Efficiency of Chili and Sweet Pepper on Lipid Profile and Glucose Level in obese Rats

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Abstract

This study investigated the effect of sweet peppers (yellow, red and green) and hot peppers on blood sugar and blood lipids in obese rats that were induced to become obese by feeding them a high-fat diet for four weeks. 42 rats were used and the rats were divided into a negative healthy group (6 mice) and an obese group (36 rats) that were divided into 6 groups: the first group was positive and fed an ideal diet, the second group was fed 10% dry hot peppers, the third group was fed 10% dry sweet red peppers, the fourth group was fed 10% sweet yellow peppers, the fifth group was fed 10% dry green peppers, and the sixth group was fed a mixture of hot, green, red and yellow peppers at a ratio of 10% (1:1:1:1). The experiment continued for 6 weeks, after which the rats were slaughtered, the serum was extracted, and cholesterol, triglycerides, high-density cholesterol and low-density cholesterol were estimated. The very low density, liver function, blood glucose, malonaldehyde and catalase in addition to biological estimates such as food intake, weight and food efficiency ratio. The results showed a significant decrease in weight for groups fed sweet and hot peppers as well as the mixture compared to the negative and positive groups. Also, catalase increased significantly and malonaldehyde decreased significantly in the groups fed hot and sweet peppers and the mixture between them compared to the negative and positive groups. The results also indicated a significant decrease in liver function, blood triglycerides, total cholesterol, low-density cholesterol and very low-density cholesterol, while high-density cholesterol increased in groups fed hot and sweet peppers and the mixture between them, and blood glucose decreased compared to the negative and positive groups

Key words: Chili . Sweet Pepper. Lipid Profile. Glucose . obesity . Rats.

فاعلية الفلفل الحار والفلفل الحلو على مستوى الدهون والجلوكوز في الفئران البدينة

الملخص العربي

هذه الدراسة قامت ببحث تأثير الفل الحلو (الأصفر والاحمر والاخضر) والفلل الحار علي سكر الدم ودهون الدم في الفئران المصابة بالبدانة والتي تم احداث البدانة لها بتغذيتها علي غذاء عالي الدهون لمده اربع اسابيع تم استخدام ٤٢ فار وتم تقسيم الفئران الي مجموعه سليمه سالبه (٦ فئران) ومجموعه مصابه بالبدانة (٣٦ فار) تم تقسيمها الي ٦ مجاميع مجموعه الاولي موجبه تتغذي غلي غذاء مثالي والمجموعة الثانية تتغذي علي الفلل الحار الجاف بنسبه ١٠% والمجموعة الثالثة علي الفلل الأحمر الحلو الجاف بنسبه ١٠% والمجموعة الرابعة علي فلفل الصفر الحلو بنسبه ١٠% والمجموعة الخامسة غلي الفلفل الأخضر الجاف بنسبه ١٠% والمجموعة السادسة علي خليط من الفلفل الحار والاخضر والاحمر والاصفر الجاف بنسبه ١٠%(١:١:١:١) وتم استمرار التجربة لمده ٦ أسابيع وتم بعدها ذبح الفئران واستخلاص السيرم وتم تقدير الكوليسترول والدهون الثلاثية والكولسترول العالي الكثافة والمنخفض الكثافة والمخفض الكثافة جدا ووظائف الكبد والجلكوز في الدم والميلويندهيد والكاتليز بالإضافة الي التقديرات البيولوجية مثل المأخوذ من الطعام والوزن ومدي كفاءه الغذاء وأوضحت النتائج انخفاض معنوي في الوزن للفئران التي تغت علي الفلفل احلو والحار وكذلك الخليط بالمقارنة بالمجموعة السالبة والموجبة وأيضا زاد الكاتليز معنويا وانخفض الميلويندهيد معنويا في المجموعات التي تغذت علي الفلل الحار والحلو والخليط ما بينهم بالمقارنة بالمجموعة السالبة والموجبة أيضا اشارت النتائج الي انخفاض وظائف الكبد ودهون الدم الثلاثية والكوليسترول الكلي والكوليسترول منخفض الكثافة ومنخفض الكثافة جدا معنويا بينما زاد الكولسترول عالي الكثافة في الفئران التي تغذت علي الفلفل الحار والحلو الخليط ما بينهم وانخفض الجلوكوز بالدم بالمقارنة بالمجموعات السالبة.

