Research Article

iMedPub Journals
www.imedpub.com

Journal of Clinical Nutrition & Dietetics
ISSN 2472-1921

2024
Vol.10 No.1:190

# Influence of Extraction Time on the Total Phenolic Content of Hemp Seeds (*Cannabis sativa* Sb. Sativa) Water-Extracts

**Samanta Reyes-Flores[1*], Taisa Sabrina Silva Pereira[1] and Milena Ramírez-Rodrigues[2]**

[1]Department of Chemical, Food and Environmental Engineering, Universidad de las Américas Puebla, San Andrés Cholula, Pu[illegible], México

[2]Department of Food Science and Nutrition, California Polytechnic State University, San Luis Obispo, USA

**Corresponding author:** Samanta Reyes-Flores, Department of Chemical, Food and Environmental Engineering, Universidad d[illegible] Américas Pueb[illegible] San Andrés Cholula, Puebla, México, E-mail: samanta.reyesfs@udlap.mx

**Received date:** January 12, 2024, Manuscript No. IPJCND-24-18547; **Editor assigned date:** January 15, 20[illegible] PreQC [illegible] IPJCND-2[illegible] (PQ); **Reviewed date:** January 29, 2024, QC No. IPJCND-24-18547; **Revised date:** February 05, 2024, Manusc[illegible] No. IPJCN[illegible]4-18547 (R); **Published date:** February 12, 2024, DOI: 10.36648/2472-1921.10.1.190

**Citation:** Reyes-Flores S, Pereira TSS, Ramirez-Rodrigues M (2024) Influence of Extract[illegible] Time on the [illegible]al [illegible]nolic Con[illegible] of Hemp Seeds (*Cannabis sativa* Sb. Sativa) Water-Extracts. J Clin Nutr Diet Vol.10 No.1: 190.

## Abstract

Water extraction of hemp seeds could be performed to isolate water-soluble compounds such as proteins, carbohydrates and potentially other bioactive compounds. The aim of this study was to determine the influence of extraction time on the content of total phenolic compound[illegible] in water extracts of hemp seeds. The extracts were m[illegible] taking different extractions times and using a 1:100 r[illegible] of hemp seeds-water. Total phenolic compounds [illegible]ere determined in microplate by the Folin-Ciocalteu n[illegible]od and a Gallic Acid (GA) calibration curve [illegible].94). The results showed that GA equivalents were sig[illegible]cantly higher at 60 min extraction time. The evaluatio[illegible]he influences of time in extractions allow[illegible]o have a b[illegible] selection of parameters for a thermal pr[illegible]siderin[illegible] objective response, in this case total phe[illegible]ontent.

**Keywords:** Hempseeds; Water-extra[illegible]n; Total ph[illegible]ic content; Antioxidant capacity

## Introduction

Water[illegible]action ([illegible]s a commo[illegible]ethod used to isolate bioactive c[illegible]pounds, [illegible]nts a[illegible] other components from various pla[illegible]materials, incl[illegible]g seeds. WE is a versatile and essential [illegible]cess in food science, impacting the flavor, texture, safety [illegible]f food products. It plays a vital role in ing[illegible]ent preparation, [illegible]eservation and the development of [illegible]food innovations while also contributing to sustainable food p[illegible]ction practices. Several factors influence the efficiency and outc[illegible] of water extraction processes in food science, mainly temper[illegible] and time. Time is a critical factor that influences extraction[illegible] including various extraction processes in chemistry, food science and other industries. The duration of the extraction process, often referred to as the extraction time or contact time, is critical. Longer contact times generally lead to more extensive extraction, but there is an optimal point beyond which further extraction may not yield significant improvements and could lead to the extraction of unwanted compounds. The extraction time in water-b[illegible]e[illegible]racts can [illegible]icant impact on the composition, concen[illegible]on and quality of the extracted compo[illegible].

