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Monitoring of Se contents of bread and durum wheat grains provided from different locations

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Abstract

Se contents of bread wheats harvested in Eastern Mediterranean Agricultural Research Institute ranged from 89 µg/kg (Ceyhan 99) to 145.0 µg/kg (Seri 82). While Se contents of bread wheat grains harvested from Transitional Zone Agricultural Research Institute change between 10 µg/kg (Yıldız 98) and 27 µg/kg (Altay 2000), Se contents of bread wheat grains harvested Bahri Dagdas International Agricultural Research Institute varied between 11.0 µg/kg (Konya 2002) and 25.0 µg/kg (Dagdaş 94). Also, Se contents of bread wheat samples harvested from Trakya Agricultural Research Institute varied from 12 µg/kg (Atilla 12) to 23 µg/kg (Tekirdağ). Durum wheats were provided from five reseach Institutes in Turkey. Se contents were found high in durum wheats provided from Eastern Mediterranean Agricultural Research Institute, and its level changed between 100 µg/kg (Fuatbey 2000) and 142 µg/kg (Sham 1). While Se level of durum wheat harvested in Transitional Zone Agricultural Research Institute change between 17 µg/kg (Kunduru 1149) and 26 µg/kg (Yelken 2000), Se contents of durum wheat samples harvested from Field CropsCentral Research Institute ranged from 13 µg/kg (Berkmen) to 19 µg/kg (Ankara 98). Generally, Se contents of bread wheat samples were found high according to results of durum wheat samples.

Keywords: Bread wheat, durum wheat, Se contents, locations, ICP-AES

1.Introduction

Selenium (Se) is an essential micronutrient for humans and animals, with antioxidant, anti-cancer and anti-viral effects, and wheat is an important dietary source of this element [19-22]. Selenium (Se) is a trace element essential to the well-being and health quality of humankind [6, 11]. The soil Se-content of a geographical region is reflected in locally produced foodstuffs, which in turn determine the regional nutritional Se supply of animal and man [32, 35]. There is also increasing evidence that Se plays an important protective role both in the human immune system and in the prevention and suppression of a number of specific disorders such as carcinomas, cardiovascular diseases, cystic fibrosis and low fertility [8, 30]. Although the selenium content of food is primarily determined by soil selenium content, it is also characteristically higher for some foods than for others [5]. The organic compounds of selenium and selenates are the most available for uptake by plants. Their presence in soil over a certain level (seleniferous soil) can lead to increase of selenium content in plants who grow on respective soils [1]. Interest in selenium (Se) has escalated in the past two decades. In trace amounts, Se is an essential micronutrient and has important benefits for animal and human nutrition. At high dosages, however, Se may be toxic to animals [16, 39] and to humans [38]. The major source of selenium in most diets are meats and cereal products [17]. Wheat is an important dietary source of Se [18]. Selenium content in plants depends on Se quantity in soil and its biological availability [13]. Low Se status in human organism may increase the risk of cardiovascular, cancer and other diseases, which are caused by free radicals [27, 31]. During the last 20 years researchers in different countries have been interested in selenium content in frequently consumed food [5, 33, 36]. Selenium concentrations in plants reflect [14]. Plant-derived foodstuffs, namely cereals, are the major dietary sources of Se

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in most countries throughout the world, even if Se contents are strongly dependent upon the corresponding levels in cereal-growing soils. Therefore, wheat is one of the staple crops that appears as an obvious candidate for Se biofortification, considering its gross-tonnage production and nutritional relevance worldwide [11]. This element enters the food chain through plants and, consequently, it is highly dependent upon its bioavailability in soils [9]. The aim of current study was to determine Se contents wheat grains collected from several Agricultural Instituents in Turkey.

2.Material and Method

2.1.Material

In this study, selected 64 bread wheat and 19 durum wheat varieties commonly growing in Turkey were used (Table 1). Wheat varieties were registered by the following institutes: Transitional Zone Agricultural Research Institute, Bahri Dagdas International Agricultural Research Institute, Eastern Mediterranean Agricultural Research Institute, Gap International Agricultural Research And Training Center, Black Sea Agricultural Research Institute, Maize Research Institute, Field Crops Central Research Institute, Trakya Agricultural Research Institute, General Directorate of Agricultural Enterprises, TİVAK A.Ş.,Tareks A.Ş . Locations where the wheat varieties used in this study were given in Figure 1.

