

NOISE EXPOSURE LEVELS IN OLIVE OIL EXTRACTION PLANTS AND ITS EFFECTS ON EMPLOYEES

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Abstract

The aim of this study is to determine noise levels in continuous olive oil extraction plants and to evaluate their effects on worker health. The study was conducted in 17 continuous system plants. The sound pressure level (dBA) measurements were carried out at the ear levels of operators working in all units used in olive oil production. In the study, considering A weighted equivalent sound pressure levels and working durations, personal daily noise exposure levels were calculated. It was determined that the daily personal noise exposure levels in the loading units located outside the plants ranged from 65 to 85 dBA, and these values were found to be between 72 and 99 dBA in all other indoor units. As a result, it was observed that the upper daily noise exposure action value (85 dBA) was exceeded in all indoor units.

ZEYTİN YAĞI FABRİKALARINDA GÜRÜLTÜ MARUZİYET SEVİYELERİ VE ÇALIŞANLAR ÜZERİNDEKİ ETKİLERİ

Anahtar Kelimeler

Ses basınç düzeyi
Kapalı alan gürültüsü
Günlük gürültü maruziyeti
Ergonomi

Öz

Bu çalışmanın amacı, sürekli zeytinyağı çıkarma tesislerinde gürültü parametrelerini belirlemek ve bunların işçi sağlığı üzerindeki etkilerini değerlendirmektir. Çalışma 17 sürekli zeytinyağı ekstraksiyon tesisinde yürütülmüştür. Ses basıncı düzeyi (dBA) ölçümleri zeytinyağı üretiminde kullanılan tüm ünitelerde çalışan operatörlerin kulak seviyelerinde gerçekleştirilmiştir. Çalışmada A ağırlıklı eşdeğer ses basıncı düzeyleri ve çalışma süreleri dikkate alınarak kişisel günlük gürültü maruziyet seviyeleri hesaplanmıştır. Tesislerin dışında bulunan yükleme ünitelerinde günlük kişisel gürültüye maruz kalma seviyelerinin 65 ile 85 dBA arasında değiştiği ve bu değerlerin diğer tüm iç ünitelerde 72 ila 99 dBA arasında olduğu belirlenmiştir. Sonuç olarak, tüm iç ünitelerde günlük en yüksek gürültü maruziyeti eylem değerinin (85 dBA) aşıldığı bulunmuştur.

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1. Introduction

Olive cultivation is carried out with 900 million olive trees on an area of approximately 9 million hectares in the world and 90% of the production takes place in Mediterranean countries. World olive oil production is 2.85 million tons according to the average of the last five years (2012-2017). Important olive oil producing countries are Spain, Italy, Greece, Portugal, Turkey, Tunisia and Syria. EU countries have an important share of 68% in production (Sümer et al., 2016; TAGEM, 2018). Classical press systems used in olive oil extraction in the past have been replaced by modern continuous systems today (Savran and Demirbaş, 2011; Mumkaya, 2012; TAGEM, 2018). The concerns such as saving time in all kinds of production activities, reducing dependence on people, increasing quality and quantity can be counted as the main reasons for using new technologies in production facilities. While these technologies and innovations provide important advantages, they can also cause some undesirable situations for employees. Particularly, machine operators and the other employees work under various hazards and risks in terms of occupational health and safety. Noise is one of the most widely and frequently experienced problems of the man-machine systems (Stangl et al., 1973). Noise is generally defined as unwanted or bothersome sound and affects man physically, psychologically, and physiologically (Bruel and Kjaer, 1986; Sümer et al., 2006; Sabancı and Sümer, 2015). The effects of noise in indoor studies have attracted the attention of many researchers and studies have been carried out to determine noise levels and their effects on people in factories.

Yağmur (2016) conducted a study on the evaluation of the vibration and noise exposures of workers in flour production and put forward some protective and preventive suggestions. Konuklar (2016) carried out a study to determine the noise exposures of workers in weaving factories. Daily personal noise exposure levels of the employees were determined with the task-based measurement strategy. In a study conducted by Gönüllü et al. (2002), the sources that cause noise according to the types of processes at the different indoor industries were defined and the equivalent sound pressure levels (L_{eq}) were determined. Ege et al. (2003) conducted a study on determining noise levels and evaluating their effects in textile factories. Özgüven (2012) determined the noise levels of some units (mixer, selector and

hammer feed crushing machine) used for post-harvest operations indoor and created noise maps. Ateş and Alagöz (2018) measured sound pressure levels (dBA) in a factory manufacturing agricultural machinery and evaluated their effects on workers according to the relevant regulations.

