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Quality assessment of the chips produced with Pezzolato SpA chippers

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1. Introduction

At first glance, the quality of a batch of wood chips is defined by its moisture content, the prevailing wood species and the size of the particles, as well as the level of contamination of the material with metal, soil and/or stones. Contaminationis mainly related to production chain logistics, notto machine characteristics.

While moisture and species are not influenced by the characteristics of the chipper, particle size distribution depends significantly on what kind of machine is used and the way in which it has been set: the size distribution of wood chips produced by a certain machine is therefore the best indicator of the quality of the work that the machine is able to perform.

Why is the particle size of wood chips so important for marketing purposes? Essentially because it influences both the conservation of the product, and the type of plant with which it can be used. In particular, the presence of particles longer than 60 mm may cause mechanical feeding problems, especially in plants that use a feeding auger, and in many medium-small sized district heating systems (≤ 1 MW). By contrast, the fine and dusty fraction is undesirable because it makes the environment in which wood chips are stored unhealthy and it tends to disperse when handled. Above all, fine fraction in boilers can generate sparks and increases dust emissions in the boiler.

Generally speaking, each type of plant has an optimal target size, with which the maximum yield is obtained. While small-medium sized plants usually prefer smaller chips (target 20 mm), gasification systems use a much coarser product, with an average length around 40-45 mm. These systems are relatively new, given that the gasification boom is a relatively recent phenomenon. Thus, manufacturers are only

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now adapting their machines to produce larger chips, since previously the focus was in the opposite direction, that is, to produce chips as fine as possible (at the limit of wood shavings, to be used as a pellet substitute). In its wide range of models and versions, Pezzolato offers various machines equipped to cover all market sectors, namely those for large chips for use in gasification plants, for medium and fine chips for use in cogeneration and district heating systems, and lastly, for those that use wood shavings in minimum size plants suitable for use in individual homes.

Normally, a chipper itself is not able to alternately produce all types of chips since the length of cut can only be set within a relatively narrow range around the design specification. For this reason, a radical change in cut length requires the chipper drum to be replaced - a task which can be carried out without too much difficulty in a fully equipped workshop.

The purpose of this study was to determine the dimensional characteristics of the chips produced by 13 different Pezzolato chippers, designed for the production of wood chips of long, medium and short length.

2. Materials and methods

The characterization of the chips was carried out on chip samples produced using the following machines:

1) Bosnia chipper fed with beech logs
2) HedeDanmark chipper fed with two types of material
3) Agostinis chipper fed with two types of beech trim material
4) Hackertruck PTH chipper 1000/1000 fed with two types of material
5) H880/250 disc chipper with 50x50 mm screen
6) PTH 300 drum chipper with 50x50 mm screen
7) Hackertruck PTH 1000/1000 chipper with 100x100 mm screen
8) PTH 700/660 chipper with 50x50 mm screen
9) PTH 700/660 chipper with 60x60 mm screen
10) PTH 700/660 chipper with 80x80 mm screen
11) PTH 900/660 M chipper with 50 mm vertical bar spacing
12) PTH 900/820 chipper with 80 mm vertical bar spacing

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All samples were collected directly from the CNR staff who were on site during chipping tests.

Each samples had a fresh weight of between 500 and 1000 g, and was obtained from the random fractioning of a larger sample, assembled on site at the time of chipping. The samples were taken and placed in paper bags on which the following information was reported: date, machine model used and wood species used. The samples were placed in a ventilated room to reduce moisture and prevent deterioration: this made screening easier, as it avoided the conglomeration of the finest particles.

A few days later the measurement of all the samples was carried out using an automatic oscillating screen with sieves of different sizes to separate the wood chips into the following size classes: 100-63 mm, 63-45 mm, 45-16 mm, 16-8 mm, 8-3 mm, <3 mm (dust); pieces longer than 100 mm were separated manually.

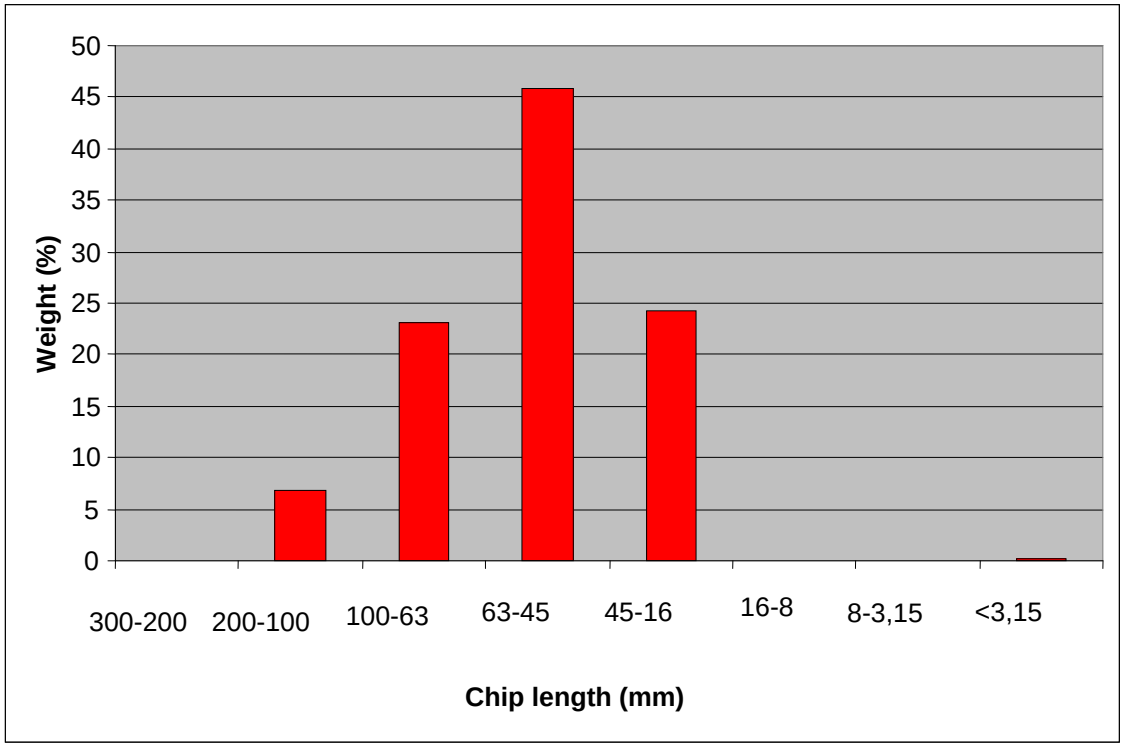
The fractions passed through the sieves were weighed using a precision scale and the data was organized on a spreadsheet and statistically analyzed using the SAS Statview application. The preparation consisted primarily in producing descriptive statistics, followed by the verification of any differences in the quality of wood chips obtained from the same machine used on different materials. This verification was carried out using the Mann-Whitney non-parametric test, as it is particularly compatible with the data distribution that is typically different from a classical Gaussian.