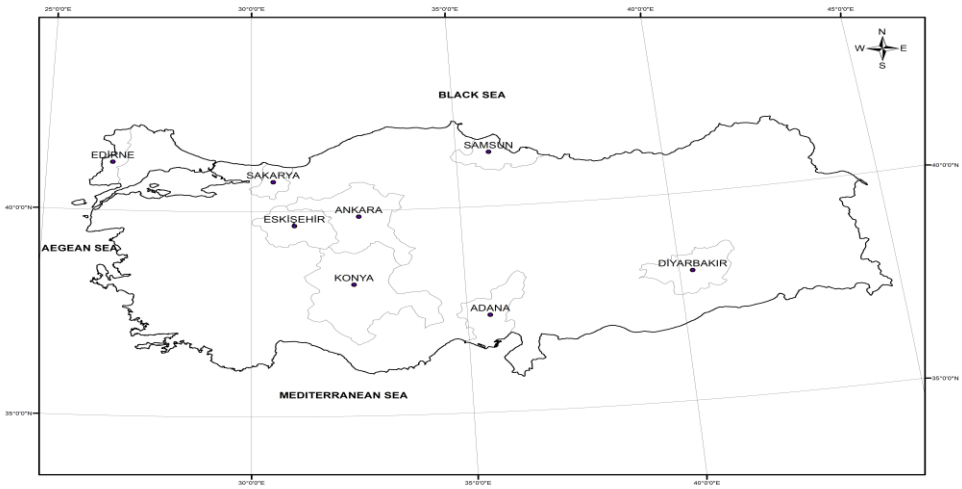

Figure 1. Locations where the wheat varieties used in this study were obtained

Table 1. Wheat varieties used in experiment

Variety name	Wheat species	Certificiate	Locations
Atay 85	Bread wheat	Transitional Zone Agricultural Research Institute	Eskişehir
Bezostaja 1	Bread wheat	Transitional Zone Agricultural Research Institute	Eskişehir
Altay 2000	Bread wheat	Transitional Zone Agricultural Research Institute	Eskişehir
Gerek 79	Bread wheat	Transitional Zone Agricultural Research Institute	Eskişehir
Sönmez 2001	Bread wheat	Transitional Zone Agricultural Research Institute	Eskişehir
Sultan 95	Bread wheat	Transitional Zone Agricultural Research Institute	Eskişehir
Yıldız 98	Bread wheat	Transitional Zone Agricultural Research Institute	Eskişehir
Alpu 2001	Bread wheat	Transitional Zone Agricultural Research Institute	Eskişehir
Yelken 2000	Durum wheat	Transitional Zone Agricultural Research Institute	Eskişehir
Kunduru 1149	Durum wheat	Transitional Zone Agricultural Research Institute	Eskişehir
Kümbet	Durum wheat	Transitional Zone Agricultural Research Institute	Eskişehir
Altıntaş 95	Durum wheat	Transitional Zone Agricultural Research Institute	Eskişehir
Dağdaş 94	Bread wheat	Bahri Dagdas International Agricultural Research Institute	Konya
Göksu 99	Bread wheat	Bahri Dagdas International Agricultural Research Institute	Konya
Bağcı 2002	Bread wheat	Bahri Dagdas International Agricultural Research Institute	Konya
Ahmetağa	Bread wheat	Bahri Dagdas International Agricultural Research Institute	Konya
Kınacı 97	Bread wheat	Bahri Dagdas International Agricultural Research Institute	Konya
Konya 2002	Bread wheat	Bahri Dagdas International Agricultural Research Institute	Konya