As can be seen, various studies have been conducted to determine the noise level in indoor production facilities including some agricultural products. However, no studies have been conducted on the noise level and effects in the facilities for olive oil production. Olive oil factories with electrically driven mechanical units contain many risk factors for employees, including noise. The objective of this study was to determine the daily personal noise exposure levels and to evaluate the possible effects on the workers. For this purpose, sound pressure level (SPL) measurements were made in continuous olive oil extraction plants and the results were evaluated by considering the relevant regulations.

2. Method

The study was conducted in 17 continuous olive oil extraction plants operating in the Marmara and Aegean Region of Turkey. The codes defining the plants and some technical specifications are given in Table 1. Each plant given in Table 1 consists of the units shown in Fig. 1. Operators constantly control the production flow in these units. Therefore, employees spend most of their daily working hours near the machines they are responsible for. In continuous systems also known as uninterrupted or constantly working system, olive oil is produced by passing the olive fruit through loading, cleaning, crushing kneading (malaxer), centrifuge (decanter) and separation (Separator) units, in the given order. Although there is a variety of brands in the production units, they do not have any functional differences.

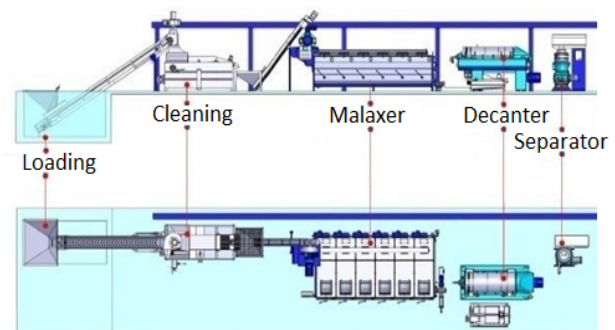


Figure 1. Scheme of Olive Oil Extraction Line

Table 1. Some Technical and Other Features of Olive Oil Extraction Plants

Plant Code	Number of Lines	Brand	Number of Workers	Active Working Time, h	Turn of work	Break, h
P1	1	Rapanelli	4	11	Single	1
P2	2	Haus	4	11	Single	1
P3	2	Pieralisi, Polat	5	11	Single	1
P4	1	Haus	5	13	Single	2
P5	1	Amenduni	5	8	Single	1
P6	1	Polat	5	7	Single	1
P7	3	Haus	13	11	Double	1
P8	1	Pieralisi	2	7	Single	1
P9	2	Rapanelli	5	11	Single	1
P10	4	Amenduni	9	7	Single	1
P11	3	2 Amenduni, 1 Haus	8	11	Single	1
P12	1	Pieralisi	4	9	Single	1
P13	6	4 Haus, 1 Pieralisi, 1 Amenduni	13	10	Double	2
F14	2	1 Amenduni, 1 Haus	10	11	Single	1
F15	2	Haus	12	8	Single	1
F16	2	1 Pieralisi, 1 Haus	10	8	Double	1
F17	1	Polat	4	11	Single	1

In order to determine the measurement strategy in the study, all factors (work, production, process, organization, employees, working time) that can contribute to noise exposure were analyzed. When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each (OSHA, 2020). As a result of the analysis done with this approach, it was determined that the task-based measurement strategy was suitable for the study and measurements were performed. According to the task-based measurement strategy, all tasks performed by the employees within a working day were defined, the working time of each task was determined precisely, and sound pressure level measurements were made for each task separately. In the measurements, a SPL meter in Type-2 class complying with the requirements of IEC 61672-1: 2002 was used. (TESTO 816-1). Calibration of sound level meter was performed by using Testo Schall IEC 60942 Class 2 calibrator complying with the of IEC 61672-1: 2002, which defines the SPL as 94 and 114 dBA. A MASTECH brand MS6252B model wind meter was used to determine the wind speed in the loading units located outdoor. The measurements of A weighted SPL (dBA) for all sub-tasks of the operators in each unit were conducted for about 5 min with three replications. In all measurements, the microphone was located 20 cm to the right side of the center plane of the operator's head, in line with the eyes, with its axis parallel to the operator's line of vision (ISO 9612:2009).