الكلمات المفتاحية: فلفل حار . فلفل حلو . ملف الدهون . جلوكوز . سمنة . الفئران .

introduction

Previous studies have reported the beneficial effects of spice consumption on cardiovascular disease, and diabetes mellitus **(Hashemian, et al., 2019).** Culinary herbs and spices are widely used as a traditional medicine in the treatment of diabetes and its complications **(Andreia et al., 2019).**

Atherosclerotic plaques are known to start in adolescence, and, therefore, young adults can be affected by coronary artery disease. Children with known risk factors, such as genetic predisposition, including familial hyperlipidemias, diabetes, and renal diseases, are at higher risk **(Jeremy et al., 2020).**

Diabetes is one of the fastest growing diseases worldwide, projected to affect 693 million adults by 2045. Devastating macrovascular complications (cardiovascular disease) and microvascular complications (such as diabetic kidney disease, diabetic retinopathy and neuropathy) lead to increased mortality, blindness, kidney failure and an overall decreased quality of life in individuals with diabetes **(Joanne** and **Jose, 2020).**

Rapid urbanization, busy lifestyles, and simplicity of manufacture lead to an increase in the trend of fast foods consumption **(Cizza and Rother et al., 2012**). Fried fast food contains a high level of refined sugar, polyunsaturated fats, salts, and numerous food additives but lacking in proteins, vitamins, and fibers. Unhealthy levels of lipids can cause block in blood vessels and increase the risk of heart disease and stroke. These lipids are also responsible for unhealthy weight gain **(Hesamedin et al., 2016).** This study was conducted to investigate the effect of different levels of sweet (red, yellow, green) and chili pepper on serum lipid and glucose in obese rats fed high fat diet. Chili pepper is a common ingredient in the diets of various communities and civilizations across the world to make a desirable taste for food, particularly fast food like spicy chicken. Studies indicate that red chili pepper makes some alterations in liver enzymes and lipid profiles **(** Bahattab **et al., 2022).** Capsaicin is a key component in chili peppers, can regulate glucose and lipid homeostasis, improve cardiovascular function, and inhibit obesity **(Jing, et al., 2022).**

Chilies and spices provide health benefits such as reduced cancer incidence, hunger, obesity and cardiovascular disease **(Qin et al., 2014).**

Sweet bell peppers (*Capsicum annuum* L.) belong to the Solanaceae family and are cultivated worldwide, being a highly consumed food due to its attractive color, freshness and typical aroma, **(Eggink et al., 2012).** Pepper is the fourth most important vegetable in the world food economy, and especially popular because of the distinctive red color and sweet taste of the fruit (**Mougiou et al., (2021), and** contain different pigments (e.g. chlorophyll and carotenoids) leading to green, yellow, orange and red fruits **(Ghasemnezhad et al., 2011).** The sweet peppers are rich in carotenoids, capsaicinoids, flavonoids, vitamin C, and tocopherols that exhibit antiinflammatory and antioxidant activities which optimize human health **(Wahyuni et al., 2011).**

Many epidemiologic and clinical studies have shown that lipid-lowering treatment that lowered lipoproteins decreases the severity of coronary atherosclerosis and the incidence of clinical events like myocardial infarction, stroke, and death. Hence, there is a strong need to evaluate newer hypolipidemic agents with better therapeutic index and improved cost-effectiveness **(Shaikh et al., 2022).**

Materials and Methods

Materials

- **Chemicals**: The reagents kits for blood analysis were purchased from "Gama Trade Company for Chemical, Cairo, Egypt".
- **Basal Diet**: cellulose, minerals, vitamins, Casein, and cholesterol were purchased from "El-Gomhoria company – Cairo – Egypt"., lard was obtained from the local market.
- **Plants**: sweet (red, yellow, green) and chili pepper were obtained from the agriculture research center
- **Animals**: forty-two adult male Albino rats were purchased from Agriculture Research Centre.
- **Plants**: plants were dried by using solar system at the agriculture research center

Methods

- **High fat diet (HFD):** The high fat diet was prepared according to **(Reeves et al., 1993)** with some modifications containing Casein 14%, cellulose 5%, vitamin mixture 1%, sucrose 10%, mineral mixture 3.5%, choline bitartrate 2.5%, fat (19 % lard+ 1% soya oil), and the remainder was starch for 4 weeks **(Liu, et al., 2004).**
- **Experimental animal and diet:** The animals were kept in good circumstances in "The Post Graduated Lab of the Faculty of Home Economics, Helwan University". They will be kept in standard cages at room temperature (25 ± 3 °C) with a 12 h dark/ light cycle. They were given a basal diet **Reeves et al., (1993),** for seven days as an acclimatization period, then the rats were categorized into two groups:
- **The first main group** (n=6) was fed a standard diet as a normal control group (- ve) during the experimental period,
- **The second main group** (n=36) was fed on HFD. Then the rats were then split into 6 subgroups, 6 rats each: subgroup

(1): Rats were fed on HFD for 4 weeks and served as a positive control group. Subgroups (2) were fed on HFD and supplemented with chili pepper at the level of 10%. Subgroups (3) were fed on HFD and supplemented with sweet yellow pepper at the level of 10%.

