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DERLEME / REVIEW

EFFECTS OF ROYAL JELLY ON OBESITY

Arı sütünün obezite üzerine etkileri

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ABSTRACT

Obesity is a disease that affects people's quality of life and is a risk factor for some fatal diseases. Its prevalence is increasing in the world and the biggest factor is nutritional problems and a sedentary lifestyle. Royal jelly (RJ), a natural product for obesity, a preventable disease, has been the subject of various studies. RJ secreted by young honey bees (worker bees) is the only food source for the queen bee and the first three days of food for immature bees. Several studies have shown RJ's anti-obesity, antioxidant, anticarcinogenic, antimicrobial, and anti-inflammatory activities. In addition, RJ is seen as a promising functional food in the prevention of obesity and protection from its negative effects. This study is an examination of studies on the effects of RJ on obesity and its accompanying problems.

Keywords: Obesity, Royal jelly, Bee

ÖZ

Obezite insanların yaşam kalitesini etkileyen ve bazı ölümcül hastalıklar için risk faktörü oluşturan bir hastalıktır. Dünyada prevalansı artmaktadır ve en büyük etken beslenme sorunları ve hareketsiz yaşam tarzıdır. Önlenebilir bir hastalık olan obezite için doğal bir ürün, arı sütü (RJ) çeşitli çalışmalara konu olmuştur. Genç bal arıları (işçi arılar) tarafından salgılanan RJ kraliçe arının tek besin kaynağı ve olgunlaşmamış arıların ilk üç günlük besinleridir. RJ'nin antioksidan, antikanserojen, antimikrobiyal, antienflamatuar ve antiobezite aktiviteleri çeşitli çalışmalarla gösterilmiştir. Bu çalışma RJ'nin obezite ve beraberinde getirdiği sorunlar üzerindeki etkilerini konu alan çalışmaların bir derlemesidir.

Anahtar Kelimeler: Obezite, Arı sütü, Arı

GENİŞLETİLMİŞ TÜKÇE ÖZET

Amaç: Arı ve ürünleri antik çağlardan beri insan sağlığını olumlu yönde etkilemesinden dolayı tüketilmektedir. Arı ürünlerinden RJ''nin antioksidan, antifungal, antibakteriyel, antiviral, antikanserojen, antienflamatuar ve antiobezite gibi biyoaktif özellikleri çeşitli in vitro ve in vivo çeşitli çalışmalarla gösterilmiştir. RJ genç işçi arıların yaşamlarının ilk üç günü beslendiği ve kraliçe arının ise hayat boyu beslendiği, arıların hipofarengeal ve mandibular bezlerinden salgılanan vizkoz, asidik, sarımsı renkte karbonhidrat, protein, lipit ve serbest aminoasitlerce zengin suda çözünür bir salgı maddesidir. Arı ürünlerinin bileşenleri, bulundukları ekosistem ve çevre şartlarına göre değişiklik göstermesi nedeniyle standardize edilememiştir. Fakat RJ içeriğinde bulunan ve diğer doğal ürünlerde bulunmayan 10-HDA molekülü kalite

belirteci olarak kullanılıp miktarı %0.75 ile %3.39 arasında değişmektedir. RJ obezite ve getirdiği sorunların çözümü konusunda birçok araştırmacı tarafından ilgi çekici bulunmuştur. Özellikle insülin benzeri aktivite gösteren biyoaktif maddeleri içeriğinde bulundurması, antioksidan ve antiinflamatuar aktiviteye sahip olması, östrojen sinyal yolağında rol oynaması gibi potansiyelleri nedeniyle yardımcı ve tamamlayıcı tedaviler için umut vadetmektedir. Bu çalışmada RJ ve 10-HDA'nın obezite ve beraberinde getirdiği sorunları çözmedeki potansiyelini konu alan çalışmalar incelenmiştir.