The measurements were performed by recording data every second and 300 values were obtained in each repetition. Equivalent SPL (L_{Aeq}) values were calculated by Equation (1) using the obtained SPLs dBA. Durations (T_m) for each task were determined by observing workers' occupational activities in plants and interviewing them.

$$L_{p,AeqT,m} = 10 \lg \left[\frac{1}{I} \sum_{i=1}^I 10^{0.1 \times L_{p,AeqT,mi}} \right] \quad (1)$$

where;

$L_{p,AeqT,mi}$: LAeq for task m, dBA

i : Task sample number

I : Total number of task samples

m: Task number

Equation (2) was used to calculate the relative contribution of each task to the Daily personal noise exposure levels of operators according to the task-based measurement strategy specified in the EN ISO 9612 standard, using the LAeq values determined by Equation (1) and effective duration of each task in the working day.

$$L_{EX,8h,m} = L_{p,AeqT,m} + 10 \lg \left[\frac{\bar{T}_m}{T_0} \right] \quad (2)$$

where;

$L_{EX,8h,m}$: LAeq for task m contributing to the daily noise exposure level, dBA

\bar{T}_m : Effective duration of the working day for task m, h

T_0 : Reference duration, 8 h

Daily personal noise exposure levels were calculated with Equation (3).

$$L_{EX,8h} = 10 \log \left[\sum_{m=1}^M \frac{\bar{T}_m}{T_0} 10^{0,1 \times L_{p,A,eqT,m}} \right] \quad (3)$$

Where;

$L_{EX,8h}$: Daily noise exposure level normalized to nominal 8 h working day, dBA

M : Total number of tasks

In the study, plant and production unit-based comparisons and evaluations were made considering the noise parameters measured and calculated. The parameters were summarized with charts and graphs, including standard deviation values. The possible effects of daily noise exposure values on operators were evaluated and discussed by considering Directive 2003/10/EC of the European Parliament and of the Council (minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents).

3. Results

The averaged levels of maximum sound pressure (L_{max}), equivalent sound pressure (L_{eq}) and Daily personal noise exposure (L_{EX}) for each production unit are shown in Fig. 2. According to the averaged data of 17 plants, loading and cleaning units are determined to have lower noise parameters compared to other units. The fact that these units are in outdoor or nearest to the open area at the plant entrance is an effective factor that can be cause low levels of noise parameters (Fig. 2, Table 2).

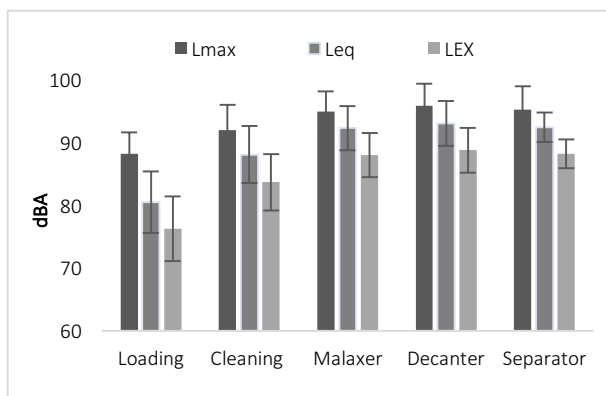


Figure 2. Averaged L_{eq} , L_{max} and L_{EX} Levels of 17 Plants in Production Units

In the loading units, it was determined that the highest L_{eq} and L_{EX} values were at the P2 coded plant, while the lowest L_{eq} and L_{EX} values were at the P15 coded plant. In these units, unlike the units located indoors, vehicles used in loading works (forklift, tractor, truck) are effective in noise formations. For

instance, unlike other plants, use of truck and forklift with internal combustion engine during the measurements caused higher L_{max} values in loading process of P17 coded plant (Table 2). In the measurements performed simultaneously with the SPL measurements at the loading units, the wind speed values were found to be between 0.20-1.41 m/s. These values have no effect on noise measurements according to ISO 9612:2009 standard.