Subgroups (4) were fed on HFD and supplemented with sweet red pepper at the level of 10%. Subgroups (5) were fed on HFD and supplemented with sweet green pepper at the level of 10%.

Subgroups (6) were fed on HFD and supplemented with 10% mixture of (sweet green, yellow, red and chili pepper) at (1:1:1:1)

At the end of the experiment (6 weeks) blood samples were taken and processed to extract serum, which will be stored frozen at (-20˚c) until biochemical analysis. The determination of feed intake was used to conduct biological analyses. The feed efficiency ratio and body weight gain percent estimated.

Biochemical analysis:

Serum was chemically analyzed to determine the following parameters:

1. **Lipid profile**: total cholesterol, triglycerides, high density lipoprotein, low density lipoprotein and very low-density lipoprotein
2. **Liver functions**: aspartate aminotransferase and alanine aminotransferase and serum alkaline phosphates.
3. **Glucose**.
4. **Malondialdehyde and catalase.**

Statistical analysis:

Statistical analysis performed using SPSS computer program (Graph pad software Inc, San Diego, CA, USA). One-way analysis of variance (ANOVA) followed Duncan's multiple tests be done. $P \le 0.05$ was significant to Armitage and Berry, (1987) Results are expressed as mean ± SE.

Result and discussion

Table (1)

Parameters Groups	IBW (g)	FBW(g)	BWG%	FI (g/d/rat)	FER
Control (-ve)	206.66±1.32 a	237.80±0.89 f	15.08±1.03d	19.3	0.035±0.022 d
Control (+ve)	207.10±1.08 a	271.66±1.66 a	31.17±0.45a	24.5	0.058±0.008 a
Chill pepper	205.00±2.04 a	247.50±0.93 d	20.79±1.55c	22	0.042±0.027 c
sweet red pepper	205.66±1.38 a	255.13±1.06 c	24.07±1.10b	21.5	0.051±0.020 b
sweet yellow pepper	205.30±1.00 a	255.96±1.54 c	24.68±0.81b	21.7	0.051±0.016 b
sweet green pepper	206.26±0.72 a	261.66±1.21 b	24.61±0.27b	21.3	0.52±0.004b
mixture	208.20±0.97 a	243.26±1.18 e	16.85±0.97d	20.4	0.038±0.020c d

Results are expressed as mean ± SE.

Values in each column which have different letters are significantly different at (P<0.05).

Table(1) showed the effect of Chili and Sweet Pepper on body weight in obese Rats the results indicated that body weight decreased significantly in groups fed on Chill pepper , sweet red pepper, sweet yellow pepper, sweet green pepper and the mixture as compared with control .positive group while fed efficiency ratio decreased significantly in groups fed on Chill pepper , sweet red pepper, sweet yellow pepper, sweet green pepper and the mixture as compared with control .positive group

Recent reviews (Ludy & Mattes 2011; Whiting et al. 2014) showed strong evidence for significant and positive effects of chili consumption in aggravating energy metabolism. Capsaicin has been reported to increase energy expenditure and diet-induced thermogenesis probably due to b-adrenergic stimulation and a decrease in the respiratory quotient, implying a shift in substrate oxidation from carbohydrate to fat oxidation (Ludy & Mattes 2011; Smeets et al. 2013; Shook et al. 2015). Reduced lipoprotein oxidation and increased lipid oxidation supports weight loss (Vasankari et al. 2001; Berggren et al. 2008)

Chili increases anorexigenicity (Janssens et al. 2014) and chili users were not only less hungry but also had a reduced desire to eat fatty, salty and sweet foods. This later effect is more prominent in irregular consumers of chili than habitual consumers (Ludy &s 2011). Chili reduced the desire to eat, tested in Matte a HF and a HC diet with the effect being more pronounced in the HF diet. Adding chili increased the sensation of oiliness thereby resulting in satiety (Yoshioka et al. 1998; Yoshioka et al. 1999) .A meta-analysis of human studies suggested that capsaicin and capsiate can help in weight management (. Ludy et al 2012). This response of capsaicin has been linked with its capacity to induce thermogenesis and the browning effect in white adipose tissue (Saito 2015). Capsaicin administration induced increased UCP1, PPAR_, PPAR, SIRT1, and PRDM-16 expression in adipocytes from mice (Baskaran et al ,2016)