3. Results

Below are the results organized by machine model. Where the same chipper processed multiple types of material, the difference between the different types of material has been reported and analyzed statistically.

3.1 PTH 1300/1500 chipper (Bosnia)

The average particle size distribution obtained by the Bosnia chipper is represented in Figure 1. which highlights the prevalence of medium-sized particles, and the almost complete absence of dust (the fraction with length <3.15 mm represents only 0.2% in weight). This is an exceptionally good result, only compatible with the chipping of logs and a rubber belt conveyor evacuation system, without blower.

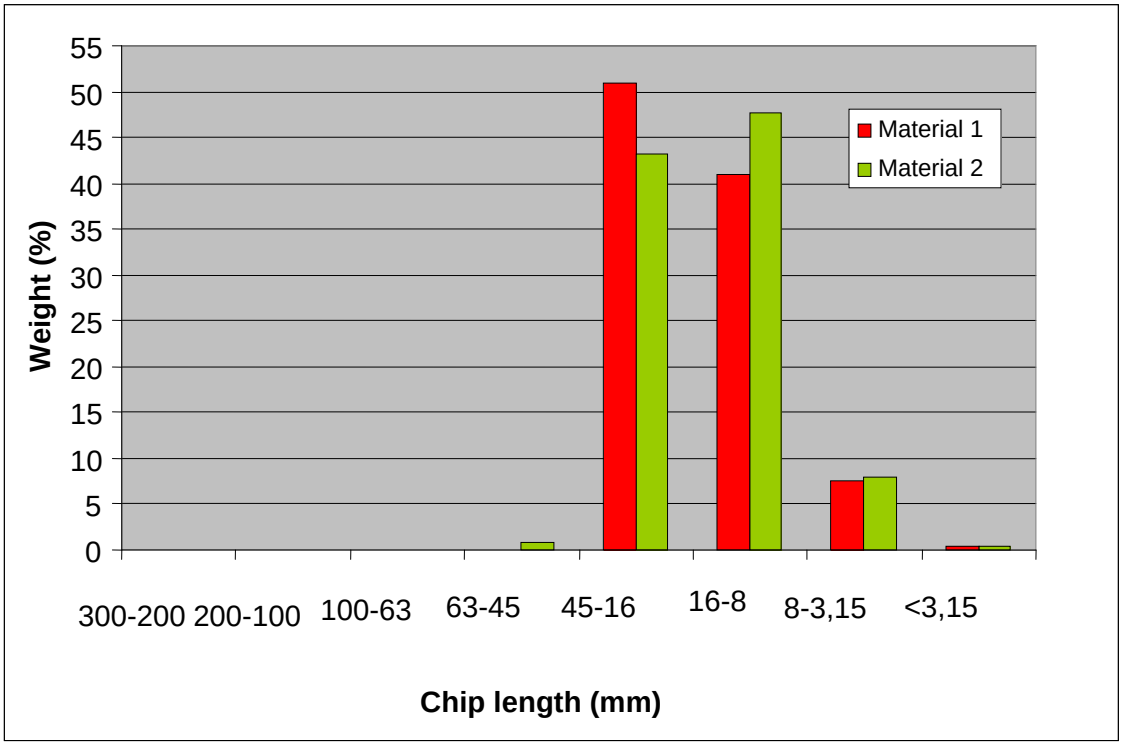


Graph 1 – Particle size distribution of wood produced by the Bosnia chipper

In general, the chips produced by the machine sold in Bosnia has a very uniform size, with a predominant distribution in the middle target class (63-45 mm).

3.2 PTH 1400/1000 chipper (HedeDanmark)

The average particle size distribution obtained from the chipper purchased by Hede-Danmark shows exceptionally uniform chips, completely free of over-sized particles and with a very low incidence of dust (0.3-0.5% depending on the chip material).

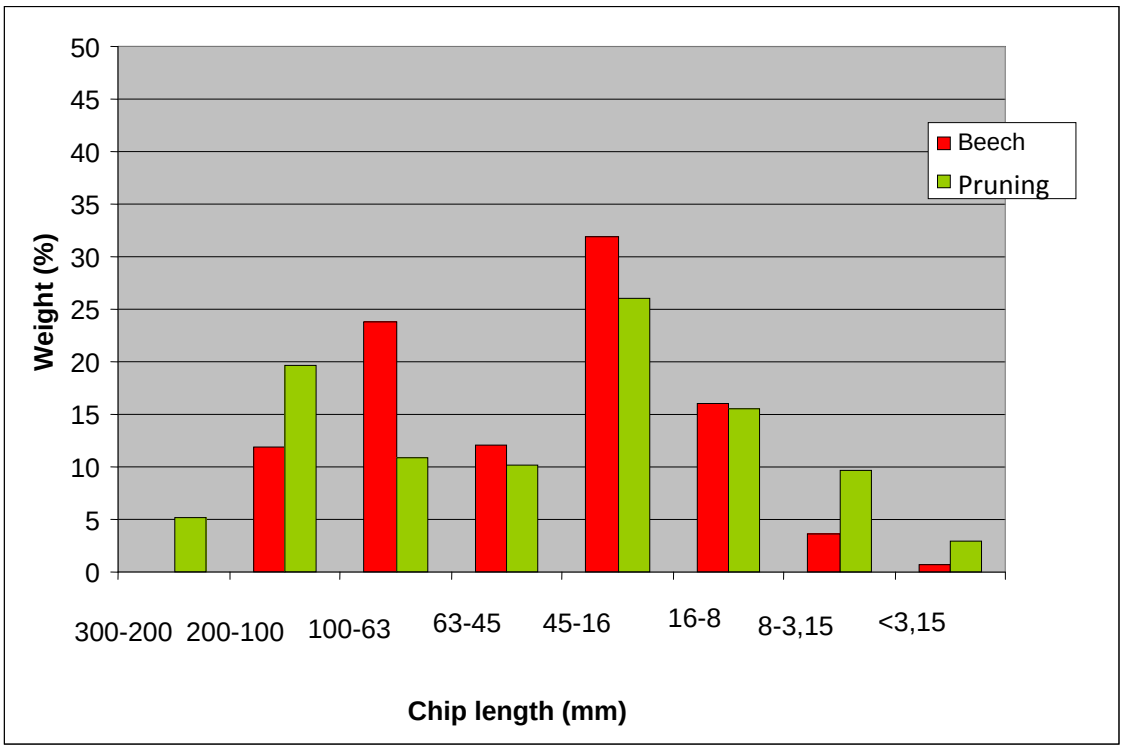


Graph 2 – Particle size distribution of chips produced by the HedeDanmark chipper

The two distinct types of material do not have a statistically significant influence on the particle size distribution of the chips, and therefore the differences identified in our study cannot be considered significant, regularly observed each time the test is repeated.