Tartışma: RJ içeriğinde genellikle %1,5 mineral, %7-21,2 karbonhidrat, %8-9 protein ve çeşitli karboksilik asitler, vitaminler ve serbest aminoasitler bulundurmaktadır. Bunlara ek olarak çeşitli polifenoller ve flavonoidler bulundurur. Polifenoller, flavonoidler ve serbest aminoasitler araştırmacılar tarafından antioksidan aktiviteyle ilişkili bulunmuştur. İçeriğindeki yağ asitlerinden 10-HDA antibakteriyel, antiinflamatuar, hücre immün aktivite düzenleyici role sahip olduğu bulunmuştur. RJ'nin hücre büyümesinde, farklılaşmasında, hayatta kalımında etkili ve insülin benzeri aktiviteye sahip olduğu çeşitli çalışmalarla gösterilmiştir. RJ, günlük toplam enerji alımını düşürmüştür, yaşa bağlı kas zayıflığını azaltmıştır. RJ KK-Ay (KK-Ay fareleri: diyabetik KK ve lethal yellow (Ay) farelerinin melezi. değiştirilmiş adipokin ekspresyonu, obezite, dislipidemi ve insülin direnci gösteren özel farelerdir.) farelerinde kısmen vücut ağırlığını düşürmüştür, hiperglisemiyi iyileştirmiştir. Yaşlı obez sıçanlarda RJ takviyesi kullanımı kas lipotoksisitesine karşı koruyucu olup, insülin direncini azaltmıştır. Ek olarak di yete bağlı obezitenin etkilerini ve kas iskelet fonksiyonlarını iyileştirdiği bildirilmiştir. 10-HDA, 3 T3-L1 adiposit hücrelerinde adipojenik aktivite göstermiştir. Asemptomatik aşırı kilolu yetişkinlerde RJ takviyesi lipit profili, tokluk, iltihaplanma ve antioksidan kapasitesi üzerindeki olumlu etkiler göstermiştir. RJ sıçanlarda oksidatif stresi inhibe etmiştir, serum lipit profilindeki olumsuzluklar, karaciğerdeki lipit birikimi, lipit peroksidasyonu ve sirkadyen gen ifadesindeki bozuklukları gibi olumsuzlukları iyileştirmiştir. Tüm bu bilgiler RJ'nin obezite ve beraberinde getirdiği metabolik problemlerin çözümünde etkili olabileceğini göstermektedir fakat RJ'nin standardizasyonu ile ilgili belirsizlikler ve örneklem sayısının azlığı daha çok araştırma sonuçlarıyla desteklenmesi gerektiğini göstermektedir.

Sonuç: Sonuç olarak RJ'nin obezite ve metabolik bozukluklarla mücadele için umut verici olduğu, obezite için terapötik ilaç olma potansiyelinin bulunduğunu, obeziteyi azaltmak için yeni bir seçenek olarak diyete eklenebileceğini, yağ dokusu disfonksiyonuna ve inflamasyona karşı koruyucu etkilerinin bulunduğunu fakat daha çok çalışmayla desteklenmesi gerektiğini, obeziteyle ilgili komplikasyonları önleme ve olumsuz etkilerden koruma potansiyelinin bulunduğunu göstermektedir. Tüm bu nedenlerden dolayı terapötik olarak ve bu hastalığı önleme için umut vadeden fonksiyonel bir gıda olduğu düşünülmektedir. Daha geniş örneklem kitlesiyle sonuçlar desteklenmelidir.

INTRODUCTION

This review is about the studies on obesity and the possible prevention and improvement of obesity with royal jelly (RJ). Bee products and the RJ in these products have been a source of healing for people since ancient times (Pasupuleti et al., 2017). Nowadays, bee products and other similar natural foods are used as auxiliary, complementary, and supportive products in the prevention of various diseases and the treatment of diseases. Various studies have shown that people improve their survival and quality of life. Longevity and procreation, which are thought to be provided by RJ to the queen bee, are the subjects of much research (Kunugi & Mohammed Ali, 2019). Apart from these, one of the benefits that should be taken into account is the prevention of obesity and increasing the quality of life by mitigating the consequences of obesity. This study, in which current publications are compiled to draw attention to this issue, emphasizes that RJ is very important and remarkable in obesity.

Obesity

Obesity, which causes various health problems and reduces the quality of life; is one of the leading problems in the world. Obesity is defined as excessive fat accumulation or abnormal distribution of fat in the body (Li et al., 2020). If an adult's body mass index is more than 30, it is considered obese, and increasing obesity is a risk factor for many fatal diseases (Thomas, 2020). According to WHO data, approximately 13% of the world's population was obese in 2016, and the prevalence has tripled

compared to 1975. Obesity is caused by both genetic and environmental factors, and WHO states that obesity can be prevented. To prevent it, easy regulations such as limiting energy intake from fat and sugar, increasing fruit and vegetable consumption, increasing physical activity, and choosing healthy diets are sufficient.