Cleaning units are usually located indoors, while some of them are in semi-open areas. In these units, differently from the machines in other units, noise formation is caused by olive washing equipment, conveyor belt reducers and especially leaf suction fans. The average L_{eq} , L_{max} and L_{EX} values of cleaning units in all plants were found to be 88.12 dBA, 91.98 dBA and 83.70 dBA, respectively. It was determined that the cleaning unit of the P1 coded plant had higher noise parameters compared to other plants. Continuing production using a defective and neglected leaf suction fan in the cleaning unit can be considered as the main reason for this result (Fig. 3, Table 2).

In malaxer units, electric motors and reducers used for crushing and kneading olives are the main sources of noise. The average L_{eq} , L_{max} and L_{EX} values of malaxer units in all plants were 92,31 dBA, 95,00 dBA and 88,03 dBA, respectively. It was determined that the malaxer unit of the P6 coded plant had higher values in all three parameters compared to other plants. In this plant, it has been determined that the decanter unit, which is located between malaxer and separator units, has continued production with a defective bearing. This unsuitable situation had an impact on the noise parameters of all units located indoor in P6 coded plant. All units of this plant, except for the loading unit, have higher noise parameters than those of other plants (Fig. 3, Table 2, Table 3).

In the decanter units, solid-liquid phase separation is performed using high-speed rotating drums. In this unit, vibration motor, drum and gear box can be described as the main noise sources. The average L_{eq} , L_{max} and L_{EX} values of decanter units in all plants were 93.07 dBA, 95.84 dBA and 88.80 dBA, respectively.

In the separation units, the main noise sources were separator bowls, electric motor and reducer. It is clear that the old and neglected parts in the separation unit of P6 coded plant contribute to the determined high noise parameters (Fig. 2, Table 3).

Table 2. L_{eq} , L_{max} and L_{EX} Values of Loading, Cleaning and Malaxer Units

Noise parameters of the units, dBA									
Plant code	Loading			Cleaning			Malaxer		
	L_{eq}	L_{max}	L_{EX}	L_{eq}	L_{max}	L_{EX}	L_{eq}	L_{max}	L_{EX}
P1	81,04±0,63	87,50±1,42	76,90±0,62	94,91±0,13	98,90±1,55	90,65±0,12	96,04±0,34	97,80±0,29	92,66±0,33
P2	87,89±0,12	89,10±0,21	84,52±0,11	87,92±0,17	89,20±0,21	84,55±0,16	91,50±0,90	93,60±0,61	88,12±0,89
P3	76,10±3,67	87,70±3,66	73,00±3,66	89,76±0,42	94,30±0,71	86,38±0,41	93,06±0,02	94,30±0,06	89,68±0,01
P4	79,71±1,50	90,50±2,83	76,84±1,49	84,70±0,15	87,10±0,74	81,73±0,14	91,21±0,73	94,60±1,14	88,21±0,72
P5	87,67±0,20	91,10±0,19	82,90±1,15	91,18±0,39	92,70±0,38	86,41±0,15	91,68±0,18	93,70±0,17	86,33±0,47
P6	85,80±0,58	92,60±1,18	80,67±0,57	87,81±0,95	93,40±2,50	82,18±0,94	102,27±0,16	104,30±0,23	96,92±0,15
P7	82,49±0,52	91,30±2,21	78,69±0,51	85,17±0,49	93,90±2,69	81,37±0,49	92,61±1,50	96,10±1,36	88,81±1,50
P8	81,45±4,29	88,40±2,28	75,44±4,28	93,93±0,53	96,30±0,60	87,91±0,52	89,56±0,36	92,70±0,60	83,54±0,35
P9	86,83±0,05	88,70±0,31	83,44±0,04	88,16±0,55	90,60±0,35	82,81±0,54	90,14±0,03	91,50±0,38	86,75±0,02
P10	77,52±0,42	87,40±2,12	71,93±0,41	81,85±0,24	86,80±1,38	76,00±0,23	87,52±0,56	93,40±3,20	81,54±0,55
P11	82,68±0,58	88,60±2,25	78,88±0,57	93,13±0,80	95,30±0,31	89,33±0,79	90,57±0,11	92,30±0,26	86,77±0,10
P12	69,48±0,55	80,70±4,16	65,28±0,54	84,18±0,21	90,50±2,64	79,92±0,20	85,87±0,11	90,30±1,46	81,61±0,10
P13	81,76±0,80	90,90±2,91	77,96±0,79	84,66±0,16	86,50±0,59	80,86±0,15	92,48±0,16	95,50±0,06	88,68±0,15
P14	81,12±1,24	85,60±1,55	77,74±1,23	91,16±0,82	95,90±0,47	87,77±0,81	95,70±0,19	97,50±0,25	92,31±0,18
P15	74,69±0,96	84,70±0,68	69,38±0,95	77,63±0,78	83,30±0,23	72,30±0,77	93,75±0,06	94,80±0,12	88,40±0,05
P16	74,69±0,71	81,80±2,54	69,19±0,70	89,37±1,82	94,10±2,61	84,02±1,81	91,05±0,21	93,50±0,62	85,70±0,20
P17	78,03±1,28	93,70±5,25	74,24±1,27	92,47±0,36	94,80±0,38	88,67±0,35	94,29±3,38	99,10±2,52	90,49±3,37

