OCCUPATIONAL NOISE LEVEL IN MECHANIZED AND SEMIMECANIZED HARVEST OF COFFEE FRUITS

José Antonio Ramos da Silva¹, Geraldo Gomes de Oliveira Júnior², Carlos Emanuel de Melo Costa¹, Adriano Bortolotti da Silva³, Camila Pires Cremasco Gabriel⁵, Fernando Ferrari Putti⁶

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ABSTRACT: Coffee cultivation has undergone significant changes, especially with regard to the mechanization process of the various existing operations that were previously carried out manually by the workers. It is observed that the intensification of mechanized activities can expose workers to noise levels capable of compromising their hearing health. In this sense, the objective in the present study was to determine the level of occupational noise in the activities of mechanized and semi-mechanized harvesting of coffee fruits and compare them with the limits of tolerance of the current legislation. The occupational noise level was determined considering the exposure of homogeneous groups, using an integrative meter for personal use, noise dosimeter, electromechanically calibrated and with field calibration. The results demonstrate that the noise levels found are above the limits allowed for an 8-hour working day. The highest observed level was 100.7 dB (A) in the sweeping operation with the blower equipment and the lowest level 89.0 dB (A) in the auxiliary activity of the selected collection equipment Vicon H3000. Harvesting activity with a portable mechanical stripper equipment showed a noise level 4.2% higher compared to harvesting with automotive harvester equipment.

Index terms: Coffee cultivation, mechanization, occupational risk.

1 INTRODUCTION

Coffee production is an important activity in Brazilian agribusiness (APARECIDO et al., 2017), responsible for a large financial movement in the country, as well as being a financial base for several municipalities and regions (FERREIRA JÚNIOR et al., 2015).

It has been verified that the activities of the coffee crop have undergone significant changes over time, especially with regard to the mechanization process of the several existing operations that were previously performed manually by the workers (CUNHA et al., 2016).

The harvesting process is one of the main coffee operations that influence the production activity, and due to the need for changes, these activities are carried out through mechanized systems, being able to be harvesters and / or mechanical stripper (SANTINATO et al., 2015; SILVA et al. 2013).

Studies have shown that the harvest yield of semi-mechanized fruits is eight times higher than the manual harvest (MATIELLO et al., 2013) and that manual harvesting is 50% to 60% more expensive than mechanized harvesting (SANTINATO et al., 2014).
However, even contributing to the optimization of agricultural operations, the intensification of the use of mechanized equipment in the coffee harvesting process can expose workers to high levels of noise that, depending on the intensity and time of exposure, can compromise their occupational health (LIMA JUNIOR et al., 2014; VALLONE et al., 2016).

In this way, exposure to noise over a long period can lead to hearing loss, psychological damage, sleep disturbances, cardiovascular alterations, immune system dysfunction, fatigue, irritability, also increase the risk of work-related accidents and decrease the performance of workers (SILVA et al., 2014).

Noise is a type of sound or mixture of these that has the capacity to cause harm to the health of the people who perceive it, characterized by being a set of unpleasant sounds in the ear of individuals (COSTA et al., 2015).

It is worth noting that hearing loss, in addition to the physiological and mental damages caused to the worker, may also progress to more severe stages over the years (SANTOS; ALMEIDA, 2016).

Therefore, the quantitative evaluation of the physical noise risk allows verifying that the limits of tolerance are within those allowed in the current legislation, subsidizing the selection of occupational protection measures to reduce the health damages of workers who are connected to these operations (SANT’ANA; ZANNIN, 2016).

In this sense, the objective in the present study was to determine the level of occupational noise in the mechanized and semi-mechanized harvesting activities of coffee fruits and compare them with the tolerance limits of the current legislation, since the tolerance limit is 85 dB (A) for an 8-hour workday and 82 dB (A) for the action level, according to Regulatory Standard NR 15 and Occupational Hygiene Standard NHO 01.

2 MATERIAL AND METHODS

The present case study was carried out at São Manoel Farm, located in the municipality of Muzambinho, in the south of Minas Gerais, with a total area of 98 ha, of which 60 ha are occupied by coffee cultivation, whose average annual production is 2,400 bags per year.

Data collection was carried out during coffee harvesting activities from July to August 2017, in the so-called “Café do Curral”, red catuai 144 variety, spacing 3.5 x 0.8 m; “Café da Casa”, red catuai 144, spacing 3.5 x 0.8 m; “Café da Paineira”, red catuai 144, spacing 3.6 x 0.8 m and “Café do Coqueiro”, acaiá variety, spacing 2.5 x 1.0 m.