H[illegible]p seeds (*Cannabis sa[illegible]*. sativa) are known for their nut[illegible]nal value, co[illegible]ning essential fatty acids, protein, fiber and [illegible]ous vitamins a[illegible] minerals. Likewise, hemp seed is also rich in [illegible]yphenols, as [illegible]proximately 500 compounds have been [illegible]dentifie[illegible]t ma[illegible] include bioactive compounds such as [illegible]oxycinnam[illegible]c acids, hydroxybenzoic acids, flavonoids and [illegible]mides [4]. The antioxidant capacity of these compounds is ev[illegible] in several chemical and *in vitro* studies [5]. The antio[illegible]ant properties of hemp seed lignanamides have been doc[illegible]ented in several studies and N-trans-cafeoyltyramine and it[illegible]ow-density lipoprotein oxidation suppressing ability, [illegible]annabisin B and its oxidation inhibitory effect have been reported., 3.3 dimethyl-heliotropamide and its potent DPPH radical scavenging activity at 81.5%, *etc.*

Moreover, apart from lignanamides, the abundance of flavonoids in the seed oil has been positioned with high antioxidant activity (695.2 and 3,690.6 µmol Trolox Equivalent (TE)/100 g) [6]. Hemp oil is predominantly derived from hemp seeds and is rich in essential fatty acids, notably alpha-linolenic acid (omega-3) and linolenic acid (omega-6), which offer various health benefits. The oil concentration in hemp seeds can fluctuate due to factors like hemp variety, cultivation conditions and processing techniques, typically falling within the range of 30% to 35% or potentially higher. It's worth noting that certain phenolic compounds found in hemp seeds may have solubility in oil. Consequently, if the oil is separated during processing, it might impact the phenolic content within the residual seed material [7,8]. The principal oil-soluble constituents in hemp seeds include lignans and phytosterols. Lignans represent a category of phenolic compounds, with notable examples like Secoisolariciresinol Diglucoside (SDG) present in hemp seeds, believed to offer potential health advantages. Phytosterols, while not genuine phenolic compounds, are frequently linked to the phenolic composition of plant-based foods. Hemp seeds contain a range of phytosterols, such as α, γ and δ-tocopherol and γ-tocotrienol. These compounds share a chemical structure akin to cholesterol [9,10].

Hemp seeds contain a diverse array of proteins, encompassing globulins, albumin, edestin and peptides. Among these, hempseed peptides, which are short amino acid chains derived from proteins, have the potential to enhance the antioxidant capacity of hemp seeds. These hempseed peptides may feature specific amino acid sequences with inherent antioxidant properties. These peptides can scavenge free radicals and reduce oxidative stress, contributing to the overall antioxidant capacity of the seeds [8,11]. Peptides can be more easily absorbed and utilized by the body than larger proteins. This improved bioavailability means that the antioxidant peptides in hemp seeds may have a more significant impact on reducing oxidative damage in the body compared to larger protein molecules. Peptides and phenolic compounds can interact in various ways, often leading to synergistic effects in terms of their antioxidant and health-promoting properties [12,13].

Water extraction of hemp seeds could be performed to isolate water-soluble compounds such as proteins, carbohydrates and potentially other bioactive compounds. Hempseed Water-Extracts (HWE) could contain various bioactive compounds, including phytosterols, terpenes and phenolic compounds, which have potential health benefits. Extracts enriched with these compounds might have antioxidant, anti-inflammatory and other beneficial properties. The aim of this study was to determine the influence of extraction time on the conte total phenolic compounds in water extracts of hemp seed

## Methodology

### Plant material

The hemp seeds hearts (*Cannabis sa* sb. sativa) v obtained through Manitoba Ha m Ma a, Canada.

### Chemicals

6-hydroxy-2,5,7,8-etramethylchroma carboxylic id (Tr-olox), ethanol reagent Folin a iocalteu's phenol reagent were purcha from S Aldrich A. All other chemicals were of alytical g e, sodium hydroxide (NaOH), sodium chloride, bu solut PH4 a buffer solution PH7.

### water- tions and a water-extractions

The extra were mad Izzo et al. taking different extraction mes and using a 1:100 ratio of hemp seeds-water, respecti 14]. All the extracts were carried out at 98°C 2°C for 30 mi ; 60 min (E3). After boiling process each ext was vacuum filtered using a 11 µm medium-flow filter er (Whatman, Little Chalfont, Buckinghamshire, United Ki m) to remove excess solids. Each extract was made by tripli **(Table 1)**.

**Table 1:** H pseed water-extractions conditions.

| | Extractions | | |
|---|---|---|---|
| | E1 | E2 | E3 |
| Temperature (°C) | 30 ± 1 | 60 ± 1 | 90 ± 1 |
| Temperature (°C) | 30 ± 1 | 60 ± 1 | 90 ± 1 |

Subsequently, in order to compare the extracts and relating it to its future applications, it was compared with extracts of black tea and chai tea. The tea extracts were made 1:100 ratio of tea-water, respectively. Then the extracts were c d out at 98°C 2° C for 60 min.