The average L_{eq} , L_{max} and L_{EX} values of separator units in all plants were 92.45 dBA, 95.25 dBA and 88.20 dBA, respectively. When the factories are examined over the average of all units, it is seen that the P10 coded plant has the lowest L_{EX} (79.61 dBA)

value, while the coded P6 plant has the highest L_{EX} (91.67 dBA) value (Fig. 3, Table 3). The workers of the P6 coded plant are exposed to higher noise levels due to continuing production even though there are various mechanical faults in the production units.

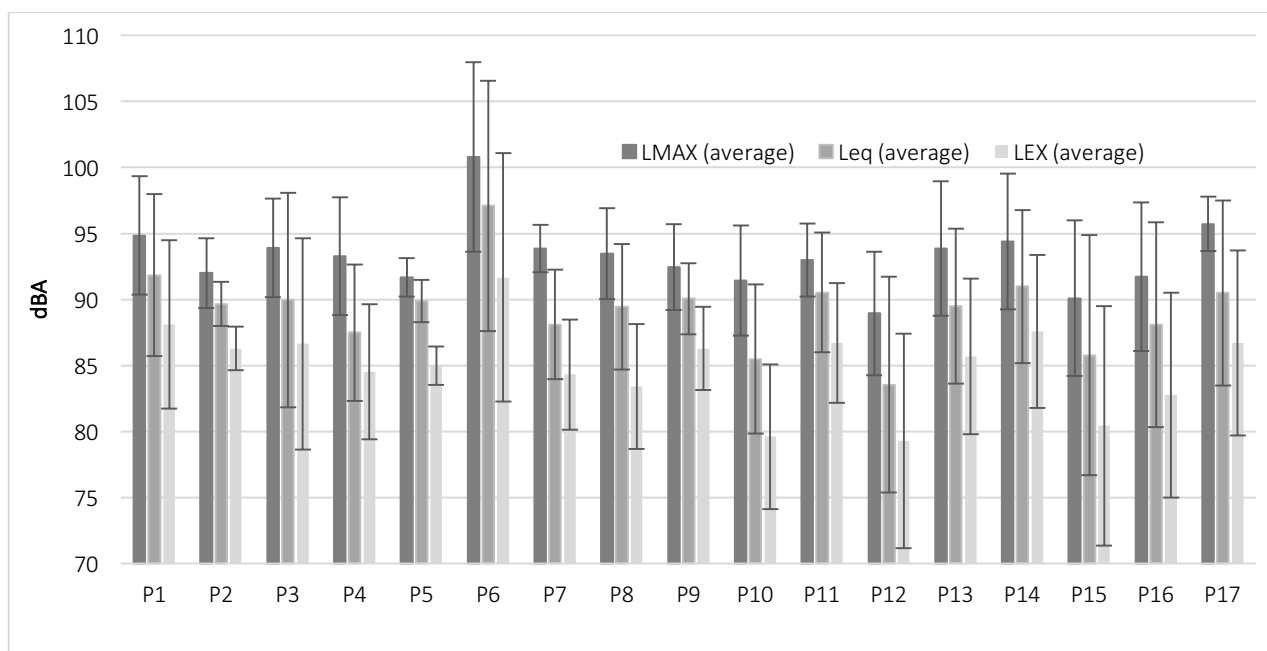


Figure 3. Averaged L_{max} , L_{eq} and L_{EX} Levels of The Plants

4. Discussion

L_{max} , L_{eq} and L_{EX} parameters are generally determined in the studies conducted on the assessment of noise levels in the workplace and evaluations are made considering these values. Considering L_{max} values in evaluating the effects of noise on people at workplace will not give realistic results. This value, which expresses the highest (peak) SPLs among the values recorded during the measurement period, may vary depending on various external factors (people's shouting, phone conversation, hammer drop, etc.). Even the equivalent SPLs are not sufficient to evaluate the effects of noise. In order to evaluate the effects of ambient noise on workers, daily personal noise exposure levels (L_{EX}) calculated using the equivalent SPL and durations exposed should be considered. The maximum noise level to which employees are permitted to be exposed within a working day (exposure action values) specified in the noise regulations refers to the daily personal noise exposure value (L_{EX}). In other words, the noise exposure limits have been determined considering the L_{EX} values. When the literature is examined, it is possible to come across many studies in which the effects of noise on persons are evaluated only by determining L_{eq} and L_{max} values. In some of these studies, the equivalent SPLs determined have been incorrectly compared with the noise exposure limits specified in the regulations. This approach is like comparing apples and pears. In order to assess whether the employees work in accordance with the noise regulations, it is necessary to determine the daily personal noise exposure levels of the employees. Thanks to this approach, the effects of measured ambient noise on employees can be evaluated more accurately and adequate noise control measures can be effectively taken.