Table (2): The effect of Chili and Sweet Pepper on serum CAT and MDA in obese Rats

Parameters Groups	CAT (	MDA (nmol/ml)
Control (-ve)	141.90±0.72a	3.53±0.34f
Control (+ve)	87.56±2.93e	10.48±0.31a
Chill pepper	123.83±1.49c	5.63±0.16d
sweet red pepper	115.33±0.84d	6.84±0.30c
sweet yellow pepper	117.96±1.07d	7.53±0.18bc
sweet green pepper	113.86±1.68d	7.90±0.22b
mixture	132.23±0.96b	4.26±0.08e

Results are expressed as mean ± SE.

Values in each column which have different letters are significantly different at (P<0.05).

Table 2 showed the effect of Chili and Sweet Pepper on serum CAT and MDA in obese Rats

The results indicated that CAT increased significantly in all groups fed on Chill pepper , sweet red pepper, sweet yellow pepper, sweet green pepper and the mixture as compared with control .positive group while MDA decreased significantly in all groups fed on Chill pepper , sweet red pepper, sweet yellow pepper, sweet green pepper and the mixture as compared with control .positive group. capsaicin demonstrated significant antioxidant and metal-binding properties and therefore it was postulated that this compound has important implications in the prevention or treatment of neurodegenerative diseases such as Alzheimer's disease (Dairam et al. 2008).

The antioxidative and antimicrobial properties of many plant extracts are of great interest, as there is a growing tendency to replace synthetic antioxidants with natural ones as natural additives used in both academic and industrial research (Shah et al 2022). The bioactive compounds in the species of *Capsicum* mainly consist of capsaicin, 6,7-dihydrocapsaicin, homodihy-drocapsain, nordihydro-capsaicin and homo-capsaicin (Deepa et al 2007). Capsicum also is a good source of bioactive compounds, such as flavonoids, phenolic acids, carotenoids, and ascorbic acid. These compounds have been reported to have antioxidant and anti-inflammatory activities (Janssens et al,2014). They are also important components for building up and maintaining the human immune system (Howard et al ,1994). On the other hand, Capsaicin, chemically identified as 8-methyl-N-vanillyl-6-none, is the main compound in the genus, together with a group of similar substances called capsaicinoids. These compounds have been shown as potent antioxidant agents in the plant. Concerning their biofunctional activities, capsaicinoids exhibit both pharmacological and physiological actions.

Table (3): The effect of Chili and Sweet Pepper on liver functions in obese Rats2

Parameters Groups	**AST**	**ALT**	**ALP**
	(μ/L)		
Control (-ve)	44.26±1.57f	58.40±0.61e	76.72±2.79d
Control (+ve)	120.48±0.98a	141.62±0.63a	117.46±0.95a
Chill pepper	93.13±1.72d	118.66±0.77c	84.14±0.98c
sweet red pepper	104.86±2.26c	124.93±1.88b	95.63±2.51b
sweet yellow pepper	109.10±1.14bc	127.30±1.10b	97.36±3.06b
sweet green pepper	111.43±1.38b	124.26±1.43b	101.00±2.44b
mixture	85.50±2.24e	106.36±1.35d	80.81±2.25cd

Results are expressed as mean ± SE.

Values in each column which have different letters are significantly different at ($P<0.05$).

The results in table (3) and figure (3) indicated that AST , ALT and ALP decreased significantly in all groups fed on Chill pepper , sweet red pepper, sweet yellow pepper, sweet green pepper and the mixture as compared with control .positive group

the main active constituent in hot chilies, capsaicin, has been shown to affect lipid profiles and reduce liver damage (. Dkhil and S. Al-Quraishy, 2010, Kim et al 2017, . McCarty et al 2015, Li 2015). Herein, RC powder extract mixed with a standard diet had best effect on liver function and structure compared to deep fried food with RC integrated into the recipe. Al-Jumayi *et al.(* 2020) reported the same effect, with lowered alanine aminotransferase, aspartate aminotransferase, and bilirubin compared. Capsaicin in high-fat diet-fed rats decreased serum ALT and AST, along with decreases in serum glucose and HOMA-IR (Sekero et al 2018). In high-fat diet-fed mice, combinations of eicosatetraenoic acid and capsaicin reduced body weight, fat tissue weights, serum total cholesterol concentration, and serum activities of AST and ALT, while improving insulin sensitivity (Hirotani et al 2017)