After boiling process each extract was vacuum fi d using a 11 µm medium-flow filter paper (Whatm Little lfont, Buckinghamshire, United Kingdom) to re ve excess ds. Each extract was made by triplicate. All erminations v performed in duplicate and were statistically alyzed.

### Proximate analysis

Hemp seeds proximate c position oisture, crude protein, crude fat, tot l ash) was d rmine sing t official methods of analysis DAC Total rates w determined by difference. For ate the in content 6.25 factor was used. Lipids w cted fro he Soxhlet method and stored at -20°C further analysis. The dietary fiber was calculat defa samples according NMX-F-622-NOR -2008. All assays w rmed in triplicate.

### Mi al and heav etals content

The ermination he mineral composition was carried out ith IC s (Inductively Coupled Plasma-Optical sion Spectroscopy) according Intema® internal method A (Agilent 5110, ICP-OES). The minerals chosen as the focus of th dy were sodium (Na), potassium (K), calcium (Ca), zinc (Zn), agnesium (Mg), copper (Cu), iron (Fe) and manganese (Mn) Briefly, an acid digestion of the samples was carried out. M ral calibration standards for ICP-OES analysis were prepared y dilution of NIST-traceable 1,000 mg/L Ca, Mg, Na, Fe and K standards.

### Total phenolic content

Determination of polyphenols was performed according to Ramírez-Rodrigues. Total phenolics were estimated using the Folin–Ciocalteu colorimetric method. Briefly, 200 µL of the sample was diluted with 1 mL of distilled water and 250 µL of undiluted Folin-Ciocalteu reagent. Immediately, 2.5 mL 7% (w/v) $Na_2CO_3$ was added. Then, a standing time was taken (90 min) in the dark.

The absorbance was measured at 760 nm using a UV-Vis spectrophotometer model Multiskan Sky Microplate (Thermo Fischer Scientific, Waltham, MA, USA) and compared to a pre-prepared gallic acid calibration curve ($R^2$>0.94). Determinations were performed in triplicate. Results were expressed as milligram of Gallic Acid Equivalents (GAE) per mL of extract (0-800 mg/L of gallic acid).

### Total soluble solids and pH of extracts

Total soluble solids (°Brix) were determined in the extracts with a hand refractometer (Reichert technologies AR 200) and the pH was measured with a potentiometer (Hanna Instruments, HI5522-02).

### Statistical analysis

For the analysis of the experimental data, the mean and Standard Deviation (SD) of all the determinations were reported. The differences between sample were considered statistically different for $p<0.05$ through the Analysis of Variance Test (ANOVA). All collected data were analyzed using Minitab statistical so tware. 17.2020 (Minitab Inc., State College, PA, USA). The differences between the means will be considered statistically different for $p<0.05$ through Tukey's analysis.

## Results

### Proximate analysis

**Table 2** shows the result for the proximate analysis of hemp seeds. It was found that hemp seeds contain approximately 30% of lipids, 29% of carbohydrates where 21% is dietary iber (including cellulose, hemicellulose, lignin, soluble and insoluble ibers), 28% of crude proteins, 6% of ashes and inally 5.7% of moisture content. The results of the current study were consistent with the previously reported ranges by Callaway (2004) and Russo and Reggiani (2013) since hemp seeds exhibited an average content of 27%-39% for lipids, 28%-30% for carbohydrates where 19%-23% includes dietary iber, 24%-30% for crude proteins, 6%-7.2% for ashes and inally 4.8%-56.3% moisture content [15-17].

**Table 2:** Proximate analysis of hemp seeds.

| Compound | (%) |
|---|---|
| Moisture | 5.70 ± 0.14 |
| Ashes | ± 0.01 |
| Proteins | 28.11 ± 0.28 |
| Fat | 24 ± 0.0 |
| Carbohydrates | 9.61 ± 0.02 |
| | 21.18 ± 0.23 |

**Note:** The data shown correspond to means ± standard deviations from three independent measurements.

Lin and pro ere two of the most abundant ounds in the samples which are known to have an rtant role in contribution of nutrients in the daily diet [18]. Re ng lipids, on the one hand the abundance of flavonoids in the l oil has been positioned with high antioxidant activity and on the other side the oil extraction process can indirectly influence the phenolic content. Certain phenolic compounds in hemp seeds might be oil-soluble, so the removal of oil during processing could potentially alter the phenolic content in the remaining seed material. Nevertheless, the degree of this influence would be contingent upon the particular processing method employed [6,7,10].