In olive oil plants, operators have 1 to 2-hour breaks within a working day. Approximately 0.5-1 hour of this period is used for smoking, toilet and similar needs, and the rest is used for eating. The L_{eq} values determined in the dining halls of the plants are on average 65.47 ± 4.15 dBA. The breaks for the needs other than eating are generally spent outside the plant and average L_{eq} value determined in these areas is 71.64 ± 5.68 dBA. A short duration spent in a less noisy ambiance can significantly reduce the employee's personal daily noise exposure level. For example, at P10 coded plant, the L_{eq} value was determined as 90.46 dBA, however the L_{EX} value of the operator, who had a 2-hour break, was calculated as 84.47 dBA.

The noise, which is one of the most important detrimental factors affecting the employees' carelessness, tiredness, and working capacity, should be reduced to safety limits (Sümer et al., 2006). Therefore, the noise control measures are of

great importance in a workplace to protect the health of employees. The best way to reduce noise is to completely enclose its source, which is called "engineering control" (Kroemer, 2017). Another way of effective engineering control to reduce the noise exposure is isolating the operator from the noise source using an acoustically designed cab or barrier (Sümer et al., 2006). "Management controls" is another effective way to reduce noise exposure, such as regulating duration and frequency of breaks and limiting worker exposure (Harris, 1991). The last way, which is an alternative to reduce the noise exposure, is the use of personal protective equipment (PPE). This way is also called "temporary measure". The two basic types of hearing protection are the earmuffs and earplugs. These PPEs can reduce the sound levels by 15-30 dBA. Earmuffs usually provide better hearing protection than earplugs. Earplugs are also effective, but they may become irritating inside the ear and often are not inserted correctly, making them ineffective (Baker, 1993; Wilkinson, 2002). It was observed that none of the olive oil extraction plants examined had any engineering control to reduce noise. It has been determined that only two plants used PPE (P7 and P10).

Noise will continue to adversely affect human health, in physiological, physical and psychological context, unless necessary precautions are taken. Many acoustic studies report that different noise levels have an impact on employees, such as cognition, decision making, learning, calculation and hand-eye coordination (Sabancı and Sümer, 2015; Thatcher and Yeow, 2018). Thus, the noise has negative effects on the employees in terms of occupational health and safety, and it can also decrease the productivity of employees.