The evaluation was performed by means of the quantification of the occupational noise level for the activities developed in the mechanized and semi-mechanized harvesting stage, using the automotive harvester Electron Auto TDI, MWM D229-4 model, with booth, 2012 manufacturing, 4 engine cylinders, power of 67 hp, working with a rotation of 1800 rpm; the portable mechanical stripper Shindaiwa, C230 model, with 22.5/1.4 displacement (cc/Pol), with power/rpm of 1.2 hp/7500 rpm; homemade blower, with SWZ blower turbine, with working rotation of 2200 rpm; the SWZ picker, B-900 model, 2016 manufacturing, work rotation of 1450 rpm and an auxiliary worker positioned at the coffee exit in the Vicon picker (Figure 1).

The implements, blower and pickers SWZ and Vicon were dragged by the Yanmar tractor, 1155-4 SR model, year of manufacture 2010, power of 40.5 kw (55 hp), unmanned.

The data collection was done in a way to represent the working day, respecting the meal schedule, totaling 8 hours of work a day.

The noise quantification was developed in order to characterize the exposure of workers through homogeneous groups, considering the following treatments: Harvester, Blower; SWZ picker; Vicon picker, Vicon auxiliary picker and Shindaiwa C230 picker.

For the data collection, 21 (twenty-one) dosimetry repetitions were performed for the picker, 5 (five) for the harvester, blower, pickers and Vicon auxiliary picker.

For this study, the noises were classified as continuous and for their evaluation was used personal integrator meter, noise dosimeter DOS-100 model of SKILL TEC brand, which were calibrated electromechanically with certificate of the Brazilian Calibration Network (RBC) and calibration before and after the evaluation, using the CAL-4000 calibrator, INSTRUTHERM, IEC 942/CLASSE 2, with output sound pressure levels of 94 and 114 dB.

The dosimeter was set up according to the following parameters: reference criterion of 85 dB (A), which corresponds to the 100% dose for an 8 hours exposure, integration threshold level of 80 dB(A), increased dose doubling of 3 dB (q-3) and indication of occurrence levels above 115 dB (A) (GIAMPAOLI et al., 2001).
Throughout the data collection process, a wind shield was used in the dosimeter microphone to avoid possible air velocity interference and to protect the microphone against dust, as recommended by Giampaoli et al. (2001).

The noise dosimeter was installed with the microphone positioned in the auditory zone, near the ear of the worker. After the evaluation and data collection, the SEL - Standard Exposure Level in dB (A) was determined, using the following expression:

$$SEL = EL + 10 \log \left( \frac{T_E}{480} \right) [dB(A)]$$  \hspace{1cm} (1)

On what,

EL - is the exposure level; it is the average representative level of daily occupational exposure; and

$T_E$ - is the duration time, in minutes, of the daily workday.

The Exposure Level (EL) - was calculated by the following formula:

$$EL = 10 \log \left( \frac{480}{T_E} \right) x \left( \frac{D}{100} \right) + 85$$  \hspace{1cm} (2)

On what,

EL - is the level of exposure;

$T_E$ - is the duration time, in minutes, of the daily workday.

$D$ - Daily dose of noise in percentage;

For this criterion it is considered as action level the SEL value equal to 82 dB (A).

Note that the working day established was 8 hours daily (480 minutes) to which workers were exposed to the physical agent noise, therefore $T_E$ will be 480 minutes daily.

After the evaluation, the mean results obtained were compared with the tolerance limits established by the Occupational Hygiene Standard NHO 01 (GIAMPAOLI et al., 2001). From the mean data found, the maximum time of exposure to occupational noise in which the operators and auxiliary workers could be exposed without adequate ear protection was evaluated, and for the intermediate values found, the maximum allowable daily exposure was considered relative to the immediately higher level according to Occupational Hygiene Standard NHO 01 (CUNHA; TEODORO, 2006).

Data on the occupational noise levels of the mechanized and semi-mechanized harvesting coffee fruits: a) automotive harvester Electron Auto TDI, b) homemade blower, c) portable mechanical stripper, d) SWZ picker, e) Vicon picker and f) auxiliary worker position in the Vicon picker.
In the present study, the equipment, mechanical stripper and automotive harvester, presented noise levels above 85 dB (A) allowed for an 8-hour work day (Table 2).

The average level of occupational noise obtained in the harvesting activity with the evaluated portable mechanical stripper equipment, whose value is 97.8 dB(A), is below the values found by Cunha and Teodoro (2006) 104.6, 100.7 e 102.2 dB(A) respectively, when evaluating different types of mechanical stripper. Also, according to the same authors, when the mechanical stripper worked at idle, the average level of occupational noise reached high values approaching the acceptable maximum limit. Possibly the difference in noise levels found between the present study 2017 and the values pointed out by Cunha and Teodoro (2006) stems from the evolution in the equipment of the breakers over time, considering that the work of Cunha and Teodoro was carried out 11 years ago.

It is worth noting that the harvesting activity with the mechanical stripper equipment presented a higher level of occupational noise compared to that found in the harvesting activity using automotive harvester equipment, that is, the automotive harvester emitted 4.2% less occupational noise when compared to the mechanical stripper. According to Sales et al. (2015) the activity with the operation of the collapsible equipment can present a high potential of health risk of the workers in function of the level of noise to which they are exposed during the activities of semi-mechanized harvesting.