High temperatures can promote the hydr lysis of proteins, leading to the breaking of peptide bonds. As temperature increases, the kinetic energy of molecules rise and this can result in the cleavage of peptide bonds [13]. C quently, proteins may fragment into smaller peptides even into individual amino acids. Although hempsee peptides, fo d from short amino acid chains derived from mp seed prote do not have a direct impact on the pheno content of her seeds, they are intricately linked to bols g the see antioxidant capacity [12]. action diff nt components in hemp see including eptides and other antioxidants like phenolic ompounds and vitamin E, can result in synergisti effects tha enhan the o all antioxidant capacity. Co in ariou idants ma provide a more potent protecti ect again idative str [19,20]. The way hemp seeds are pr ed and ap fluence the release and bioavailability of a idant peptides.

### Min als and heavy me termination

F mineral determ tion ash represents an overview of the resu where this pa meter can be interpreted as the total minera ntent of a mple, made by inorganic components. ble 3 s e more abundant minerals in the sample phosphorus, potassium and magnesium that agreed with es reported by Callaway [15] and García [21]. Findings evide at a consume of 100 g of hempseed could cover arou the 235% (P), 32% (K) and 16% (Mg) of the daily refe ce intake for adult humans, respectively [5,16,22,23]. es the results of sodium and copper were lower than eported by Callaway, Russo and Reggiani which is interpreted as an ideal due to the recommended consumption is lower than the other minerals and heavy metals [15-17].

**Table 3:** Mineral and heavy metals content of hemp seeds.

| Compound | (mg/100 g) |
|---|---|
| Sodium (Na) | 5.807 ± 0.01 |
| Phosphorus (P) | 1649.669 ± 0.43 |
| Potassium (K) | 1127.347 ± 0.18 |
| Calcium (Ca) | 63.688 ± 0.01 |
| Magnesium (Mg) | 660.439 ± 0.13 |
| Iron (Fe) | 15.914 ± 0.02 |
| Zinc (Zn) | 7.754 ± 0.01 |
| Manganese (Mn) | 5.466 ± 0 |
| Copper (Cu) | 1.391 ± 0.01 |

**Note:** The data shown correspond to means ± standard deviations from three independent measurements.

Studies have suggested that certain minerals, such as selenium and zinc, have antioxidant abilities of their own. They can help protect plant tissues from oxidative damage. In response, the plant may make fewer phenolic compounds if it doesn't need as many antioxidants. Furthermore, other minerals, including copper and iron, serve as cofactors for enzymes responsible for producing phenolic compounds [24-26].

## Total phenolic content

Phenolic compounds are valued for their potential health bene its, as they are known to have antioxidant properties and may contribute to the overall health benefits of consuming tea. The results showed that when the extraction time is 60 min, the measurement from GA equivalents was significantly higher p(0.05) than E1 and E3. However, if the time of the water extractions was 90 min, the values start to decrease. The findings of the study could be attributed to the fact that the best extraction time varies depending on affinity of the compounds to be extracted and which extraction method is used. Related results were found by Ferrante et al. where they evaluated hemp lower water extracts as potential source of antioxidants with potential efficacy in managing clinical symptoms related to ulcerative colitis [27]. The inding showed that at longer exposure time during extraction, the target responses increased until a latent point was reached where they began to decrease [27].

Similarly, Nuapia et al. applied response surface met odology to investigate the in luence of extraction time (5 mi 0 min), extraction temperature (50°C-200°C) and collec vess temperature (25°C-200°C) on the recovery cannabin compounds (THC: Indelta-9-Tetrahydroc nabinol; : Cannabinol; CBD: Cannabidiol; CBG: Canne omene and Cannabigerol) of hemp seeds *anal s sativ* ]. In the same line, they found that extraction erature time have a significant negative in luence o xtracted a t with a p=0.003, however just extraction tim s shown a ificant positive influence on the amount extrac of most all target compounds. As well, d an i extraction between 45 min decrea values o e extracted compounds when e eding th ime [