Karahan 99	Bread wheat	Bahri Dagdas International Agricultural Research Institute	Konya
Ekiz	Bread wheat	Bahri Dagdas International Agricultural Research Institute	Konya
Eraybey	Bread wheat	Bahri Dagdas International Agricultural Research Institute	Konya
Selçuklu 97	Durum wheat	Bahri Dagdas International Agricultural Research Institute	Konya
Meram 2002	Durum wheat	Bahri Dagdas International Agricultural Research Institute	Konya
Adana 99	Bread wheat	Eastern Mediterranean Agricultural Research Institute	Adana
Osmaniyem	Bread wheat	Eastern Mediterranean Agricultural Research Institute	Adana
Seri 82	Bread wheat	Eastern Mediterranean Agricultural Research Institute	Adana
Yüreğir 89	Bread wheat	Eastern Mediterranean Agricultural Research Institute	Adana
Seyhan 95	Bread wheat	Eastern Mediterranean Agricultural Research Institute	Adana
Doğankent 1	Bread wheat	Eastern Mediterranean Agricultural Research Institute	Adana
Ceyhan 99	Bread wheat	Eastern Mediterranean Agricultural Research Institute	Adana
Karatoprak	Bread wheat	Eastern Mediterranean Agricultural Research Institute	Adana
Fuatbey 2000	Durum wheat	Eastern Mediterranean Agricultural Research Institute	Adana
Sham 1	Durum wheat	Eastern Mediterranean Agricultural Research Institute	Adana
Nurkent	Bread wheat	Gap International Agricultural Research and Training Center	Diyarbakır
Diyarbakır 81	Durum wheat	Gap International Agricultural Research and Training Center	Diyarbakır
Fırat 93	Durum wheat	Gap International Agricultural Research and Training Center	Diyarbakır
Sarıçanak 98	Durum wheat	Gap International Agricultural Research and Training Center	Diyarbakır
Harran 95	Durum wheat	Gap International Agricultural Research and Training Center	Diyarbakır
Canik 2003	Bread wheat	Black Sea Agricultural Research Institute	Samsun
Sakin	Bread wheat	Black Sea Agricultural Research Institute	Samsun
Özcan	Bread wheat	Black Sea Agricultural Research Institute	Samsun
Tahirova 2000	Bread wheat	Maize Research Institute	Sakarya
Pamukova 97	Bread wheat	Maize Research Institute	Sakarya
Momtchil	Bread wheat	Maize Research Institute	Sakarya
Bandırma 97	Bread wheat	Maize Research Institute	Sakarya
Karacabey 97	Bread wheat	Maize Research Institute	Sakarya
Kaynarca	Bread wheat	Maize Research Institute	Sakarya
Beşköprü	Bread wheat	Maize Research Institute	Sakarya
Zencirci 2002	Bread wheat	Field Crops Central Research Institute	Ankara
İkizce 96	Bread wheat	Field Crops Central Research Institute	Ankara
Bayraktar 2000	Bread wheat	Field Crops Central Research Institute	Ankara
Tosunbey	Bread wheat	Field Crops Central Research Institute	Ankara
Gün 91	Bread wheat	Field Crops Central Research Institute	Ankara
Seval	Bread wheat	Field Crops Central Research Institute	Ankara
Demir 2002	Bread wheat	Field Crops Central Research Institute	Ankara
Uzunyayla	Bread wheat	Field Crops Central Research Institute	Ankara
Yakar 99	Bread wheat	Field Crops Central Research Institute	Ankara
Atlı 2002	Bread wheat	Field Crops Central Research Institute	Ankara
Mızrak	Bread wheat	Field Crops Central Research Institute	Ankara
Türkmen	Bread wheat	Field Crops Central Research Institute	Ankara
Eser	Bread wheat	Field Crops Central Research Institute	Ankara
Haymana 79	Bread wheat	Field Crops Central Research Institute	Ankara
Aksel 2000	Bread wheat	Field Crops Central Research Institute	Ankara
Ankara 98	Durum wheat	Field Crops Central Research Institute	Ankara
Mirzabey	Durum wheat	Field Crops Central Research Institute	Ankara
Altın 40/98	Durum wheat	Field Crops Central Research Institute	Ankara
Çakmak 79	Durum wheat	Field Crops Central Research Institute	Ankara
Kızıltan 91	Durum wheat	Field Crops Central Research Institute	Ankara
Berkmen	Durum wheat	Field Crops Central Research Institute	Ankara
Ç 1252	Durum wheat	Field Crops Central Research Institute	Ankara
Pehlivan	Bread wheat	Trakya Agricultural Research Institute	Edirne
Yunak	Bread wheat	Trakya Agricultural Research Institute	Edirne
Atilla 12	Bread wheat	Trakya Agricultural Research Institute	Edirne
Saraybosna	Bread wheat	Trakya Agricultural Research Institute	Edirne
Tekirdağ	Bread wheat	Trakya Agricultural Research Institute	Edirne
Prostor	Bread wheat	Trakya Agricultural Research Institute	Edirne