Many physiological problems, such as obesity, impaired glucose tolerance, and hyperglycemia, are metabolic syndromes resulting from disturbances in the maintenance of glucose homeostasis (Pandey & Rizvi, 2009). These syndromes are caused by disorders in diet and sedentary lifestyle, genetic and environmental factors and insulin resistance develops (Manach et al., 2004; Sun et al., 2015). This situation, which develops with the deterioration of glucose metabolism and insulin resistance, causes increased oxidative stress and inflammation in the body, and then muscle and adipose tissue, liver, etc. causes dysfunction of many organs (Knekt et al., 2002). An important reason for the disorder in glucose metabolism is the consumption of a high glycemic diet, which causes rapid absorption of glucose, which increases the risk of obesity (Yarmolinsky et al., 2015). In addition, inflammation throughout the body is effective in the development of obesity by increasing the development of free oxygen species and oxidative stress (Alvehus et al.). The antioxidant activity ability, which is generally attributed to polyphenols and flavonoids, has been proven in various studies to be protective from the damage of free oxygen species and free radicals (Lin et al., 2002).

Royal Jelly (RJ)

Named by the Swiss botanist Francois Hubber in 1788, RJ is secreted from the hypopharyngeal and mandibular glands of young bees and is a white/yellow viscous, acidic substance (Crane, 1990; Willson, 1955). The secretion secreted by young worker bees to feed the queen for life and the immature females for the first 3 days of their lives is considered responsible for the differentiation of the queen bee (Kanelis et al., 2018).

RJ is an aqueous emulsion of lipid, protein, sugar, free amino acids, and vitamins. It contains about 1.5% mineral salts (Fe, Zn, Na, K, Ca, Mn, Cu) and small amounts of vitamins (B1, B2, B3, B5, B7, folic acid, inositol, and vitamin E), polyphenols, flavonoids contains. The flavonides reported to be present in RJ are: herperetin, isosacuranetin and naringenin flavanones; acetin, luteolin, apigenin, and crisis glucoside flavones; kaempferol and isorhamnetin are the glucoside flavonols, and coumestrol and genistein are isoflavonoids. It has been demonstrated that the water content of RJ varies between 50% and 70%. It has been shown that the sugar composition, mainly consisting of fructose and glucose, varies between 7% and 21.2%. Apart from this, there are also studies reporting the presence of sucrose, trehalose, maltose, gentiobiose, isomaltose, raffinose, erlos, and hybridize oligosaccharides. Major RJ proteins (MRJP) make up 90% of the protein content of RJ. The free amino acid composition, which is also associated with antioxidant activity, has been reported as alanine, aspartic acid, phenylalanine, glycine, glutamic acid, glutamine, hydroxyproline, isoleucine, lysine, leucine, proline, serine, cysteine, cystine, tyrosine, threonine, valine(Isidorov et al., 2012). It is estimated that the total content of fat and fatty acids in RJ is in the range of 7-18%. 80-85% of RJ fatty acids and the main component of the sieve residue are lipids. The most important of the fatty acids contained in RJ and what makes it special is 10-hydroxydecanoic acid (10-HDA), which is not found in any other natural raw material, and its content varies between 0.75% and 3.39%. In addition, 10-HDA is used to determine the product quality index of RJ (Ramadan & Al-Ghamdi, 2012).

RJ fatty acids exist in solid crystal form at room temperature, the melting point of 10-HDA is 52ºC (Barker et al., 1959). 10-HDA is antibacterial (Fratini et al., 2016), anti-inflammatory (Chen et al., 2018), and cell immune activity regulator (Mihajlovic et al., 2013). Apart from 10-HDA, there are short hydroxy fatty acids and dicarboxylic acids with 8-12 carbon atoms, and 10-hydroxy-2-decenoic acid ($10H_2DA$) and sebacic acid (Isidorov et al., 2012).

RJ; It contains bioactive substances that are effective in cell growth, differentiation, survival and show insulin-like activity proven by various *in vivo* and *in vitro* studies (Dixit & Patel, 1964; Kramer et al., 1977). RJ can activate the estrogen receptor (ER) and play an active role in the estrogen signaling pathway (Moutsatsou et al., 2010; Suzuki et al., 2008). Royalactin, one of the proteins in the RJ content, was found to be effective in the differentiation of the queen bee (Kamakura, 2011).