in **Figu** sample E ot the highest value of .63 m E/mL. I r to contr the extract and relating it to its fu e applicati ompared with extracts of black tea d chai tea. **Figure 2** shows the result of total phenolic mpounds for all samples, where the best extract of hemp e than black tea extract. However, C of E2 were lower than chai tea extract. These may be to chai tea, a traditional Indian beverage, is often found to ha relatively high total phenolic content compared to other types eas, such as black or green tea [28]. There are several factors his difference: a) Chai tea is typically made from a combination of black tea leaves and various spices like cinnamon, cloves, cardamom and ginger [29]; b) These spices are known for their high phenolic content where phenolic compounds not only add flavor and aroma but also contribute significantly to the antioxidant capacity of the tea [28,30]; c) The addition of spices to the existing black tea has a cumulative effect and d) Combination of tea leaves and spices in chai may result in synergistic effects, where the phenolic compounds work together to provide greater antioxidan e its than they would individually [2,28,31].

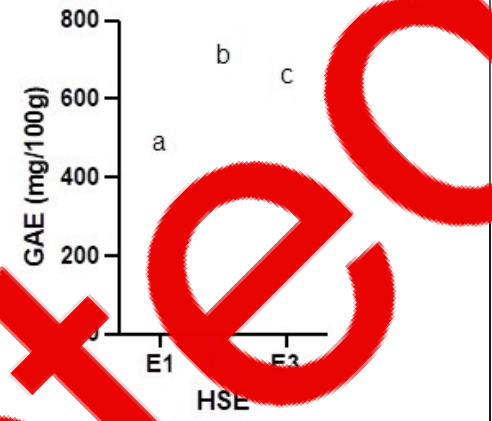


**Fig 1:** Total phenol ter of hempseed water-e acts. The data show respond to means ± ndard deviatio om three independent measure nts. Different le s indicate significant differences (p 5) between mples where extractions time were 0 min ), 60 min (E2) or 90 min (E3) and GAE is ga equivalents.

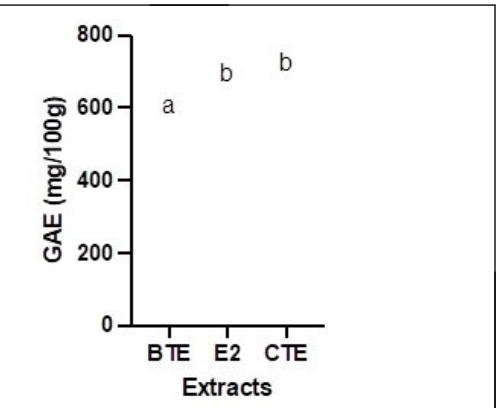


**Figure 2:** Comparison of total phenolic content to hempseed water-extract, black tea and chai tea extracts. The data shown correspond to means ± standard deviations from three independent measure-ments. Different letters indicate significant differences (p<0.05) between samples where BTE is Black Tea Extract, E2 is 60 min hemp seeds water-extraction, CTE is Chai Tea Extract and GAE is Gallic Acid Equivalents.

## Total soluble solids and pH of extracts

**Table 4** shows the results of pH a Total Soluble Solids (TSS) for all hemp seeds water-extractions. No sample got a significant difference. However, the values were close to a neutral pH and it is known that pH of water-extractions can influence of polyphenols from various sources, such as tea, coffee, fruits and vegetables [32]. The pH influences the structure, stability and

solubility of the source material, like plant cell walls and membranes, which can make it easier or harder for the polyphenols to be released into the water. The pH of the environment has an effect on polyphenols in that they can take up different forms (as acids or bases) depending on the acidity or alkalinity. This is because polyphenols can exist in various forms according to the surrounding pH level [3,33,34].

**Table 4:** Results of pH and total soluble solids of hemp seeds water-extractions.

| | E1 | E2 | E3 |
|---|---|---|---|
| pH | 6.55 ± 0.32[a] | 6.64 ± 1.03[a] | 6.85 ± 0.93[a] |
| TSS (°Brix) | 0.50 ± 1[a] | 0.61 ± 1[a] | 0.55 ± 1[a] |

**Note:** The data shown correspond to means ± standard deviations from three independent measurements. [a]Indicate significant differences ($p<0.05$) between samples. Where TSS are Total Soluble Solids.