3.3 Agostinis chipper

The sampling in this case was carried out directly by CNR staff, who travelled to the Agostinis site in Udine to see the machine at work.



Graph 3 – Particle size distribution of chips produced by the Agostinis chipper

The particle size distribution is less uniform than in the previous cases, because the material chipped was different. Beech logs produced relatively uniform wood chips, with a prevalence of large and medium-sized particles (> 16 mm) and a small percentage of dust (0.7%). The situation changed when feeding the machine with pruning residues, which led to the inevitable increase in over-sized particles and dust - the latter, however, was still within the limit of 3%.

According to the Mann-Whitney non-parametric test, differences in the over-sized particles and dust were statistically significant.

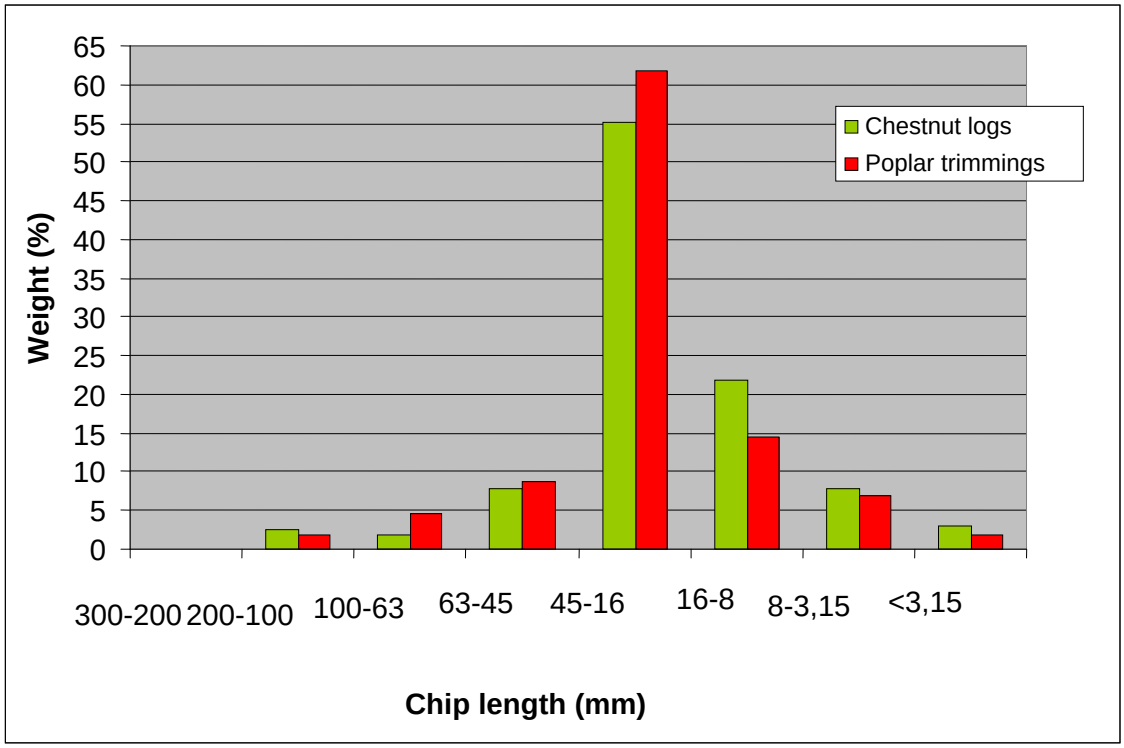
3.4 Hackertruck PTH 1000/1000

Once again, the samples were taken directly by CNR staff, who travelled to the Mombracco power plant in Envie to see the machine at work.

Regardless of the material type, the Envie machine produced very uniform chips, with a dominant share of the particles contained in a single size class (45-16 mm).

The presence of over-sized particles and dust was very low, with the fraction of particles smaller than 3.15 mm (dust) remaining below the limit of 3% in weight.

Even in this case, it was possible to statistically correlate the possible differences between the incidence of the different particle size classes and the type of wood, with the exception of the 16-8 mm size class which was systematically different in the samples obtained from two different types of material.



Graph 4 – Particle size distribution of chips produced by the PTH 1000/1000.

3.5 Pezzolato H880/250 chipper with 50x50 mm screen

The average particle size distribution obtained from the Pezzolato H880/250 disc chipper is represented in Graph 5, which shows the prevalence of medium-small particles, with a strong presence of the 16-8 mm size class (57.6%), and the almost complete absence of particles greater than 45 mm. In this study, the chipper was driven by a Case New Holland 140 100 kW tractor.

