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RESEARCH ARTICLE

COFFEE BENEFITS WITH DRAWBACKS

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Abstract

Coffee is the most commonly consumed beverage, therefore to prevent unwanted consequences of its use, it is advisable to expand knowledge about coffee ingredients impact on the body, to know not only its positive effects on the body, but also negative ones. The well-known beneficial properties of coffee, such as its antioxidant content and potential cognitive and metabolic benefits, must be weighed against its numerous drawbacks, including potential overconsumption, adverse cardiovascular effects, and disruptions to sleep patterns. In recent years, it has become clear that caffeine-containing beverages can cause reflux, aggravate the situation and even provoke tumors in the gastrointestinal tract, stimulate hypertension, arrhythmia, cardiovascular diseases, type 2 diabetes, cirrhosis, liver cancer, obesity, and cause addiction with withdrawal syndrome. Recent publications have shown a decrease in the psychological reactivity and cognitive abilities, as well as tolerance to sleep deprivation in coffee lovers. This should be a signal for physicians to take into account the patient's addiction to caffeinated drinks during the survey/anamnesis collection in order to determine whether they were the cause of the onset and/or complication of the patient condition.

Introduction:-

Coffee drive mechanism and amenities.

Coffee, despite the fact that it, like any other drink, has its negative effects on our body systems, is one of the most widely consumed drinks in the world. In this regard, we have taken on the task of briefly presenting in the article the results of studies available to date, conducted in relation to the consideration of the pros and cons of the components contained in it. Caffeine, its main active compound, has a dose-dependent effect. It is generally accepted that in high doses it has an inhibitory effect, and in moderate doses - a stimulating effect. Few people know that excessive caffeine consumption, leading to a concentration in the blood exceeding 80 mg / l, is dangerous to health and can even be fatal [1]. For this reason, the US Food and Drug Administration (FDA) recommends a daily caffeine limit of 400 mg, including consumption from sources such as Coca-Cola, Pepsi-Cola, energy drinks, coffee, chocolate and carbonated drinks with caffeine [2]. Caffeine has stimulatory effects on a variety of physiological systems, including the nervous, cardiovascular, respiratory, and excretory systems. Recent analyses indicate that freshly brewed ground coffee contains approximately 60–80 mg of caffeine per cup, while whole bean coffee contains 60–140 mg [3]. Pharmacokinetics of coffee is that orally administered caffeine reaches peak plasma concentrations within 15–120 minutes and exerts its effects for approximately 3–6 hours before being metabolized by the liver.[4] The major metabolic pathway involves the cytochrome P450 enzyme system, specifically CYP1A2, which converts caffeine to

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paraxanthine, theobromine, and theophylline. These metabolites are ultimately excreted in the urine.[5]. Caffeine's effects arise primarily from its ability to competitively bind to adenosine receptors, thereby interfering with their normal signaling pathways. Adenosine, a neuromodulator, plays a critical role in regulating states of wakefulness and fatigue. Adenosine levels increase during prolonged periods of wakefulness, leading to drowsiness, helping to prepare the body for rest and recovery, while after adequate sleep, adenosine levels decrease, restoring alertness [6]. Structurally similar to adenosine, caffeine competes for binding to adenosine receptors, blocking the inhibitory signals that adenosine normally transmits to target cells. This blockage results in a temporary suppression of fatigue-related signals, resulting in increased activity.

Humans have A1, A2A, A2B, and A3 adenosine receptor types with distinct roles distributed across different tissues. For example, A1 and A3 receptors typically exhibit inhibitory effects, whereas A2A and A2B receptors play stimulatory roles. Most individuals have a predominance of inhibitory A1 and A3 receptors. Therefore, caffeine binding to these receptors prevents their inhibitory action, resulting in increased neural excitability and stimulation. Conversely, in individuals with a higher proportion of stimulatory A2A and A2B adenosine receptors, caffeine reduces their activation, paradoxically causing drowsiness. Thus, the mechanistic basis for caffeine's dual role is the ability of caffeine to act as a stimulant and anxiolytic, which is mediated by its competitive binding to adenosine receptors, modulating neuronal activity in a manner dependent on receptor subtype abundance, regional distribution, and individual neurophysiological states.[7] Over time, the body adapts to regular caffeine consumption through a compensatory mechanism known as “habituation”. This adaptation involves upregulating adenosine receptors to counteract the effects of caffeine, resulting in decreased sensitivity to its stimulant properties. Consequently, habitual caffeine consumers may experience increased sleepiness upon caffeine withdrawal and require increasingly higher doses to achieve the same level of stimulation [8].