Table (4): The effect of Chili and Sweet Pepper on lipid profile in obese Rats

Parameters Groups	**TC**	**TG**	**VLDL-C**	**HDL-C**	**LDL-C**
	(mg/dl)				
Control (-ve)	95.10±2.10d	77.83±0.82c	15.56±0.16c	63.53±0.67a	17.60±2.51d
Control (+ve)	221.33±1.24a	101.10±1.76a	20.22±0.35a	32.96±0.71d	168.14±1.00a
Chill pepper	114.66±2.30b	89.56±3.01b	17.91±0.60b	55.66±2.09bc	41.08±3.33b
sweet red pepper	118.90±1.18b	88.00±1.47b	17.60±0.29b	52.80±1.23c	48.50±2.43b
sweet yellow pepper	117.00±0.81b	85.83±1.12b	17.16±0.22b	54.66±0.84c	45.16±0.31b
sweet green pepper	116.33±1.02b	89.30±0.78b	17.86±0.15	52.66±0.85c	45.80±1.33b
mixture	102.26±2.28c	79.60±1.19c	15.92±0.23cb	59.03±1.31b	29.08±4.01c

Results are expressed as mean ± SE.

Values in each column which have different letters are significantly different at ($P<0.05$).

The results in table (4) and figure (4) indicated that TC , TG, VLDL-C and LDL-C decreased significantly in all groups fed on Chill pepper **,** sweet red pepper, sweet yellow pepper, sweet green pepper and the mixture as compared with control .positive group while HDL-C increased significantly in all groups fed on Chill pepper **,** sweet red pepper, sweet yellow pepper, sweet green pepper and the mixture as compared with control .These positive results are similar to those found in previous studies(Shah and Mir 2022 , Howard et al 1994). Importantly, the poor LDL/HDL ratio, which increases the risk of CVD, exhibited by the positive control was lowered significantly by consumption of RC as part of a standard diet or in fast food. Such RC effects could be the result of various mechanisms, In high-fat diet-fed rats, capsaicin reduced weight of perirenal adipose tissue and serum triglyceride concentrations (Kawada et al 1986),, Plasma triglyceride, total cholesterol, HDL-cholesterol, and LDL-cholesterol concentrations were not changed by capsaicin treatment, whereas hepatic total lipids, triglycerides and total cholesterol concentrations were decreased (Mun et al 2014).

Table (5): The effect of Chili and Sweet Pepper on glucose in obese Rats

Parameters Groups	**Glucose**	**% of glucose reduction**
Control (-ve)	88.63±1.73e	
Control (+ve)	128.33±1.64a	
Chill pepper	107.26±1.86c	16.41
sweet red pepper	115.40±1.62b	10.07
sweet yellow pepper	117.66±0.62b	8.31
sweet green pepper	120.56±0.90b	6.05
mixture	99.23±3.88d	22.67

Results are expressed as mean ± SE.

Values in each column which have different letters are significantly different at (P<0.05).

The results in table (5) and figure (5) indicated that **Glucose** decreased significantly in all groups fed on Chill pepper **,** sweet red pepper, sweet yellow pepper, sweet green pepper and the mixture as compared with control .reduction in glucose levels can be explained by inhibition of certain enzymes involved in glucose metabolism, like α-amylase and α-glucosidase (Smutze Smutze et al 2016, Smeets, and Westerterp-Plantenga 2009) Other mechanisms could be related to increased insulin sensitivity and improved glucose tolerance (Wang et al 2012). study on mice, with two doses of chili addition to meals, showed decreased fasting blood glucose levels in low chili consuming groups (Islam & Choi 2008). Reduction in plasma glucose and insulin level maintenance was also observed (Chaiyasit et al. 2009) with the addition of chili. The reduction observed in blood glucose levels can also be drawn as a consequence of increased GLP-1 levels with TRPV1 mediated]i increase. A more recent study showed [Ca2 that capsaicin-containing chili supplementation regularly improved postprandial hyperglycemia and hyperinsulinemia as well as fasting lipid metabolic disorders in women with gestational diabetes mellitus, and it decreased the incidence of large-for-gestational-age newborns (Yuan et al. 2015).