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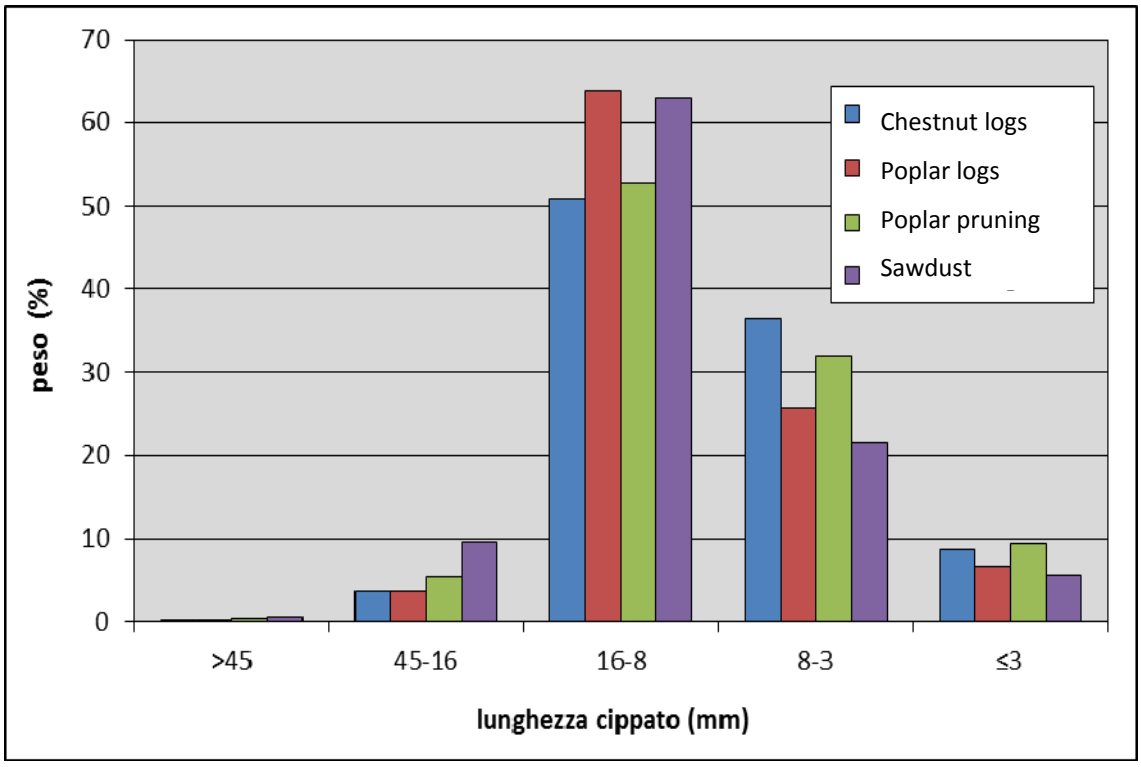
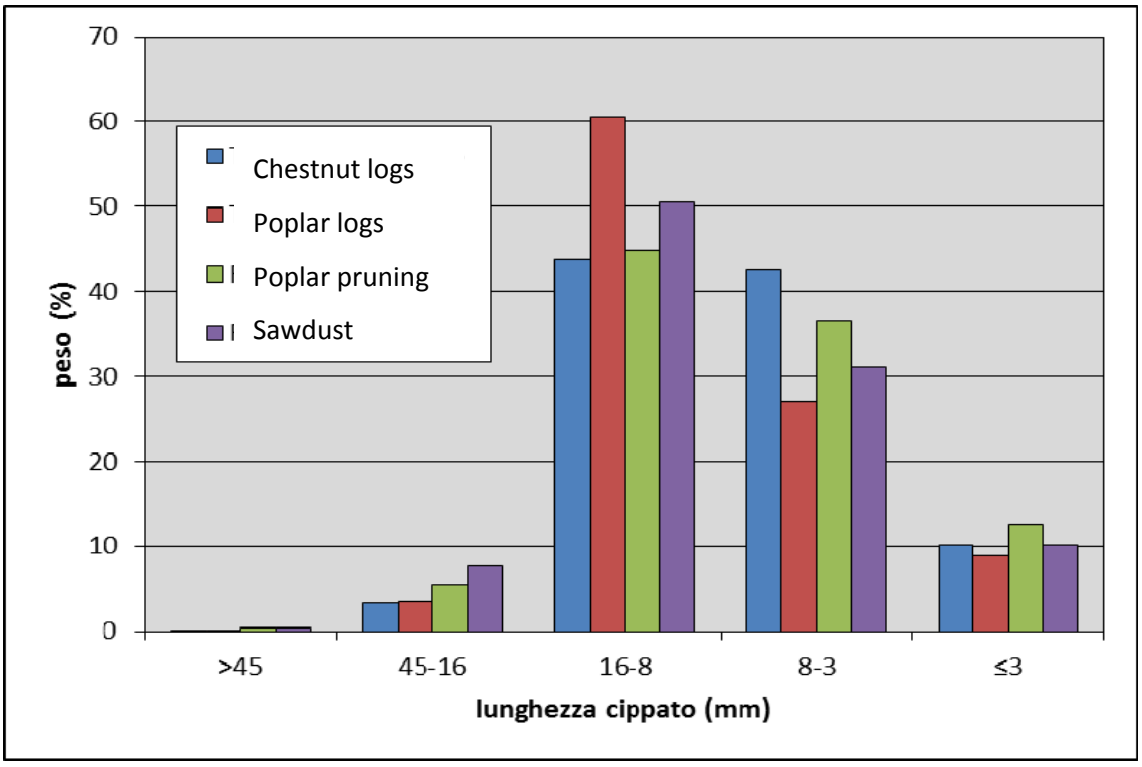
The test was carried out on 4 different materials (chestnut logs, poplar logs, poplar pruning and sawdust) and approximately 15 samples were collected for each type (total of 4 x 15 = 60). Graph 1.b. shows the distribution by type.



Graph 5 – Particle size distribution of chips produced by the Pezzolato H880/250 disc chipper with 4 different materials

3.6 Pezzolato PTH 300 chipper with 50x50 mm screen

The average particle size distribution obtained from the Pezzolato PTH 300 drum chipper shows the prevalence of medium-sized chips, between 16 and 3 mm, and the virtual absence of particles larger than 45 mm (Figure 6). Just as with the H880/250 disc chipper, the PTH 300 was driven by a Case New Holland 140 100 kW tractor and was equipped with a 50x50 mm screen.



Graph 6 – Particle size distribution of chips produced by the Pezzolato PTH 300 drum chipper with 4 different materials

Graph 6 shows the different sizes obtained for 4 different materials. Fifteen samples were collected for each type of material (total 4 x 15 = 60).