In the hearing loss classification of WHO (World Health Organization); it has been reported that prolonged exposure at 41-60 dB intervals causes hearing loss, 61-80 dB intervals can cause severe hearing loss. Additionally, it has been emphasized in the report that people working with loud machinery in industry or road construction must use PPE. Serin and Akay (2008) stated that noise exposures in the range of 66-85 dBA have disturbing psychological effects in addition to hearing loss. In another study, Sakarya (2016) reported that exposures between 65-90 dBA caused physiological reactions on workers such as increase in blood pressure, increase in heart rate and breathing, decreased pressure in brain fluid. Noise exposure has also been identified as a risk factor for cardiovascular disease (Basner et al., 2014). In a study of 1455 blue collar workers, Melamed et al. (1997) found that workers exposed to levels of noise greater than 80 dBA had significantly higher total cholesterol ($p=0.023$) and triglycerides ($p=0.001$) than workers exposed to noise below 80

dBA. In humans, several studies have shown that the noise causes mainly blood pressure elevation, changes in heartbeat and irregularities in breathing (Von Grandjean 1959; Mosskov and Ettema, 1977; Andren et al., 1980; Zamainan et al., 2013). Some researchers have reported that noise exposure may lead to elevated blood pressure levels even after the exposure to noise has ceased (Talbot et al., 1999; Zhao et al., 1991; Chang et al., 2007). Toprak and Aktürk (2004) stated that noise reduces work efficiency for white-collar and blue-collar workers by 60% and 30%, respectively. Grandjean (1988) informed that the reductions in working performance began in 50–60 dBs according to laboratory studies. Noisy workplaces can inhibit speech communication, mask warning signals, reduce mental performance, induce nausea, headaches and tinnitus (ringing in the ears), cause temporary or permanent deafness (Corlett and Clark, 2009). Exposure to noise can also lead to annoyance and stress, which can affect the mental wellbeing of workers and the general population. Studies of occupational stress have found that that noise exposure can be a contributor to worker stress and annoyance depending on the type of work being performed (Melamed et al., 1992; Leather et al., 2003).

As can be seen, the effects of noise on employees' health and work efficiency have been revealed by various studies. However, regulations regarding the limitations of noise in the workplace have been done considering the physical effects on people. This effect has been emphasized in the majority of scientific studies conducted.

This study has potential limitations on determining the effects of noise levels determined in olive oil factories on the health of employees. No study has been conducted to determine the physical, physiological, and psychological effects of noise on employee health in the factories that constitute the material of the study. Factory managers were unwilling to have audiometric tests and some other medical tests on employees. Because of the lack of necessary permissions, the literature on the effects of noise on human health was examined in the study, and the possible effects of the determined noise levels on the workers in olive oil factories were evaluated.

There are many regulations that specify the permissible noise levels in the workplace. Noise in the workplace in Europe is regulated by the EU Directive 2003/10/EC, and in the United States by OSHA (Occupational Safety and Health Administration) 29 CFR (Code of Federal Regulations) 1910.95 Hearing Conservation Standard. There are also countries with stricter national regulations than those specified in EU and OSHA. According to EU regulations, the noise

exposure should not exceed the exposure limit (87 dBA) during the length of a working day (8 hours) to protect employees from suffering deafness. Employers are required to take certain steps to reduce the harmful effects of noise on hearing. There are two main action levels that guide these steps: lower exposure action value ($L_{EX, 8h}$) 80 dBA, upper exposure action value ($L_{EX, 8h}$) 85 dBA. The lower exposure action value is a daily or weekly average noise exposure level of 80 dBA, at which the employer has to provide information and training and make hearing protection available. The upper exposure action value is set at a daily or weekly average noise exposure of 85 dBA, above which the employer is required to take reasonably practicable measures to reduce noise exposure, such as engineering controls or other technical measures. The use of PPE is also mandatory if the noise cannot be controlled by these measures (European Parliament and of the Council, 2003).