## Conclusion

This study has shed light on the dynamic relationship between the extraction time and the total phenolic content in hempseed water-extracts. It is evident from the research that a longer extraction time generally leads to a higher total phenolic content, as more time allows for the efficient breakdown and release of these bioactive compounds from the plant material. The results showed that GA equivalents were significantly higher at 60 min extraction time which translates into a higher concentration of phenolic compounds with possible antioxidant activity. The evaluation of the influences of time in extraction allows to have a better selection of parameters for a thermal process considering an objective response, in this case the phenolic content. To identify the most effective extraction time for each kind of plant material or compound of interest, it is essential to conduct comprehensive tests. Temperature, the amount of solvent used relative to the plant matter and agitation can also affect the process. Knowing the importance of timing extraction correctly can result in improved yields and better-quality products from optimization of the extraction process. The duration for which the extraction process is allowed to proceed plays a significant role in determining the efficiency, selectivity and overall outcome of the extraction.

In conclusion, the influence of extraction time on the total phenolic content of hemp seeds water-extracts is a critical aspect that researchers and industries should consider when aiming to harness the full potential of this versatile plant. Further research and experimentation can continue to refine the extraction process, ultimately providing a range of applications that benefit from the unique phenolic profile of hemp seeds.

## Acknowledgments

The authors thank the Consejo Nacional de Ciencia y Tecnología (CONAHCyT) and the Universidad de las Américas Puebla for financial support for their doctoral studies in food science. We thank the Consejo de Ciencia y Tecnología del Estado de Puebla (CONCYTEP) for funding the development of the project as well as the Food Analysis Laboratory, Intema S.A. de C.V. for its contribution in the performed analyses.

## References

1. Nuapia Y, Tutu H, Chimuka L, Cukrowska E (2020) Selective extraction of cannabinoid compounds from cannabis sativa using pressurized hot water extraction. Molecules 25: 13.
2. Shi L, Zhao W, Yang Z, Subbiah V, Suleria HAR (2022) Extraction and characterization of phenolic compounds and their potential antioxidant activities. Environ Sci Pollut Res Int 29: 81112-29.
3. Roselló-Soto E, Martí-Quijal FJ, Cilla A, Munekata PES, Lorenzo JM, et al. (2019) Influence of temperature, solvent and ph on the selective extraction of phenolic compounds from tiger nut by-products: Triple-TOF-LC-MS-MS characterization. Molecules 24: 797.
4. Angeles LGE, Brindis F, Mendoza NS, Ventura MR (2014) *Cannabis sativa* L. a singular plant. Rev Mex Cienc Farm 45: 6.
5. Crescente G, Piccolella S, Esposito A, Scognamiglio M, Fiorentino A, et al. (2018) Chemical composition and nutraceutical properties of hempseed: An ancient food with actual functional value. Phytochem Rev 17: 733-749.
6. Di Pacifico S, Piccolella S, Castaldo L, Narváez A, et al. (2020) Chemical analysis of minor bioactive components and cannabidiolic acid in commercial hemp seed oil. Molecules 25: 3710.
7. Leizer C, Ribnicky D, Poulev A, Dushenkov S, Raskin I (2000) The composition of hemp seed oil and its potential as an important source of nutrition. J Nutraceuticals Funct Med Foods 2: 35-53.
8. Schwab US, Callaway CJ, Erkkilä AT, Gynther J, Uusitupa MIJ, et al. (2006) Effects of hempseed and flaxseed oils on the profile of serum lipids, serum total and lipoprotein lipid concentrations and haemostatic factors. Eur J Nutr 45: 470-477.
9. Kwon Y, Kim K, Heo H, Lee J, Sung J (2023) Vitamin E, phytosterol and carotenoid contents of hemp (*Cannabis sativa* L.) seed. J Korean Soc Food Sci Nutr 52: 975-981.
10. Montserrat-de la PS, Marín-Aguilar F, García-Giménez MD, Fernández-Arche MA (2014) Hemp (*Cannabis sativa* L.) seed oil: Analytical and phytochemical characterization of the unsaponifiable fraction. J Agric Food Chem 62: 1105-1110.
11. Ajibola CF, Aluko RE (2022) Physicochemical and functional properties of 2S, 7S and 11S enriched hemp seed protein fractions. Molecules 27: 1059.
12. Cruz-Chamorro I, Santos-Sánchez G, Bollati C, Bartolomei M, Li J, et al. (2022) Hempseed (*Cannabis sativa*) peptides WVSPLAGRT and IGFLIIWV exert anti-inflammatory activity

in the LPS-stimulated human hepatic cell line. J Agric Food Chem 70: 577-583.