3.7 Pezzolato Hackertruck PTH1000/1000 chipper with 100x100 mm screen

The particle size distribution obtained with the Hackertruck PTH1000/1000 chipper shows rather uniform chips, almost completely free of particles larger than 45 mm and with a rather low incidence of dust (4.8%). The particles are mostly medium

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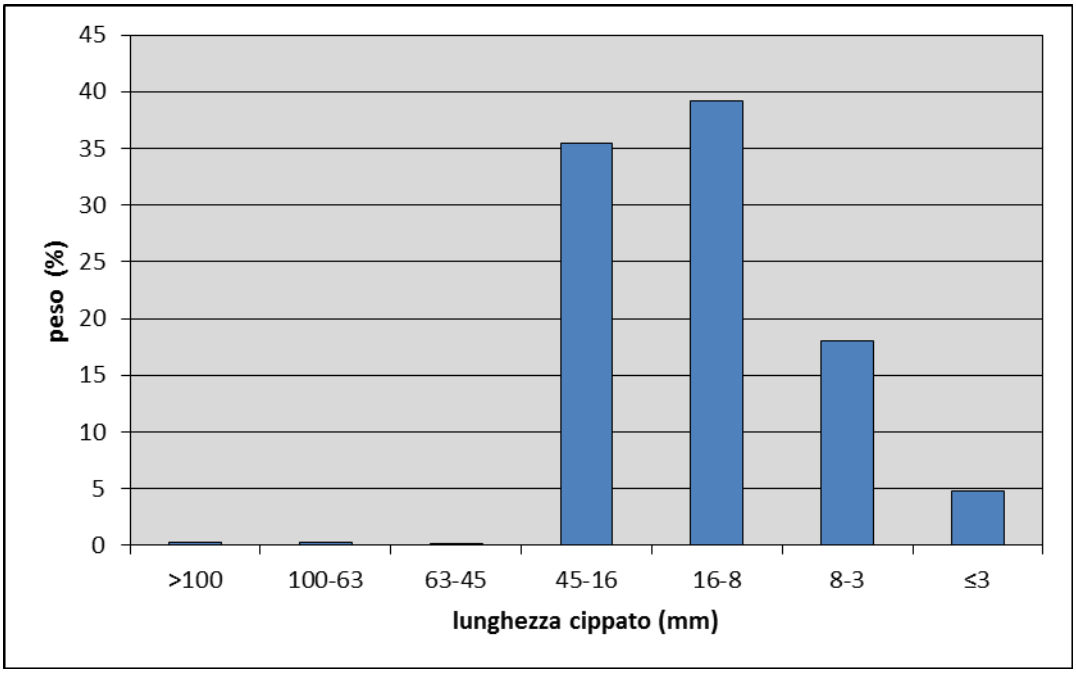
sized and concentrate in both the 45-16 and 16-8 mm length classes. Twenty samples were collected for this study.



Graph 7 – Particle size distribution of chips produced by the Pezzolato Hackertruck PTH1000/1000

3.8 Pezzolato PTH 700/660 with 50x50mm screen

The chipper was driven by a FIAT 130 95kW tractor, and produced uniform wood chips, with a predominant share of particles in a single size class (16-8 mm).

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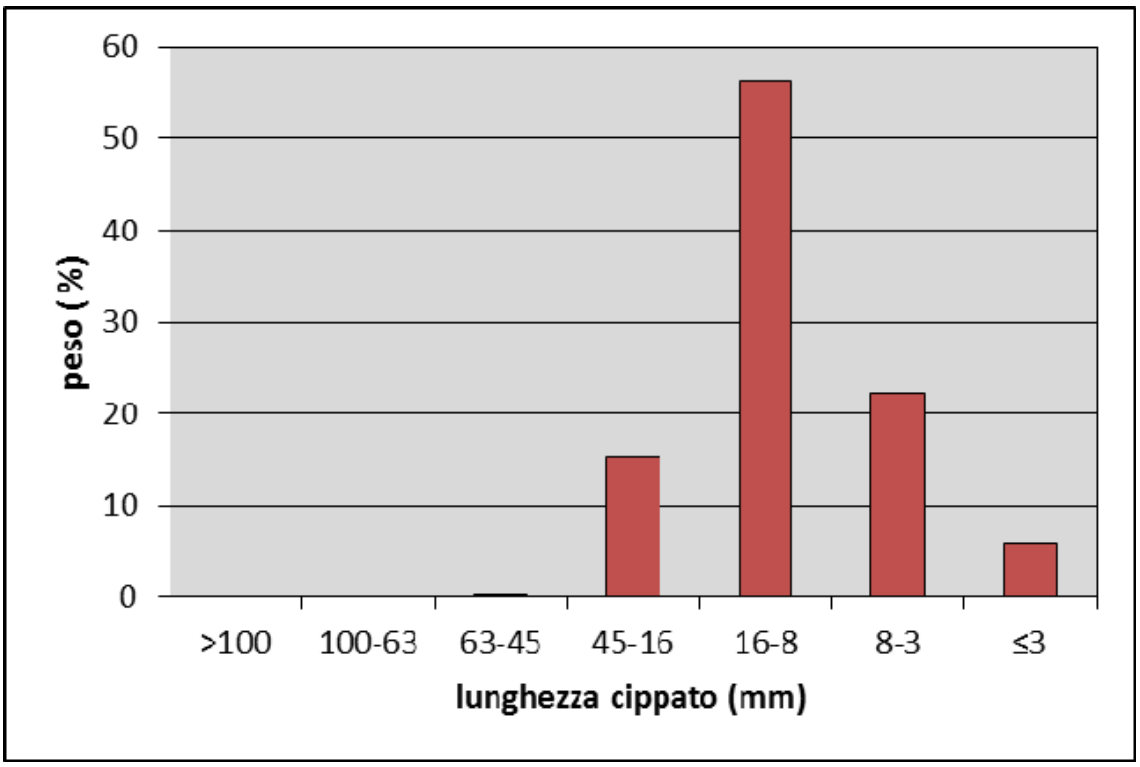
The presence of dust was rather low, with the average fraction smaller than 3.15 mm (dust) below 6% in weight (graph 4). For the assessment 10 samples of wood chips produced with the same forestry material were collected.



Graph 8 – Particle size distribution of chips produced by the PTH 700/660 chipper with 50x50 mm screen

3.9 Pezzolato PTH 700/660 with 60x60 mm screen

The chipper was driven by a Case MX 270 231 kW tractor, equipped with a 60x60 mm screen and processed 2 different materials: stems and lops. As shown in graph 5.b., there isn't a great difference between the two batches of chips obtained from the