Selimiye	Bread wheat	Trakya Agricultural Research Institute	Edirne
Kate A-1	Bread wheat	Trakya Agricultural Research Institute	Edirne
Flamura 85	Durum wheat	Tareks A.Ş.	Ankara
Dropia	Durum wheat	Tareks A.Ş.	Ankara
Golia	Durum wheat	General Directorate of Agricultural Enterprises	Ankara
Tina	Durum wheat	TİVAK A.Ş.	Ankara
Nina	Durum wheat	TİVAK A.Ş.	Ankara

Table 2. Selenium concentrations in bread wheat varieties growing in Turkey **(**Data are presented as means±SD,n=3 replicates)

Variety name	**Se (µg kg^{-1})**	**Variety name**	**Se (µg kg^{-1})**
Atay 85	20 ± 0.5	Kaynarca	20 ± 3.9
Bezostaja 1	18 ± 1.4	Beşköprü	18.1 ± 17
Altay 2000	27 ± 1.2	Zencirci 2002	11 ± 0.7
Gerek 79	23 ± 1.6	İkizce 96	11 ± 0.8
Sönmez 2001	14 ± 1.9	Bayraktar 2000	13 ± 1.5
Sultan 95	12 ± 0.6	Tosunbey	13 ± 0.2
Yıldız 98	10 ± 1.6	Gün 91	14 ± 1.6
Alpu 2001	19 ± 1.7	Seval	19 ± 1.4
Dağdaş 94	25 ± 0.1	Demir 2002	22 ± 3.4
Göksu 99	14 ± 0.9	Uzunyayla	13 ± 1.9
Bağcı 2002	12 ± 2.5	Yakar 99	15 ± 0.2
Ahmetağa	15 ± 0.5	Atlı 2002	21 ± 0.0
Kınacı 97	12 ± 1.1	Mızrak	21 ± 0.4
Konya 2002	11 ± 1.7	Türkmen	24 ± 0.1
Karahan 99	16 ± 0.6	Eser	19 ± 0.3
Ekiz	14 ± 0.5	Haymana 79	24 ± 1.7
Eraybey	15 ± 1.7	Aksel 2000	21 ± 1.9
Adana 99	98 ± 12	Pehlivan	16 ± 0.0
Osmaniyem	131 ± 18	Yunak	16 ± 0.1
Seri 82	145 ± 10	Atilla 12	12 ± 0.9
Yüreğir 89	121 ± 10	Saraybosna	17 ± 1.9
Seyhan 95	120 ± 14	Tekirdağ	21 ± 0.9
Doğankent 1	136 ± 6.0	Prostor	19 ± 0.8
Ceyhan 99	89 ± 5.0	Selimiye	23 ± 1.8
Karatoprak	101 ± 15	Kate A-1	20 ± 0.3
Nurkent	45 ± 1.0	Flamura 85	23 ± 2.5
Canik 2003	34 ± 2.5	Dropia	23 ± 3.3
Sakin	34 ± 2.9	Golia	25 ± 1.7
Özcan	30 ± 2.7	Tina	23 ± 2.7
Tahirova 2000	53 ± 2.3	Nina	18 ± 1.9
Pamukova 97	36 ± 0.7		
Momtchil	40 ± 3.5	**minimum**	**10**
Bandırma 97	44 ± 1.5	**maximum**	**25**
Karacabey 97	29 ± 1.1	**mean**	**34**

2.2.Method

Collected wheat grain samples were dried at 70°C in a drying cabinet with air circulation until they reached constant weight. Later, about 0.2 g dried and ground sample was digested by using 5 ml of 65% HNO_3 and 2 ml of 35% H_2O_2 in a closed microwave system (Cem-MARS Xpress). The volumes of the digested samples were completed to 20 ml with ultra-deionized water.