Therefore, comparing the exposure time and the occupational noise level found, it is verified that the workers involved in all activities of mechanized and semi-mechanized coffee harvesting cannot carry out their activities without the use of adequate ear protection, as seen that according to the Regulatory Standard NR 15 and Occupational Hygiene Standard NHO 01, the exposure of workers to occupational noise levels exceeding 85 dB (A) exceeds the tolerance limit for an 8-hour working day (BRAISL, 1978; GIAMPAOLI et al., 2001).

Also, according to Regulatory Standard NR 15, the exposure of workers to occupational noise levels of more than 85 dB(A) for an 8-hour workday, without due preventive control, requires the payment of an additional health insurance of 20% (BRASIL, 1978).
From the analysis of Figure 2, it is possible to observe the behavior of the data in the mechanized and semi-mechanized coffee harvest stages, since these present good behavior, that is, they do not present great variation, being able to say that the data of the noise levels generated by the mechanized and semi-mechanized harvesting operations of coffee trees did not suffer significant variations (Figure 2).

Table 3 shows the maximum allowable daily times for noise exposure by workers, considering whether the levels found in each work situation evaluated, as recommended by Occupational Hygiene Standard NHO 01 (GIAMPAOLI et al., 2001).

It is also worth noting that the exposure limit, also known as the tolerance limit, does not constitute the protection of all workers involved in the activity, since Occupational Hygiene Standard NHO 01 defines as the exposure limit the parameter that represents conditions on which it is believed that most workers may be exposed repeatedly without adverse effects on their ability to hear and understand normal conversation (GIAMPAOLI et al., 2001).

**TABLE 1 - Average noise level in mechanized coffee harvesting.**

| Tractor / Harvester | RPM  | Implement / activity | Model          | Noise dB(A)* | CV (%)^1 |
|---------------------|------|----------------------|----------------|--------------|----------|
| Yanmar 1155-4 SR    | 2200 | Blower               | Home made      | 100.7±0.51   | a        |
| Automotive harvester| 1800 | -                    | TDI MWM D229-4 | 93.8±2.49    | b        |
| Yanmar 1155-4 SR    | 2200 | Picker               | Vicon Selecta H3000 | 92.9±0.64 | b, 1,3   |
| Yanmar 1155-4 SR    | 1450 | Picker               | SWZ            | 89.1±0.20    | c        |

Means followed by the same letter in the column do not differ by Tukey’s test. * They are not significant (P> 0.05) and are significant (P≤0.05). ^1 CV - Coefficient of variation.

**TABLE 2 - Comparison of mean noise level in mechanized and semi-mechanized harvesting of coffee.**

| Harvest type    | Equipment                  | Noise dB(A)* | CV (%)^1 |
|-----------------|----------------------------|--------------|----------|
| Semi-mechanized | Mechanical stripper Shindaiwa | 97.8±1.78    | a        |
| Mechanized      | TDI Automotive Harvester    | 93.8±2.49    | b        |

Means followed by the same letter in the column do not differ by Tukey’s test. * They are not significant (P> 0.05) and are significant (P≤0.05). ^1 CV - Coefficient of variation.

**FIGURE 2 - Box-plot of noise dB (A) generated by the TDI automotive harvester and Mechanical Stripper Shindaiwa C230.**
TABLE 3 - Maximum permissible daily exposure time in the use of mechanized and semi-mechanized equipment in the coffee harvesting activity according to Occupational Hygiene Standard NHO 01.

| Equipment / Activity | Noise dB(A) | Exposure time* | CV (%)1 |
|----------------------|-------------|----------------|---------|
| Blower               | 100.7±0.51  | 11.90 min      |         |
| Mechanical Stripper Shindaiwa | 97.8±1.78   | 23.81 min      |         |
| Automotive harvester | 93.8±2.49   | 60.00 min      |         |
| Picker               | 92.9±0.64   | 75.59 min      |         |
| Picker               | 89.1±0.20   | 190.48 min     |         |
| Auxiliary            | 89.0±0.10   | 190.48 min     |         |

*Approximate exposure time allowed. 1 CV - Coefficient of variation.

4 CONCLUSIONS

Under the conditions in which the study was conducted, it was concluded that the noise levels in mechanized and semi-mechanized harvesting activities are above the limits allowed for an 8-hour workday, and individual protection devices should be used to attenuate to the tolerance limit in order to improve working conditions for the workers.

The highest noise level was found in the sweeping operation with the use of the blower equipment with 100.7 dB(A) and the lowest value in the sweeping activity with the auxiliary of the picker equipment selecta H3000 Vicon with 89.0 dB(A).

Harvesting activity with portable mechanical stripper equipment showed a 4.2% higher noise level compared to harvesting with automotive harvester equipment.

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