Athletes often consume caffeine-containing products to enhance their performance during training [9]. The effects of coffee's constituents as a whole differ significantly from those of purified caffeine due to the interaction of caffeine with other bioactive compounds present in it [10]. For example, coffee also contains polyphenolic [11] compounds with antioxidant and neuroprotective properties [8] and even as fertility enhancers [12]. Roasting coffee, often used to impart coffee flavor due to the release of trigonellin, nevertheless significantly affects the content [10] and activity of its polyphenols, including chlorogenic acid. Chlorogenic acid is an antioxidant [13] with anti-inflammatory properties that help in weight loss. Well-roasted coffee beans exhibit the lowest levels of these active compounds in their composition [14]. Light roasting and green coffee have stronger cytotoxic potential and antioxidant properties [15], which enhance their ability to reduce apoptosis and arrest the cell cycle in the S-phase [16]. However, coffee polyphenols retain significant antiproliferative and antiesterase activity, which contributes to their role in preventing the development of cancer and neurodegenerative diseases. When measuring polyphenols in coffee beans using high-performance liquid chromatography, the following was found: at a wavelength of 250 nm - flavonoids (quercetin-3-O-rutinoside, kaempferol-3-O-glucoside, myricetin, quercetin, quercetin-3-O-glucoside, apigenin, kaempferol) and caffeine, and at 370 nm - phenolic acids (gallic, chlorogenic, caffeic, p-coumaric, ferulic) [17].

Theobromine and theophylline in coffee are alkaloids of the xanthine derivative family with stimulant action [18]. Theobromine is similar to caffeine, but has different effects. It acts as a competitive inhibitor, like caffeine, binding to adenosine receptors instead, but has a milder effect [19]. By blocking adenosine receptors in the brain, it prevents the physiological tranquilizing effects of adenosine, thus helping to reduce the feeling of fatigue and increase alertness [20]. It also has a calming effect on the muscles of the bronchi, providing relief from asthma and other respiratory diseases, especially those accompanied by spasm and persistent coughing [21], which is why theophylline is often used in the treatment of respiratory diseases such as asthma or chronic obstructive pulmonary disease. By relaxing the muscles of the airways, it helps to ease the flow of air into the lungs, making breathing easier. The effect of theobromine on blood vessels is also similar to that of caffeine, but its effects are less pronounced. Thus, it acts as a vasodilator, improving blood flow, and has mild diuretic properties, and can help with cardiovascular syndromes [22].

Coffee also contains trigonelline, which flavors coffee but worsens osteoporotic skeletal changes, especially in the absence of estrogens [23]. When heated during roasting, it breaks down into nicotinic acid, which enhances the nutritional profile of coffee [24]. There are small amounts of lipids and proteins in coffee beans, which contribute only to the taste and texture of coffee. Roasting can destroy some of these compounds, too, affecting the overall

taste. Carbohydrates are also largely broken down during roasting. The amount of sugar in brewed coffee is minimal, making it safe from a glycemic index point of view for diabetics.

The therapeutic effects of coffee extend beyond caffeine alone. For example, polyphenols such as chlorogenic acids in coffee have antioxidant and anti-inflammatory properties that reduce the risk of chronic diseases. Below are some conditions where the unique properties of various coffee compounds can be effectively used. By neutralizing free radicals, antioxidants mitigate some of the negative effects of caffeine (such as oxidative stress). These compounds also enhance the anti-inflammatory and neuroprotective potential of coffee.[25] The mild stimulant effects of theobromine complement the effects of caffeine without causing the jitters or overstimulation that caffeine alone can cause. This results in a more balanced and sustainable increase in energy supply to the body's cells. Some studies suggest that regular coffee consumption may reduce the risk of neurodegenerative diseases such as Alzheimer's and Parkinson's due to the neuroprotective properties of compounds such as trigonelline and chlorogenic acids.[26] This may be due to the combined action of antioxidants, anti-inflammatory compounds, and caffeine. The effects of caffeine on dopamine and serotonin levels may have a mild antidepressant-like effect. Combined with the properties of theobromine, this makes coffee a potential mood enhancer [27]. Coffee is rich in potassium, magnesium, and other micronutrients [28] that support cardiovascular health. The anti-inflammatory properties of chlorogenic acids and coffee's ability to improve insulin sensitivity may reduce the risk of type 2 diabetes and heart disease [29]. Coffee ground fiber and related compounds may improve gastrointestinal motility, increase beneficial microbiota,[30] and exert a dose-dependent protective effect against colorectal cancer [31]. Coffee has the potential to reduce the risk of fatty liver disease [32], cirrhosis, and liver cancer [32] This is likely due to its antioxidant and anti-inflammatory properties. Diterpenes (cafestol and kahweol) found in unfiltered coffee have also been shown to support liver health and have anti-cancer properties [33]. As for pure caffeine, recent studies classify caffeine as an alkaloid with analeptic, cardiotonic, and psychostimulant pharmacological actions, primarily modulating excitability.