References

Al-Jumayi H. A. O., H. A. Elhendy, and A. M. G. Darwish, (2020) "Biological effects of red chili pepper (Capsicum annuum) consumption on high fat diet female albino rats," *Pakistan J. Biol. Sci.*, vol. 23, no. 2, pp. 150–158, 2020, doi: 10.3923/pjbs..150.158.

Andreia S.; Antonio J.; Jorge P.; Horacio S. and Zeno A. (2019): Evaluation of the Anti-Diabetic Activity of Some Common Herbs and Spices: Providing New Insights with Inverse Virtual Screening. Molecules. 7;24(22):4030.

Armitage, G. and Berry, W. (1987): Statistical methods 7th Ed. Ames., Iowa State University. Press, 39-63.

Bahattab O.; **Shaikhomar, O. and Al-Awthan Y. (2022):** Changes in Glucose levels, Liver enzymes, and Lipid Profile in Hypercholesterolemic rats after using Capsicum annuum L. with fast food. Bioscience Research 18(4):2767-2773

Baskaran, P.; Krishnan, V.; Ren, J. and Thyagarajan, B. (2016) : Capsaicin induces browning of white adipose tissue and counters obesity by activating TRPV1 channel-dependent mechanisms. Br. J. Pharmacol., 173, 2369–2389

Berggren JR, Boyle KE, Chapman WH and Houmard JA.(2008): Skeletal muscle lipid oxidation and obesity: influence of weight loss and exercise. Am J Physiol Endocrinol Metab. 294:E726–E732.

Chaiyasit K, Khovidhunkit W and Wittayalertpanya S. (2009): Pharmacokinetic and the effect of capsaicin in Capsicum frutescens on decreasing plasma glucose level. J Med Assoc Thai. 92:108–113.

Cizza G. and Rother K.I. (2012): Beyond fast food and slow motion: weighty contributors to the obesity epidemic. J Endocrinol Invest.; 35(2):236-42.

Dairam A, Fogel R, Daya S and Limson JL.(2008): Antioxidant and iron-binding properties of curcumin, capsaicin, and S-allylcysteine reduce oxidative stress in rat brain homogenate. J Agric Food Chem. 56:3350–3356.

Deepa N., Kaur C., George B., Singh B., Kapoor H.C. (2007): Antioxidant constituents in some sweet pepper (*Capsicum annuum* L.) genotypes during maturity. *LWT-Food Sci. Technol.* ;40:121–129. doi: 10.1016/j.lwt.2005.09.016.

Dkhil M. A. and S. Al-Quraishy, (2010): "Effects of extensive consumption of hot red pepper fruit on liver of rabbit," *J. Med. Plants Res.*, vol. 4, no. 23, pp. 2533–2538, , doi: 10.5897/jmpr10.497.

Eggink, P.M.; Maliepaard,C.; Tikunov,Y.; Haanstra, J.P.; Bovy, A.G. and Visser, R.G.F. (2012): A taste of sweet pepper: Volatile and nonvolatile chemical composition of fresh sweet pepper (Capsicum annuum) in relation to sensory evaluation of taste, Food Chemistry, 132:301–310.

Ghasemnezhad, M.; Sherafati, M. and Payvast, G. A. (2011): Variation in phenolic compounds, ascorbic acid and antioxidant activity of five coloured bell pepper (Capsicum annum) fruits at two different harvest times. Journal of Functional Foods, 3 (1):44 - 49.

Hashemian M.; Hossein P.; Gwen M.; Arash E.; Farin K.; Akram P.; Masoud K.; Abdolsamad G.; Paul J.; Paolo B.; Sanford M.; Christian C. and Reza M. (2019): Turmeric, Pepper, Cinnamon, and Saffron Consumption and Mortality. J Am Heart Assoc. 17;8(18):e012240.

Hesamedin A.; Mahnaz S.; Ali M.; Davoud S.; Saharnaz N.; Farideh K.; Farahani K. and Abolghasem D. (2016): Factors Influencing Fast-Food Consumption Among Adolescents in Tehran: A Qualitative Study . Iran Red Crescent Med J. March; 18(3): e23890.

Hirotani, Y.; Fukamachi, J.; Ueyama, R.; Urashima, Y. and Ikeda, K. (2017): Effects of capsaicin coadministered with eicosapentaenoic acid on obesity-related dysregulation in high-fat-fed mice. Biol. Pharm. Bull., 40, 1581–1585.

