - 25 % | oats | | ■ | | | |
| | | wheat and barley | ■ | | | | |
| | over 25 % | irrespective of grain | | | ■ | | |
| Drying | warm air drying, humidity % | under 25 % | ■ | | | | |
| | | over 25 % | | ■ | | | |
| | non-immediate drying, humidity % | under 14 % | | ■ | | | |
| | | over 15 % | | | | ■ | |
| Sorting of grain | unsorted | irrespective of grain | | | ■ | | |
| Storage of grain | storage space | inadequate | | ■ | | | |

4. CONCLUSIONS ...

It should be noted that the concentrations of toxins in ground oat hull need to be determined in order to secure safe use.



Acknowledgements

The research project “The effect of sorting and de-hulling on mycotoxin levels in cereals” was carried out between 1 March 2007 and 30 November 2008 in co-operation with MTT Agrifood Research Finland, Raisio plc, and the Kasken tila farm located in Kiikoinen. The project was funded by Raisio plc Research Foundation and Fingrain-Vilja-alan yhteistyöryhmä VYR. Our warmest thanks go to financiers and Raisio plc, Markku Välimäki from the Kasken tila, and the group of farmers in Satakunta for submitting the valuable grain samples and for taking part in the research project. Special thanks go to Kirsi Puisto and Leena Holkeri, Laboratory Assistants, and Seppo Nummela, Senior Laboratory Technician, at MTT Laboratories for the high-quality laboratory analyses.



THANK YOU FOR YOUR ATTENTION