Coffee adverse consequences

Coffee, while widely consumed and often praised for its health benefits, can have negative effects, especially when consumed in excess. These effects have been studied extensively, and scientific findings suggest that some individuals may experience adverse outcomes, depending on their sensitivity, underlying health conditions, and consumption patterns. Below are scientifically supported negative effects of coffee. For instance, a 2013 study in the Journal of Clinical Sleep Medicine showed that coffee caffeine consumed 6 hours before bedtime, significantly shortened sleep duration resulting in sleep deprivation [34]. Therefore coffee-containing beverage consumption, especially in the evening, delay sleep onset and lower sleep quality. Chronic sleep disturbances can impair cognitive function and overall health. A 2024 Frontiers in Psychology and series of scientists highlighted caffeine created aggravate anxiety disorders by stress hormones cortisol and adrenaline secretion exacerbating anxiety in sensitive individuals resulting in nervousness, restlessness, and rapid heartbeat [35, 36]. Research in the field of psychopharmacology and nutrition confirms that coffee dependence and withdrawal syndrome [37, 38] is a clinically significant syndrome that affects daily activities due to created by coffee tolerance and physical dependence by modifying adenosine receptor density and function. Withdrawal symptoms typically reach peak 1–2 days after cessation and include fatigue, difficulty concentrating, headaches, irritability, cognitive disorders. A meta-analysis in 2021, 2023 linked high caffeine intake to increase in blood pressure in coffee lovers. Symptoms are linked to caffeine stimulation sympathetic nervous system in predisposed individuals and can increase blood pressure and heart rate increasing the risk of hypertension and arrhythmias[39, 40]. A 2019 study in Tzu Chi Medical Journal associated coffee with increased symptoms in gastroesophageal reflux disease [41], since coffee stimulates gastric acid secretion and accelerates gastric emptying, which can irritate the gastrointestinal lining leading to acid reflux, heartburn, condition exacerbation in irritable bowel syndrome. High caffeine intake and calcium absorption and metabolism disorders are alerted in 2002 by Food Chemistry and Toxicology review and confirmed in 2021 in Nutrients that noted a correlation between high caffeine consumption and lower bone mineral density in postmenopausal women [42, 43]. Authors claim that the long-term coffee consumption is linked to bone mineral density decrease raising fracture risk, particularly in older adults with inadequate calcium intake. A 2022 study in JAMA Network Open found a dose-response relationship between maternal caffeine consumption and adverse pregnancy outcomes such as preterm delivery, increased miscarriage risk, low birth weight [44]. Research revealed caffeine crosses the placenta, while the fetus metabolizes it slowly, potentially leading to higher fetal exposure. A 2023 meta-analysis in Ochsner Journal confirmed the high LDL cholesterol-raising effects of unfiltered coffee increasing risk for cardiovascular disease [45]. This diverse effect is especially significant in unfiltered coffee (e.g., French press) contains diterpenes like cafestol and kahweol.