13. Santos-Sánchez G, Álvarez-López AI, Ponce-España E, Carrillo-Vico A, Bollati C, et al. (2022) Hempseed (*Cannabis sativa*) protein hydrolysates: A valuable source of bioactive peptides with pleiotropic health-promoting effects. Trends Food Sci Technol 127: 303-318.

14. Izzo L, Castaldo L, Narváez A, Graziani G, Gaspari A, et al. (2020) Analysis of phenolic compounds in commercial *Cannabis Sativa* L. inflorescences using UHPLC-Q-Orbitrap HRMS. Molecules 25: 631.

15. Callaway JC (2004) Hempseed as a nutritional resource: An overview. Euphytica 140: 65-72.

16. Russo R, Reggiani R (2013) Variability in antinutritional compounds in hempseed meal of Italian and French varieties. Plant 1: 25-29.

17. Siano F, Moccia S, Picariello G, Russo GL, Sorrentino G, et al. (2018) Comparative study of chemical, biochemical characteristic and ATR-FTIR analysis of seeds, oil and flour of the edible fedora cultivar hemp (*Cannabis sativa* L.). Molecules 24: 83.

18. Patterson E, Wall R, Fitzgerald GF, Ross RP, Stanton C (2012) Health implications of high dietary ome polyunsaturated fatty acids. J Nutr Metab: e539426.

19. Hernández-Jabalera A, Cortés-Giraldo I, Dávila rtíz G, Vioque J, Alaiz M, et al. (2015) Influence of otides phenolics interaction on the antioxidant ile o prot hydrolysates from *Brassica napus*. Food Chem : 346-357.

20. Su S, Wan Y, Guo S, Zhang Zha T, et 018) Effect of peptide-phenolic interaction e antioxi capacity of walnut protein hydrolysate Food Sci nol 53: 508-515.

21. García A (2017) He osition

22. Bakowska-Barcz A, Larmi MA de, dziejczyk PP (2020) 17-The plicatio flax nd hempseed in food, ceutical a pe al care oducts. Handbook of Fibres 2 0.

23. Kozłov RM, Mach yk M (2020) Handbook of natura bres. (2nd edn), Woodhead Publishing: 557-590.

24. Lu Wu QS, Liu SH, Sun GM (2014) Physico- nical prop antioxidant activity and mineral contents of pineapple genotypes grown in China. Molecules 19: 8518-8532.

25. Sulaiman SF, Yusoff NAMD, Eldeen IM, Se y EM, Sajak AAB, et al. (2011) Correlation between to phenolic and mineral contents with antioxidant acti of eight Malaysian bananas (*Musa* sp.). J Food Comp Anal 24: 1-10.

26. Nour V, Trandafir I, Ionica ME 013) Antiox t compounds, mineral content and ar xidant activity several tomato cultivars grown in Sou estern Roman Botanical notes of the Agrobo ical Gard f Cluj-Nap a 41: 136-142.

27. Ferrante C, Recinella L onci M, ghini L, Brunetti L, et al. (2019) Multiple p rmaco stic c acterization on hemp c nerc l cult s: cus on in rescence water extract act Food Che xicol 125: -461.

28. Willis S, Ve gh M, McColl eatom K, Willis Z, et al. (2017) A com ison of selected phytochemical and a potenti f tw tea beverages. Food and trition Sciences 8: 10

29. tgendorf P (20 Making tea in India: Chai, capitalism, ture. Thesis Ele n 113: 11-31.

30. Ca P (2021) etermination of antioxidant, nutritional and s pacity of a drink based on *Ilex guayusa* and *Avena sativa* type chai tea.

31. TY, Li JS, Chen C (2015) Effects of blending wheatgrass j ce on enhancing phenolic compounds and antioxidant tivities of traditional kombucha beverage. J Food Drug Anal 23: 709-718.

32. Sun J, Liu T, Zhang F, Huang Y, Zhang Y, et al. (2022) Tea polyphenols on emulsifying and antioxidant properties of egg white protein at acidic and neutral pH conditions. LWT 153: 112537.

33. Gil-Martín E, Forbes-Hernández T, Romero A, Cianciosi D, Giampieri F, et al. (2022) Influence of the extraction method on the recovery of bioactive phenolic compounds from food industry by-products. Food Chem 378: 131918.

34. Friedman M, Jürgens HS (2000) Effect of pH on the stability of plant phenolic compounds. J Agric Food Chem 48: 2101-2110.