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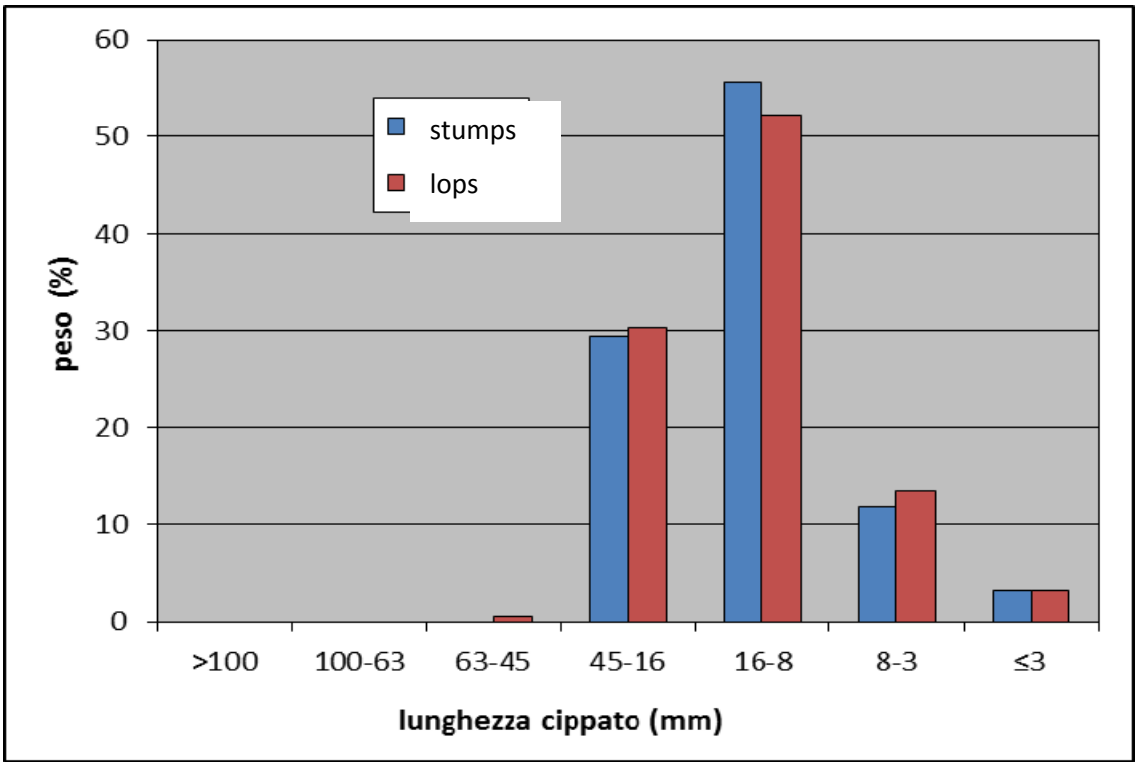
two types of material. In both cases, the medium sized wood chips were most common, with a prevalence of the classes between 16-8 and 45-16 mm (Graph 5.a.).



Graph 9 – Particle size distribution of chips produced by PTH 700/660 chipper with 60x60 mm screen using 2 different materials

3.10 Pezzolato PTH 700/660 with 80x80 mm screen

The machine, driven by a Case Maxum 140 112 kW tractor, was used on two types of materials: pruning and stems. For the analysis, 12 samples were collected for each type (24 in total).

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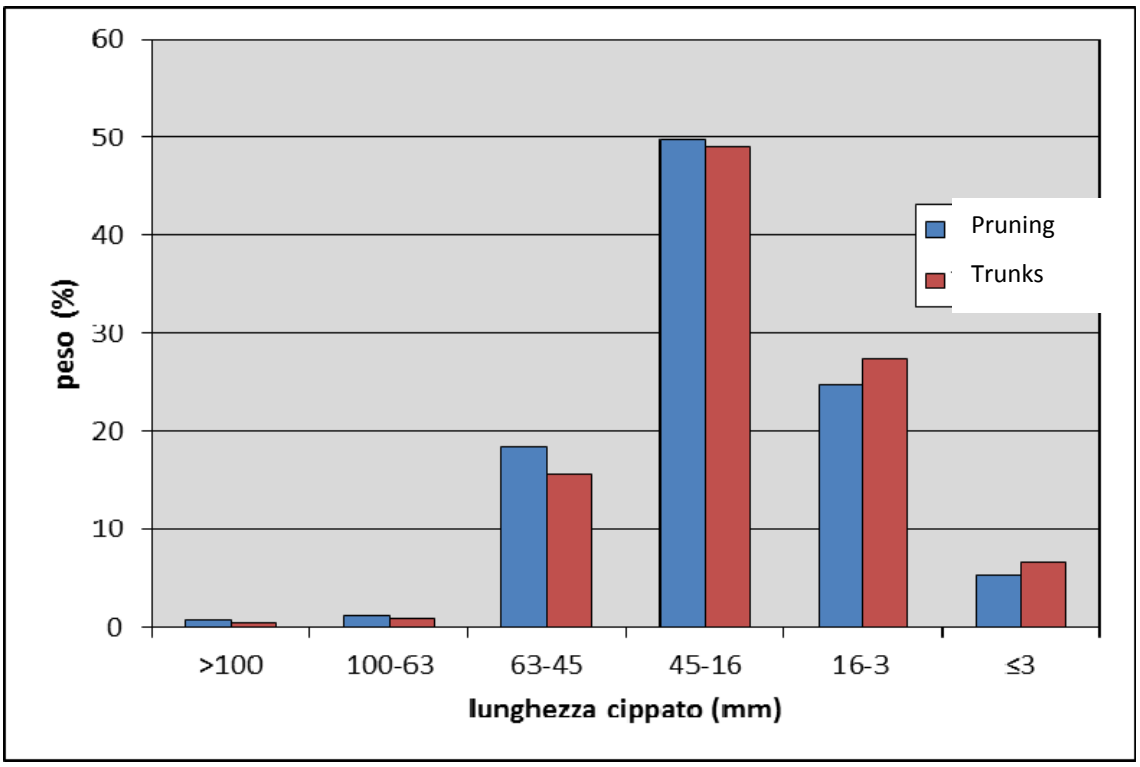
The average particle size distribution obtained from this chipper is shown in graph 6.a, which shows the prevalence of medium-large particles (45-16 mm) and a limited amount of dust (the fraction with length < 3.15 mm represents about 6% in weight).

In general, the chips produced with the 80x80 mm screen has a uniform size, with a predominant distribution in the middle target class.