Howard L.R., Smith R.T., Wagner A.B. and Villalon B., **(1994)**: Burns E.E. Provitamin A and ascorbic acid content of fresh pepper cultivars (*Capsicum annuum*) and processed jalapeños. *J. Food. Sci.* ;59:362–365. doi: 10.1111/j.1365-2621.1994.tb06967.

Islam MS and Choi H.(2008): Dietary red chilli (Capsicum frutescens L.) is insulinotropic rather than hypoglycemic in type 2 diabetes model of rats. Phytother Res. 22:1025–1029.

Janssens PL, Hursel R and Westerterp-Plantenga MS(. 2014):- Capsaicin increases sensation of fullness in energy balance, and decreases desire to eat after dinner in negative energy balance. Appetite. 77:44–49.

Jeremy S.; Tracy M.; Julian M.; Sheebu C. and Shabana Y. (2020): Hyperlipidemia. Pediatr Rev. 41(8):393-402.

Jing H.; Zhang Y. and Zhang Y. (2022): International Conference on Green Environmental Materials and Food Engineering (GEMFE 2022) , Francis Academic Press, UK

Joanne B. and Jose C. (2020): Genetics of diabetes mellitus and diabetes complications. Nat Rev Nephrol.;16(7):377-390.

Kawada, T.; Hagihara, K.and Iwai, K (1986): Effects of capsaicin on lipid metabolism in rats fed a high fat diet. J. Nutr. , 116, 1272–1278. [CrossRef] [PubMed]

Kim. J. S., T. Y. Ha, S. Kim, S. J. Lee, and J. Ahn (2017) : “Red paprika (Capsicum annuum L.) and its main carotenoid capsanthin ameliorate impaired lipid metabolism in the liver and adipose tissue of high-fat diet-induced obese mice,” *J. Funct. Foods*, vol. 31, pp. 131–140, Apr., doi: 10.1016/j.jff.2017.01.044.

Li Q. *(*2015)*:* “Dietary capsaicin prevents nonalcoholic fatty liver disease through transient receptor potential vanilloid 1-mediated peroxisome proliferator-activated receptor δ activation,” *Pflugers Arch. Eur. J. Physiol.*, vol. 465, no. 9, pp. 1303–1316, Sep., doi: 10.1007/s00424-013-1274-4.

Liu, M.; Shen, L.; Liu, Y.; Woods, S.; Seeley R.; D’Alessio, D. and Tos, P. (2004): Obesity induced by a high-fat diet down regulates Apo lipoprotein A-IV gene expression in rat hypothalamus. Am J PhysiolEndocrinolMetab., 287: E366–E370.

Ludy MJ and Mattes RD.(2011): The effects of hedonically acceptable red pepper doses on thermogenesis and appetite. Physiol Behav. 102:251–258. - Whiting S, Derbyshire EJ, Tiwari B. 2014. Could capsaicinoids help to support weight management? A systematic review and meta-analysis of energy intake data. Appetite. 73:183–188.

Ludy MJ, and Mattes RD. (2011*): The effects of hedonically acceptable red pepper doses on thermogenesis and appetite. Physiol Behav. 102:251–25*

Ludy, MJ.; Moore, G.E. and Mattes, R.D. (**2012)** :The effects of capsaicin and capsiate on energy balance: Critical review and meta-analyses of studies in humans. Chem. Senses, 37, 103–121.

McCarty M. F., J. J. DiNicolantonio, and J. H. O’Keefe(2015) :“Capsaicin may have important potential for promoting vascular and metabolic health: Table 1,” *Open Hear.*, vol. 2, no. 1, p. e000262, Jun. doi: 10.1136/openhrt-2015-000262.

Mougiou,N.; Trikka1, F.; Michailidou,S.; Pantoura,M. and Argiriou, A. (2021): Molecular and biochemical characterization of the greek pepper (Capsicum annuum) Cultivars ‘Florinis’ and ‘Karatzova’. Pol. Journal Food Nutrition Science, 71(1):89– 96.

Mun, J.M.; Ok, H.M.and Kwon, O. **(2014)** Corn gluten hydrolysate and capsaicin have complimentary actions on body weight reduction and lipid-related genes in diet-induced obese rats. Nutr. Res., 34, 458–465. [

Reeves, P.G.; Nielsen, F.H. and Fahey, G.C., (1993): AIN-93 purified diets for laboratory rodents: final report of the American Institute of Nutrition ad hoc writing committee on the reformulation of the AIN-76A rodent diet." J. Nutr. 123:1939-51

Saito, M. (2015): Capsaicin and related food ingredients reducing body fat through the activation of TRP and brown fat thermogenesis. Adv. Food Nutr. Res., 76, 1–28. [CrossRef] [PubMed]

Sekero˘ glu, V.; Aydın, B.; Atlı ¸Sekero˘ glu, Z.; and Özdener Kömpe, Y. **(2018) :**Hepatoprotective effects of capsaicin and alpha-tocopherol on mitochondrial function in mice fed a high-fat diet. Biomed. Pharmacother., 98, 821–825.