To reduce $Se^{+6}$to Se^{+4} 10 ml of samples and 10 ml conc. HCL were filled in a 100 ml flask and heated 30 minutes at 90 °C. Se concentration of the samples was determined by atomic absorption spectrometry method (HG-AAS) with a Varian SpectrAA 220FS spectrometer (Varian, Australia) equipped with Vapor Generation Accessory VGA-77 and Electrothermal Temperature Controller

ETC-60. Selenium concentrations were expressed as µg/kg dry weight.

Se measurement in wheat grains were checked against certificated Se values in differen treference plant materials (1567a wheat flour, 8346 durum wheat flour) obtained from the National Institute of Standards and Technology (Gaithersburg, MD, USA) [34].

2.3.Statistical Analysis

The results are mean±standard deviation (MSTAT C) of three replications [29].

3.Results and Discussion

Selenium contents of bread wheat varieties provided from several Agricultural Institutes in Turkey are given in Table 2. Se contents of bread whats harvested in Eastern Mediterranean Agricultural Research Institute ranged from 89 µg/kg (Ceyhan 99cv) to 145.0 µg/kg (Seri 82cv). While Se contents of bread wheat grains harvested from Transitional Zone Agricultural Research Institute change between 10 µg/kg (Yıldız 98) and 27 µg/kg (Altay 2000 cv), Se contents of bread wheat grains harvested Bahri Dagdas International Agricultural Research Institute varied between 11.0 µg/kg (Konya 2002) and 25.0 µg/kg (Dagdaş 94). In addition, Se contents of bread wheat harvested from Maize Research Institute ranged from 20 µg/kg (Kaynarca) to 52 µg/kg (Tahirova 2000cv). Also, Se contents of bread wheats harvested Field CropsCentral Research Institute were found between 11 µg/kg (Zencirci 2002cv) and İkizce 96) and 24 µg/kg (Türkmen and Haymana 79 cv). Se contents of bread wheat samples harvested from Trakya Agricultural Research Institute varied from 12 µg/kg (Atilla 12cv) to 23 µg/kg (Tekirdağ).

Durum wheats were provided from five reseach Institutes in Turkey. Se contents of durum wheat grains are shown in Table 3. Se contents were found high in durum wheats provided from Eastern Mediterranean Agricultural Research Institute, and its level changed between 100 µg/kg (Fuatbey 2000cv) and 142 µg/kg (Sham 1). While Se level of durum wheat harvested in Transitional Zone Agricultural Research Institute change between 17 µg/kg (Kunduru 1149) and 26 µg/kg (Yelken 2000cv), Se contents of durum wheat samples harvested from Field Crops Central Research Institute ranged from 13 µg/kg (Berkmen) to 19 µg/kg (Ankara 98)cv. Se contents of durum wheat harvested from Gap International Agricultural Research and Training Center changed between 25 µg/kg (Harran 95) and 44 µg/kg (Diyarbakır 81cv). As a result, The highest Se contents was found in durum wheat samples harvested from Eastern Mediterranean Agricultural Research Institute, followed by Gap International Agricultural Research and Training Center, Transitional Zone Agricultural Research Institute, Bahri Dagdas International Agricultural Research Institute and Field Crops Central Research Institute.

In previous study, Se content in wheat grain samples collected from different parts of Saudi Arabia ranged from 8 to 293 µg/kg, with an average of 78.4 µg/kg (Al-Saleh and Al-Doush, 1997). Se content in wheat grown in Hungary were found between 5 and 235 µg/kg (Alfthan et al 1992). Low Se values have been reported from Yugoslavia [23, 24] in the range of 3.6 to 65.5 µg/kg with an average of 18 µg/kg. The most extreme values for the Se content of wheat were reported from Sweden, the Federal Republic of Germany, Scotland and Norway and ranged from 9 to 34 µg/kg [15]. In seleniferous areas of Venezuela, Se content in wheat was found to be in the range of 25 to 250 µg/kg [3]. The selenium levels in wheat samples varied from 21 (Tiaret) to 153 µg/kg (Khroub), with a mean value about 52 µg/kg [2]. Average Se concentration in cereals in Slovakia amounts 0.024 mg/kg of grain dry matter, ranging from 0.006 to 0.122 mg/kg. For wheat the range fluctuates from 0.008 to 0.122 mg/kg (0.029 mg/kg on the average) [26]. Milovac et al. (1998) [28] found that foliar application of sodium selenite in the rate of 6 and 12 g Se/ha caused arise of Se content in wheat grain on the values ranging from 0.042 to 0.067 mg/kg and from 0.065 to 0.180 mg/kg dry matter, respectively, what is in harmony with our results. MacLeod et al. (1998) [25] state that the Se accumulation in barley grain achieved the level of 0.512 and 1.130 mg/kg in the consequence of the foliar application of Se in the rate of 10 to 20 g Se, respectively in the form of sodium selenate. In Hungary, the wheat grain level varied from 5 to 235 µg Se/kg (34) and in Yugoslavia from 4 to 66 µg Se/kg [24]. The selenium content in plants is also influenced by a number of [24]. In Turkey, daily Se intake is found to be around 36 µg Se day^{-1} [12] which is very low when compared to the RDA value of 75-125 µg Se day^{-1} ([10, 37]. It has been shown that daily intake of 75- 125 µg Se prevents genetic damage and cancer development in human subjects [37].