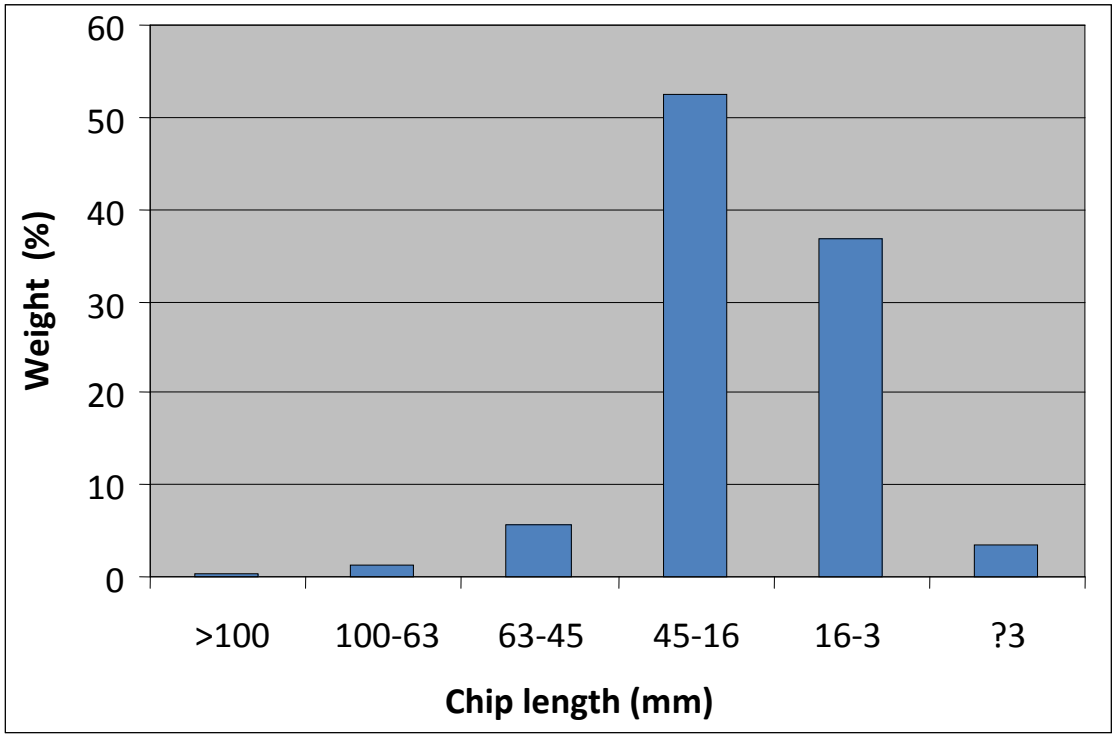


Graph 10 – Particle size distribution of chips produced by the PTH 700/660 chipper with 80x80 mm screen using 2 different materials

3.11 Pezzolato PTH 900/660 M with sieve spacing of 50 mm

This chipper, unlike the others presented so far, has an independent engine with a power of 260 kW and has a screen mounted with vertical bar spacing of 50 mm. For-

ty tests were carried out and the result of the average particle size distribution is shown in Graph 7, which highlights the prevalence of particles with an average length of 45-16 (52.5%), albeit also with a strong presence in the size class directly below it (16-3 mm - 36.8%).



Graph 11 – Particle size distribution of chips produced by PTH 900/660 M with independent engine and bar spacing of 50 mm

3.12 Pezzolato PTH 900/820 with bar spacing 80 mm

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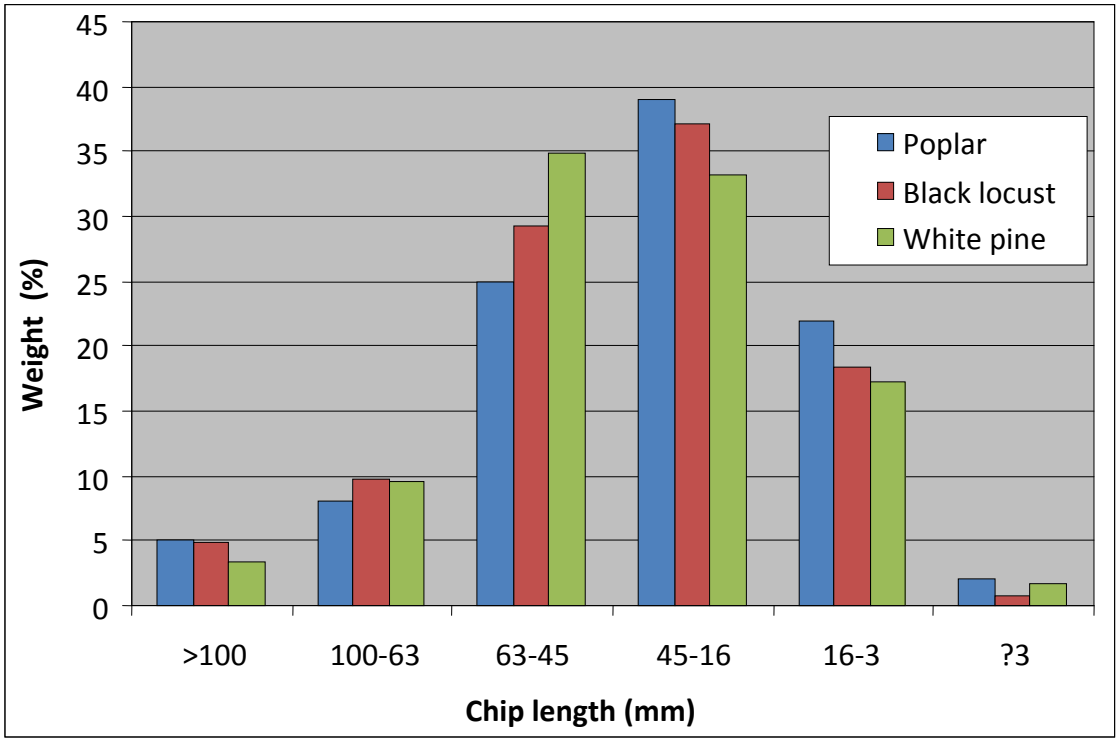
This machine was a special version, coupled with a self-propelled forage harvester John Deere 7700 409 kW and intended for the chipping of small stems obtained from short rotation plantations. The machine was equipped with a screen consisting of vertical bars spaced at 80 mm. For testing, three samples were collected for each material being processed, as the chip was made from 3 different types of wood: poplar, black locust and white pine, as shown in Graph 8.b. The particle size distribution is less uniform than in the previous cases: there is a prevalence of large and medium-sized particles (> 16 mm) and a very low percentage of dust (1%). This is probably due to the type of material being processed and to the use of a very wide screen.



Graph 11 – Particle size distribution of chips produced by PTH 900/820 chipper with bar spacing of 80 mm, on 3 different materials

3.13 Pezzolato PTH 1000/820 with 30x30 mm screen

Also in this case, the machine was a special version, specifically designed for the industrial production of micro-chips, intended for the production of pellets or for feeding small boilers for residential use. For this reason, cut length was set at 10 mm and the machine was equipped with a narrow square mesh of 30x30 mm. For the tests, locally sourced chestnut logs were used. The particle size distribution of the product is shown in Graph 13, where we can see the concentration of the product in the length class between 3 and 16 mm.