Table-1. Ingredients in royal jelly

Tablo-1. Arı sütü içeriğindeki bileşenler

Fat and fatty acids	10-hydroxy decanoic acid (10-HDA) 10-hydroxy-2-decenoic acid (10-H_2DA) Sebacic acid (SA)
Free amino acids	Alanine, aspartic acid, phenylalanine, glycine, glutamic acid, glutamine, hydroxyproline, isoleucine, lysine, leucine, proline, serine, cysteine, cystine, tyrosine, threonine, valine
Saccharides	Fructose, glucose, sucrose, trehalose, maltose, gentiobiose, isomaltose, raffinose, erlose and hybridose
Proteins	Major royal jelly proteins (MRJP), royalsin
Vitamins	B1, B2, B3, B5, B7, folic acid, inositol and vitamin E
Mineral salts	Salts of iron, zinc, copper, sodium, potassium, calcium, manganese
Polyphenols	Herperetin, isosacuranetin, naringenin, akacetin, apigenin, crisis, luteolin, isorhamnetin, kaempferol, coumestrol, genistein

Investigation of the Effects of Royal Jelly on Obesity

In an eight-week study investigating the effect of RJ (1000 mg/day) on body weight and daily energy and macronutrient intake in fifty women (25 RJ, 25 placeboes) volunteers with type 2 diabetes, the body mass index of the volunteers was calculated before and after the administration. As a result, it has been reported that RJ application reduces average body weight and average daily total energy intake. It can prevent age-related muscle wasting (Ali & Kunugi, 2020) and researchers state that RJ has the potential to be beneficial in the weight management of diabetic patients (Pourmoradian et al., 2012).

Administration of 10 mg/kg RJ for 4 weeks in KK-Ay mice with type 2 diabetes has been shown to improve hyperglycemia. The results of the study; hyperglycemia was improved, insulin resistance did not develop, and glucose 6-phosphatase mRNA expression was suppressed in the liver. Induced expression of adiponectin (AdipoQ) in abdominal fat. Expression of pAMPK, which suppresses glucose 6-phosphatase level, and adiponectin receptor-1 expression were induced in the liver of KK-Ay mice. As a result, the researchers reported that they improved hyperglycemia and partially reduced body weight in obese and diabetic KK-Ay mice. In addition, it has been suggested that activation of AMPK after activation of AdipoQ and AdioR1 expressions in the liver results in suppression of glucose 6-phosphatase expression (Yoshida et al., 2017).

In a study investigating the protective effects of RJ on skeletal muscle and adipose tissue metabolism and inflammation as a result of a high-fat diet in aged obese rats, the researchers concluded that the use of RJ suphybridizemay be protective against muscle lipotoxicity and reduces insulin resistance. In the study, 40 male rats were divided into 5 groups. The first group consisted of young rats and was fed a standard diet (Grup A). The other 4 groups consist of old rats. The first of these 4 groups were fed a standard diet (Grup B). The second group was fed with RJ only (Grup C). The third group was exposed to a high-fat diet (Grup D). Finally, the fourth group was both exposed to a high-fat diet and fed with RJ (Grup E). All diets lasted 8 weeks. From the results of the study, the order of body weight gain is A>D>E>B>C and the order of abdominal fat weight is D>E>B>C>A. The order of increase in tibialis anterior muscle weight and hind limb muscles weight is B>E>D in line with only the statistically significant data reported. Serum triglycerides and total cholesterol levels were higher in the old group of normally fed rats (B>A). Serum triglycerides and total cholesterol levels, which were found to be high with a high-fat diet in old rats, decreased in those receiving RJ supplementation (D>E>C). While the level of muscle triglycerides was higher in the old and high-fat diet group compared to the young group or the group fed with a normal diet, it was found to be lower in the RJ-fed groups (D>E>B>C>A). In the

evaluation of the amount of insulin in the serum, it was highest in the old and high-fat diet group, while it was almost as low in the old fed both high-fat diet and RJ group as in normally fed rats (D>E). TNFR1 (Tumor necrosis factor-alpha receptor 1) expression is found quite high in serum and adipose tissue in rats fed a high-fat diet (D) (respectively 1952.7±106.4; 3385.94±140.61 pg/ml). In young normally fed rats (A), 1558.7±75.01; 2117.41±140.94 pg/ml. In the old group fed with both a high-fat diet and RJ, 1615.12±123.5; 2809.41±132.1pg/ml. As a result, serum and adipose TNFR1 levels were found to be lower as a result of diets in which RJ was added. Therefore, researchers report that feeding with RJ reduced adiposity, decreased TNFR1 expression, improved lipid profile, and insulin resistance. In addition, musculoskeletal functions improved in older rats (Metwally Ibrahim & Kosba, 2018).