Shah M.A. and Mir S.A. **(2022**) : *Plant Extracts: Applications in the Food Industry*. Academic Press; Cambridge, MA, USA:. Plant extracts as food preservatives; pp. 127–141.

Shook RP, Hand GA, Paluch AE, Wang X, Moran R, H_ebert JR, Jakicic JM, and Blair SN (2015): High respiratory quotient is associated with increases in body weight and fat mass in young adults. Eur J Clin Nutr. 70:1197–1202.

Shaikh R.; Ali M.; Mohsin A.; Hiware S.; Ahmad A.; Daimi S.; Moizuddin K.; Shaikh S. and Siddiqui F. (2022): A Comparative Study on Clinical Evaluation of the Hypolipidemic Effects of Allium sativum, Trigonella foenum-graecum, Commiphora mukul, Picrorhiza kurroa, and Piper nigrum: A Pilot Study. Cureus.; 14(7): e26597.

Smeets, A.J and Westerterp (. **2009)**:Plantenga, M.S. The acute effects of a lunch containing capsaicin on energy and substrate utilisation, hormones, and satiety. Eur. J. Nutr, 48, 229–234. [CrossRef] [PubMed]

Smeets AJ, Janssens PL, Westerterp-Plantenga MS. **(2013)**: Addition of capsaicin and exchange of carbohydrate with protein counteract energy intake restriction effects on fullness and energy expenditure. J Nutr. 143:442–447.

Smutzer, G.and Devassy, R.K (. **2016)**: Integrating TRPV1 receptor function with capsaicin psychophysics. Adv. Pharmacol. Sci, 2016, 1512457.

Tan, S.; Gao, B.; Tao, Y.; Guo, J.and Su, Z.Q. (**2014**): Antiobese effects of capsaicin-chitosan microsphere (CCMS) in obese rats induced by high fat diet. J. Agric. Food Chem. 62, 1866–1874. [

Wahyuni,Y.; Ballester, A.R.; Sudarmonowati, E.k.; Bino, R.J. and Bovy, A.G. (2011): Metabolite biodiversity in pepper (capsicum) fruits of thirtytwo diverse accessions: variation in healthrelated compounds and implications for breeding. Phytochemistry, 72:1358–1370.

Wang, P.; Yan, Z.; Zhong, J.; Chen, J.; Ni, Y.; Li, L.; Ma, L.; Zhao, Z.; Liu, D and Zhu, Z. **(2012)** :Transient receptor potential vanilloid 1 activation enhances gut glucagon-like peptide-1 secretion and improves glucose homeostasis. Diabetes, 61, 2155–2165.

Yuan LJ, Qin Y, Wang L, Zeng Y, Chang H, Wang J, Wang B, Wan J, Chen SH and Zhang QY, (2015): Capsaicin-containing chili improved postprandial hyperglycemia, hyperinsulinemia, and fasting lipid disorders in women with gestational diabetes mellitus and lowered the incidence of large-for-gestational-age newborns. Clin Nutr. 35:388–393.

Yoshioka M, St-Pierre S, Drapeau V, Dionne I, Doucet E, Suzuki M, Tremblay A. **(1999)**: Effects of red pepper on appetite and energy intake. Br J Nutr. 82:115–123.

Yoshioka M, St-Pierre S, Suzuki M and Tremblay A. **(1998)**: Effects of red pepper added to high-fat and high carbohydrate meals on energy metabolism and substrate utilization in Japanese women. Br J Nutr. 80:503–510.

Vasankari T, Fogelholm M, Kukkonen-Harjula K, Nenonen A, Kujala U, Oja P, Vuori I, Pasanen P, Neuvonen K and Ahotupa M. **(2001)** :Reduced oxidized low-density lipoprotein after weight reduction in obese premenopausal women. Int J Obes Relat Metab Disord. 25:205–211.

Qin N.; Yang F, and Li A. (2014): Alterations of the human gut microbiome in liver cirrhosis. Nature; 513:59-64.