It is interesting to note that the presence of dust (particles <3 mm) is very low for such a fine product. This is definitely a very favourable result, because normally any

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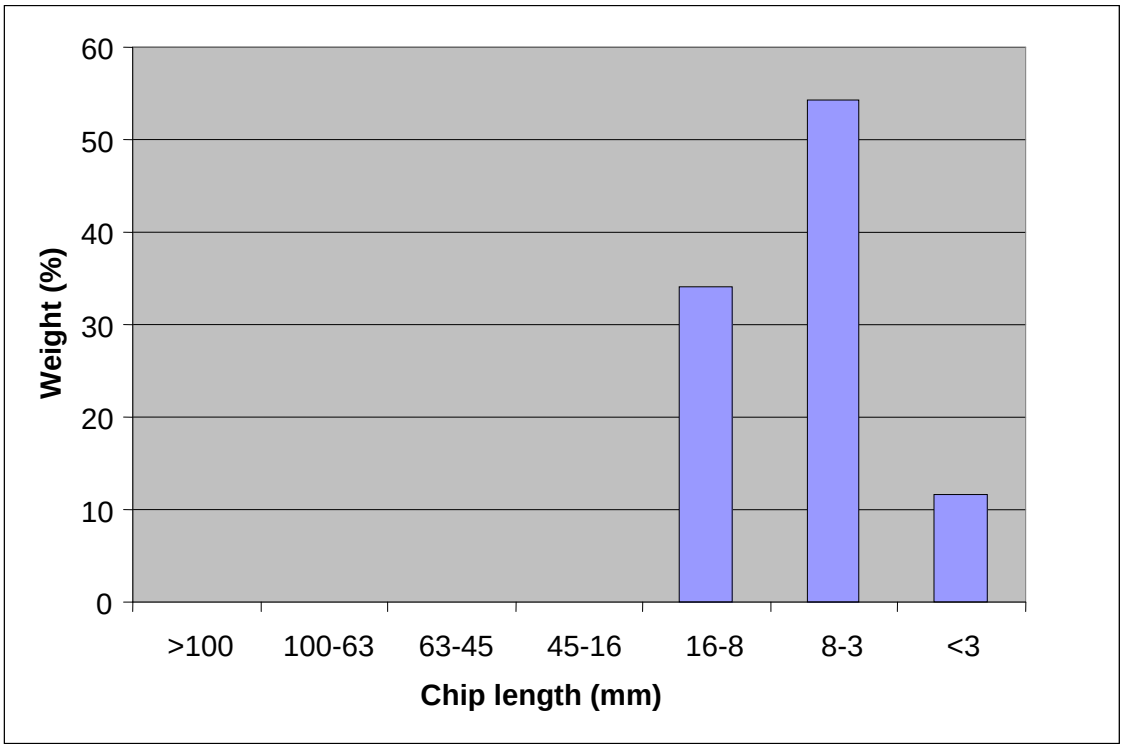
intervention to reduce chip length also causes a rapid increase in the percentage of dust, which here, on the other hand, is decidedly limited.



Graph 13 – Particle size distribution of chips produced by the PTH 1000/820 with 30x30 mm screen

Conclusion

Table 1 shows an overall view of the test results. This investigation has covered a wide range of machine models, and allows to make interesting general considerations. Obviously, the machines set up to produce larger chips offered different performances than those set up to produce medium-size, fine or micro-chips.

The former produced very uniform chips with a very small proportion of fine particles (dust), whereas the latter produced more dust (length <3 mm), but fewer over-sized particles (length> 100 mm).

TEST	CHIPPER	SIZE	SCREEN	SIZE CLASS (mm)						
n°	MODEL	mm	mm	>100	100-63	63-45	45-16	16-8	8-3	≤3
1	PTH 1300/1500	35	100x120	6.8	23.0	45.7	24.3	0.0	0.0	0.2
2	PTH 1400/1000	40	100x100	0.0	0.0	0.4	47.1	44.3	7.8	0.4
3	PTH 1000/1000 on truck	40	100x100	18.3	17.3	11.1	29.1	15.8	6.6	1.8
4	Hackertruck PTH1000/1000	42	100x100	2.1	3.2	8.3	58.4	18.2	7.4	2.4
5	H880/250	13	50x50	0.0	0.0	0.2	5.6	57.6	28.9	7.7
6	PTH 300	15	50x50	0.0	0.0	0.2	5.0	49.9	34.3	10.5
7	Hackertruck PTH1000/1000	20	100x100	0.3	0.3	0.2	35.4	39.2	18	4.8
8	PTH 700/660 - 95 kW tractor	17	50x50	0.0	0.0	0.3	15.3	56.2	22.3	5.9
9	PTH 700/660 - 231 kW tractor	20	60x60	0.0	0.0	0.6	29.95	53.8	12.6	3.1
10	PTH 700/660 - 112 kW tractor	20	80x80	0.6	1.0	17.0	49.3	26.1		5.9
11	PTH 900/660 M	20	50 bars	0.2	1.2	5.8	52.5	36.8		3.6
12	PTH 900/820 on harvester	30	80 bars	4	9	30	36	19		1
13	PTH 1000/820	10	30x30	0.0	0.0	0.0	0.0	34.0	54.3	11.7

Table 1 – Summary of test results

In fact, all the machines produced uniform chips, with a minimal incidence of over-sized particles (> 100 mm), regardless of cut length settings and screen size. An exception is the PTH 1000/1000 in test no. 3, and the exception is explained by the fact that the machine had long cut and was fed with fine green branches obtained from the maintenance of urban greenery, which are too flexible and notoriously unsuited to the production of quality chips.

On machines designed for the production of larger chips, the very low content of fine particles (<3 mm) was partly related to the use of conveyor belt evacuation systems, which characterized the machines involved in tests no. 1, 3 and 4.

On the other hand, the presence of fine particles (<3 mm) was very low even with the machines set for a very short cut length and equipped with narrow mesh screens, although, it is a general rule that the percentage of fine particles is inversely proportional to that of over-sized particles, and that it increases with decreasing of the cut length.

Finally, the machine designed to produce micro-chips (test no. 13) was particularly suited to its task since almost 90% of the product was well inside the target length, and fine particles (<3 mm) were under 12%.

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