RJ has been the subject of research on the prevention of obesity and metabolic disorders because it increases insulin sensitivity. About this, in mouse models investigating the anti-obesity effect of RJ, C57BL/6J mice were exposed to four different feeding conditions for 17 weeks. The first of these is a normal diet, the second is a high-fat diet, the third is a 5% RJ and high-fat diet, and finally the fourth is a 5% honey bee larva powder. The data obtained by the researchers as a result of the study: RJ suppressed the formation of white adipose tissue and hepatic triglyceride accumulation caused by a high-fat diet, and improved hyperglycemia and insulin resistance. In the group with RJ in their diet, thermogenic uncoupling protein 1 (UCP1) and mitochondrial cytochrome c oxidase 4 subunit (COX-4) gene and protein expressions were increased in brown adipose tissue (BAT). It has been demonstrated that the use of RJ and honey bee larva powder does not brown the white adipose tissue. As a result, it has been reported that RJ is promising for combating obesity and metabolic disorders (Yoneshiro et al., 2018).

In the study investigating the antiadipogenic activity of RJ, researchers demonstrated that adipogenic transcription factors and leptin were decreased by 10-HDA, triacylglycerol accumulation, and reactive oxygen species were suppressed in 3 T3-L1 adipocyte cells. 10-HDA, one of the most important compounds of RJ, inhibits the cyclic adenosine monophosphate/ Protein kinase A (cAMP/PKA) pathway and activates insulin-dependent mitogen with phosphorylated Akt (p-Akt). inhibited the protein kinase (MAPK) pathway. This adipogenic activity provides the potential to be a therapeutic drug for obesity (Pandeya et al., 2019).

Table-2 Results table

In a study investigating the lipid profile, satiety, inflammation, and antioxidant capacity of RJ in asymptomatic overweight adults, thirty humans were given lyophilized RJ (330 mg/capsule, two capsules daily before breakfast) supplementation for eight weeks and thirty humans were exposed to placebo. According to the results compared with placebo, RJ supplementation provided a significant decrease in cholesterol and C-reactive protein (CRP) levels. Serum total antioxidant capacity, adiponectin, bilirubin, and uric acid showed a significant increase. As a result, researchers state that RJ has been beneficial in improving human health with its positive effects on the lipid profile, satiety, inflammation, and antioxidant capacity of overweight adults (Petelin et al., 2019).

RJ inhibited oxidative stress in obese and ovariectomized rats with non-alcoholic fatty liver disease. In addition, it was concluded that Per1, Per2 (Period circadian clock 1, 2) modulate the expression of periodic circadian genes and alleviates non-alcoholic fatty liver disease. Nonalcoholic fatty liver disease is common in postmenopausal women. In this study, a non-alcoholic fatty liver disease model was created in ovariectomized rats and 150, 300, and 450 mg/kg RJ was administered intragastrically daily for 8 weeks. After the administration, weekly weight weighing and elevated plus maze (EPM) test were applied, together with the examination of blood, liver, brain, and uterus samples. As a result, researchers report that RJ can ameliorate the negative effects on serum lipid profile caused by estrogen deficiency, lipid accumulation in the liver, lipid peroxidation, and disturbances in circadian gene expression (You et al., 2020).

There is a study in which RJ and tocotrienol-rich fractions were applied in the obesity treatment of 50 obese Wistar rats with calorie restriction. In this study, BAT activation, browning, and thermogenic capacity were investigated. Rats were divided into five groups and exposed to one of the diet types of a high-fat diet, calorie restriction, RJ + calorie restriction, tocotrienol + calorie restriction, RJ + tocotrienol + calorie restriction for 8 weeks.