According to the results of the present study, employees work at noisy conditions above the upper exposure action value (daily, 8 hours) in all units except the loading at the plants. In addition, the daily 8-hour period specified in the regulation is exceeded in 11 plants (Table 1, Table 3). The effects of noise on employees vary not only depending on SPL but also on the duration of exposure (Sabancı et al., 2012). It has been determined that olive oil extraction plants have the potential to adversely affect operators' health and work efficiency, as the works is performed at long exposure times and high SPLs. In a study conducted by Yıldızlar (2018) in a tea production plant, it was reported that the measured equivalent SPL (L_{eq}) values ranged between 80 and 92 dBA, and 66% of 512 employees suffered hearing loss. In the present study, while the equivalent SPLs in outdoor areas of plants ranged from 70 to 88 dBA, these values changed in indoor areas between 82 and 105 dBA. When compared with the L_{eq} values determined in the tea production plant, it is seen that all employees face a similar risk in the olive oil extraction plants evaluated, especially in closed areas.

Production in olive oil extraction plants is carried out as a single shift, and daily working times differ according to the plants. It has been observed that management regarding lunch and other breaks is inadequate and quite irregular. In all plants except P2 coded, employees have no specified mealtime, and they usually have their meals at the workplace rather than in the lunchroom. This preference is an important factor that increases the daily noise exposure level of employees. For instance, the 8-hour 85 dBA daily noise exposure of an operator in the malaxer unit decreases to 79.66 dBA thanks to the 1-hour time spent in the lunchroom. The daily personal noise exposure level in the decanter unit of

the P4 coded plant, which worked 13 hours a day, was found to be 87.35 dBA. If the duration worked in this unit is reduced to 8 hours, the daily exposure level will be 84.98 dBA. So, management control in the workplace can be considered as one of the effective ways for the protection of employees against noise related risks.

In the present study, besides the noise in olive oil plants, it has been observed that the precautions taken for employees' health and safety are almost nonexistent. In addition, the awareness of employees regarding occupational health and safety is quite low and they are uneducated in this regard. So, it can be considered as they have performed the works, with very low risk perception.

5. Conclusion

It was concluded that the health and work efficiency of the employees were adversely affected, since the production activities in the continuous olive oil extraction plants were carried out at long exposure times and high SPLs. The duration and conditions of the breaks in the daily activities of the employees had an impact on the LEX values. The operators of the cleaning, malaxer, decanter and separator units located indoor face higher risks of noise than those working outdoor due to higher exposure levels. The age and maintenance-repair situations of the units used for olive oil production are also important in formation the noise. During noise measurements, it was determined that the units with high noise had maintenance-repair deficiencies and some malfunctions. Periodic and predictive maintenance can prevent the extending of the lifetime of the machines and prevent malfunctioning situations as well as indirectly preventing the noise caused by these malfunctions. The directives on noise control state that employers are responsible for applying engineering and management controls of noise to minimize risks and providing employees with PPE if the upper daily noise exposure action level is exceeded. In most olive oil extraction plants evaluated, these measures have not been taken, and therefore it is likely that hearing loss will occur in employees. Moreover, physiological and psychological effects may cause serious disturbances. Along with the effects of noise on human health, effects such as preventing speech and masking warning signals will not only decrease the work efficiency of employees but also increase the risk of accidents. The implementation of engineering controls in olive oil plants is not easy, and sometimes impossible, considering the functions of machinery and the continuity of production. However, the applicability of management controls is high, such as providing a lunchroom isolated from noise and encouraging employees to eat at this area. In addition, apart from lunch break, periodic breaks can

be arranged in areas with lower SPLs. As for the use of PPE, officials in the plants stated that the communication of employees with each other was important for process and malfunction checks, and that PPE use could prevent production continuity by reducing intercommunication and ability to hear sounds associated with malfunction. The use of Earmuffs with Microphones could be a good option to reduce noise exposures of employees and improve the communication between them. Moreover, plant officials who want to make PPE available to employees stated that the operators were not willing to use the PPE provided. However, it is stated in the Directives that the employees are responsible for using the PPEs given by the employer. Employees who do not want to fulfill this obligation in the olive oil production plants should be encouraged to use PPE. Training or punishment could be some other options to increase awareness.

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Conflict of Interest

No conflict of interest was declared by the authors

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