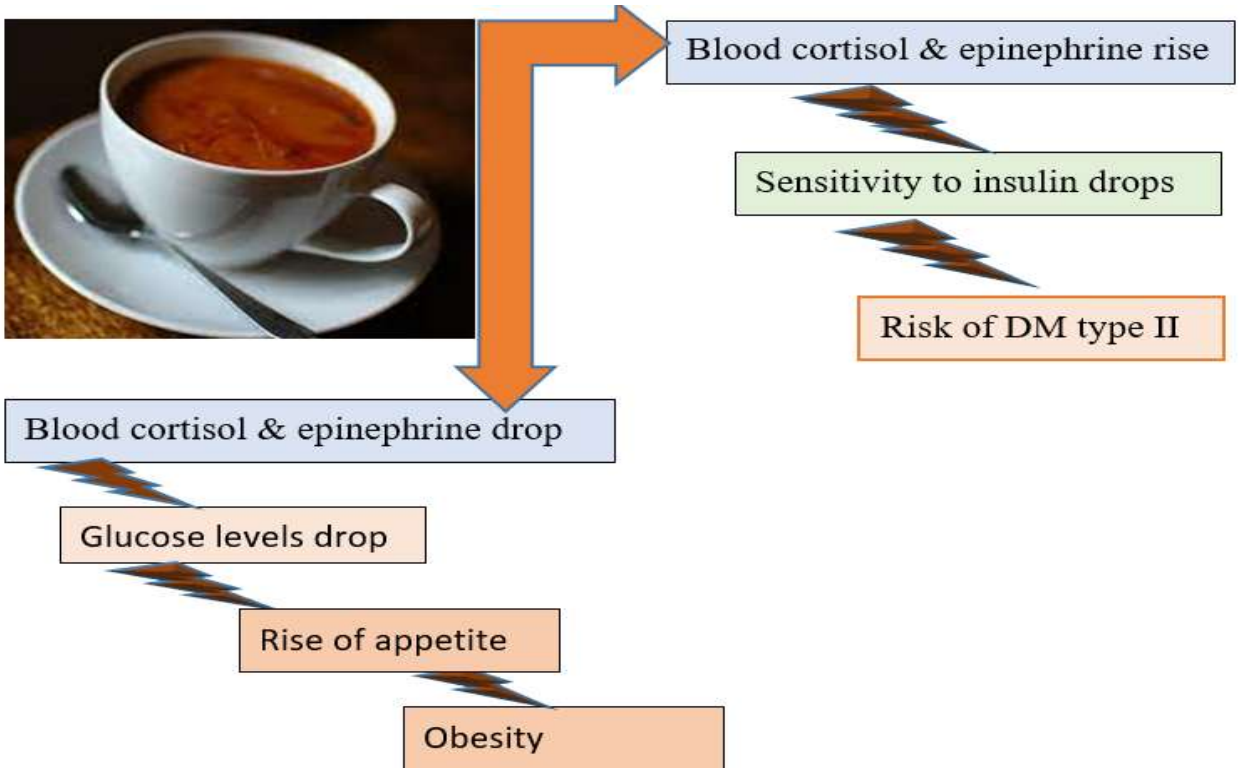

Fig. 1:- The caffeinated beverages are not save for everyone.

The caffeine contained in coffee will increase the secretion of cortisol and epinephrine, causing hyperglycemia and the release of additional insulin, while reducing the sensitivity of receptors to insulin, which can lead to non-insulin-dependent diabetes type 2. In some individuals, drinking coffee leads to a decrease in epinephrine and cortisol below physiological values, causing hypoglycemia, which leads to increased appetite and overeating, causing obesity (Fig.1).

In recent years, it has been found that coffee can even significantly reduce alertness. Thus, the effects of coffee on psychomotor alertness with electroencephalogram recordings showed that the time needed for reaction in coffee drinkers increases, indicating the presence of psychomotor retardation in the brain. in individuals with low caffeine consumption, the time needed for psychomotor reaction was shorter than in consumers with moderate and high consumption, indicating the presence of an inverse relationship between the amount of coffee consumed and brain activity. in individuals consuming a lot of caffeine, the increase in the power of the electroencephalogram in response to irritation was also weakened. in the group with high coffee consumption, the individual alpha frequency of the brain was also lower when tired. Moreover, correlation analysis showed that the higher the daily caffeine intake, the worse the mental adaptation. Thus, high coffee consumption reduces attention performance and alpha frequency, reduces tolerance to sleep deprivation. The good news is that the negative physiological changes caused by caffeine are reversible in most individuals. For example, after stopping caffeine consumption, adenosine receptor levels can gradually return to baseline levels over a period of days or weeks, restoring normal sensitivity to cues from the outside world [46]. As can be seen, coffee excessive intake or specific individual susceptibilities can lead to adverse effects. Understanding personal tolerance and moderating consumption are key to minimizing these risks.

Conclusion:-

1. Coffee is not as safe a beverage as is commonly believed, especially in case of overdose. Some beneficial effects of coffee components can be both enhanced (release of nicotinic acid from trigonelin) and weakened (decomposition of polyphenols) by roasting.
2. Coffee consumption causes a whole bunch of side effects, including a negative impact on alertness, tolerance to sleep deprivation, worsening of type 2 diabetes, excess weight.

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