Table 3. Selenium concentrations in durum wheat varieties growing in Turkey (Data are presented as means±SD,n=3 replicates)

Variety name	Se (µg kg^{-1})
Yelken 2000	26 ± 3.1
Kunduru 1149	17 ± 0.1
Kümbet	18 ± 3.1
Altıntaş 95	18 ± 0.1
Selçuklu 97	15 ± 2.3
Meram 2002	23 ± 0.5
Fuatbey 2000	100 ± 1.4
Sham 1	142 ± 3.0
Diyarbakır 81	44 ± 7.2
Fırat 93	29 ± 3.3
Sarıçanak 98	26 ± 0.2
Harran 95	25 ± 2.9
Ankara 98	19 ± 1.4
Mirzabey	15 ± 1.0
Altın 40/98	18 ± 0.1
Çakmak 79	15 ± 1.9
Kızıltan 91	16 ± 2.4
Berkmen	13 ± 2.3
Ç 1252	16 ± 2.0
minimum	**13**
maximum	**142**
mean	**31**

In Turkey, wheat is still the major source of daily calorie intake: on average, wheat alone provides nearly 45% of the daily calorie intake at country level. It is estimated that this proportion could be more than 75% in rural regions [7]. As reported by Lyons et al. (2003) [18], for a better human nutrition seed Se concentration in wheat should be between 100 to 1000 µg kg^{-1} seed. Except for Adana, we found that the concentration of Se in our illusions is very low. As the available Se concentration of soils increases, it is generally expected that the Se concentration of the plants will also increase. This situation was observed in this study and Se concentrations of wheat samples grown on these soils followed the same order when the average Se concentrations of the plants were ordered from small to large. In comparison with the other Seeds of the Cukurova Region, the Se concentrations in the seawater indicate that the lower Se concentrations may be more related to the useful amount of Se in the soil. Indeed, genotype xenvironment studies have shown that the variation in grain Se concentration is mostly due to the concentration of the suitable soil Se (Lyons ve ark., 2005a) [19]. The results obtained showed that wheat grown in Turkey has very significant Se deficiency problem. The average Se concentrations of the 83 wheat samples collected from different locations in Turkey was 36 µg kg^{-1} which is much lower than the critical minimum concentrations of Se in seeds (e.g., 100 µg kg^{-1}). In nearly % 87 of the seed samples collected, seed Se concentration was below 45 µg kg^{-1}. As seen Table 2 and , the highest Se contents were found in bread wheat grains harvested in Eastern Mediterranean Agricultural Research Institute. Generally, Se contents of bread wheat samples were found high according to results of durum wheat samples. Se contents of wheat grains changed depending on locations. Our results were found different when compared with literature values. These differences can be probably due to soil type and locations and plant species.

Author Contribution Mustafa Harmankaya: Methodology, Investigation, Formal analysis; **Sait Gezgin**: Investigation, validation, statistical analysis; **Mehmet Musa Özcan**: Data curation, software, writing, editing.

Data Availability Data available on request to the authors.

Competing interests No competing interests.

Compliance with ethical standards: This study does not concern any studies with human participants or animals.

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Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human / or animal subjects (if exist) respect the specific regulation and standards.

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