Tablo-2 Sonuçlar tablosu

Results	References
RJ inhibited oxidative stress It attenuated nonalcoholic fatty liver disease by regulating Per1 and Per2 expression.	You et al., 2020.
RJ plays a regulatory role in metabolism through the irisin protein. RJ and tocotrienol consumption decreased developmental and inflammatory parameters	Irandoost et al., 2020
The daily energy intake to the environment has been reduced. Contributed to the reduction of body weight. It prevents age-related muscle weakening.	Ali & Kunugi, 2020 Pourmoradian et al., 2012
Diets with RJ and RJ and tocotrienol significantly reduced weight gain compared to the calorie-restricted diet alone. UCP1, PRDM16, CREB1, P38MAPK, and BMP8B expressions were increased.	Mesri Alamdari et al., 2020
RJ reduced ER stress. RJ reduced the expression of GRP-78 in the hypothalamus and white adipose tissue compared to calorie restriction, and the expression of inflammatory markers in white adipose tissue.	Irandoost et al., 2020
A significant decrease was observed in cholesterol and CRP levels. A significant increase was observed in adiponectin, bilirubin, uric acid, and total antioxidant capacity in serum.	Petelin et al., 2019
It has been shown that adipogenic transcription factors and leptin are decreased by 10-HDA in 3 T3-L1 cells. 10-HDA suppressed Triacylglycerol accumulation and reactive oxygen species. 10-HDA inhibited the cAMP/PKA pathway. 10-HDA inhibited p-Akt and insulin-dependent MAPK pathway.	Pandeya et al., 2019
It has been reported to be protective against muscle lipotoxicity. Muscle fat is reduced TNFR1 expression decreased It has improved the lipid profile. Improvement was observed in insulin resistance.	Metwally Ibrahim & Kosba, 2018
White adipose tissue formation is reduced. Hepatic triglyceride accumulation is suppressed. UCP1 expression is increased in brown adipose tissue. Mitochondrial COX-4 expression is increased.	Yoneshiro et al., 2018
It showed a positive effect on hyperglycemia. Induced AdipoQ expression in abdominal fat In the liver of KK-Ay mice, pAMPK expression, which suppresses glucose 6-phosphatase level, and adiponectin receptor-1 expression were induced. It has been reported to partially reduce body weight.	Yoshida et al., 2017

Researchers have stated that diets containing RJ and RJ and tocotrienol provide a significant reduction in weight gain compared to a diet with only calorie restriction. As a result of the study, it was observed that the expression of uncoupling protein 1 (UCP1) gene, PR domain genes 16 (PRDM16), cAMP response element-binding protein1 (CREB1), P38 mitogen-activated protein kinases (P38MAPK), and Bone morphogenetic protein8B (BMP8B) increased significantly. In addition, it was stated that no significant changes were observed in CCAAT/enhancer-binding protein beta (CEBPβ) and Bone morphogenetic protein7 (BMP7) gene expressions. When all the results were evaluated, it was reported that RJ supports white adipose tissue thermogenesis and browning. In addition, it has been stated that it can be added to the diet as a new option to reduce obesity (Mesri Alamdari et al., 2020).

Irisin protein in RJ may be effective on obesity-associated inflammation and glucose intolerance. Forty-five male Wistar rats exposed to 40 high-fat diets and 5 normal diets were used in the study. In the high-fat-fed group, the obese model was provided at the end of 17 weeks, followed by exposure to RJ and tocotrienol for eight weeks. In this group, rats were randomly divided into 4 groups. These are the group fed with 100mg/kg RJ, the group fed with 85mg/kg tocotrienol, the group fed with 100mg/kg RJ and 85mg/kg tocotrienol, and the last group is the group that continues only the high-fat diet as a control. As a result of the examinations, the researchers stated that there was no change in body weight in the group fed with RJ and tocotrienol, but developmental and inflammatory parameters decreased. This shows that it can prevent metabolic disorders caused by obesity. Researchers state that RJ and tocotrienol consumption can promote healthy obesity (Irandoost, Mesri Alamdari, Saidpour, Shidfar, Roshanravan, et al., 2020).

Similarly, as a result of investigating the curative effect of RJ with a tocotrienol-rich fraction on inflammation caused by endoplasmic reticulum stress, it is stated that RJ can prevent some obesity-related disorders by reducing endoplasmic reticulum stress. Then, adipose tissues and the hypothalamus were examined for inflammation. RJ has been shown to reduce the expression of glucose-regulated protein-78 (GRP-78) and inflammation markers in white adipose tissue compared to calorie restriction in the hypothalamus and white adipose tissue. Tocotrienol-rich fractions reduced serum inflammatory markers without significant effect on endoplasmic reticulum stress. Researchers state that RJ has protective effects against adipose tissue dysfunction and inflammation, prevents some obesity-related complications, and therefore is promising therapeutically (Irandoost, Mesri Alamdari, Saidpour, Shidfar, Farsi, et al., 2020).

RJ has been successful in dealing with obesity and its various problems. But the sample should be expanded. In addition to these studies, the results should be strengthened with animal and human experiments. Although the mechanisms of success in preventing obesity and various metabolic disorders are tried to be revealed in all aspects, there are many aspects to be clarified (Table-2).

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