Knowledge E
enriching | engaging | empowering

Check for updates

Research Article

Efficacy and Safety of Gum Arabic on Renal Failure Patients: Systematic Review and Meta-analysis

Selma Abdelrahman Hussein[1], Hammad Ali Fadlalmola[2], Suzy Munir Salama[3]*, Eyas Gaffar Osman[4], Abdalbasit Adam Mariod[5]

[1]Industrial and System Engineering, Engineering College, Princess Nourah Bint Abdulrahman
[2]Nursing College, Taibah University, Saudi Arabia
[3]Indigenous Knowledge and Heritage Center, Ghibaish College of Science and Technology, Ghibaish, Sudan
[4]College of Science and Humanities-Shaqra University, Saudi Arabia
[5]College of Sciences and Arts-Alkamil, University of Jeddah, Alkamil, Saudi Arabia
ORCID:
Suzy Munir Salama: https://orcid.org/0000-0003-0430-1436

Corresponding Author: Suzy Munir Salama; email: s.salama999@hotmail.com

Production and Hosting by Knowledge E

Editor-in-Chief:

Prof. Mohammad A. M. Ibnouf

🔓 **OPEN ACCESS**

Abstract

Background: Chronic Renal Failure (CRF) is a long-term disease caused by progressive kidney dysfunction due to many reasons leading to a significant rise in serum levels of creatinine and urea reaching the advanced stage where the patient goes for frequent hemodialysis. This study aims to discuss the evaluation of the efficacy of gum Arabic (GA) supplementation on the serum level of creatinine, urea, sodium, and potassium in CRF patients.

Methods: Four databases PubMed, Web of Science, Scopus, and the Cochrane Library were searched for clinical trials assessment of gum Arabic intervention in CRF patients. Animal trials and experimental protocols were excluded. Screening of data and data extraction were done by two reviewers independently of each other. Meta-analysis was conducted on the selected studies using RevMan and the resulting description was summarized through the Forest plot tool on the efficacy of GA on 4 variables, creatinine, urea, sodium, and potassium in CRF patients.

Results: From 574 studies searched, only 4 studies were included in this systemic review and meta-analysis. Although one of the studies had proved the objectives of the review but it was removed from the meta-analysis due to the heterogeneity caused by its inclusion.

Conclusion: The few studies included in the current review revealed significant efficacy of GA treatment on the serum level of creatinine, urea, and sodium, but not potassium.

Keywords: Gum Arabic, Kidney, clinical

1. Introduction

Gum Arabic (GA) is a natural dietary fiber; it is considered as the best of all soluble fibers and a direct additive to liquid foods [1]]. In addition to its high-soluble dietary fiber content (85-90%, w/w), GA is safe, odorless, tasteless, lowest in viscosity, and stable in acid solutions [2]]. GA has a high-molecular weight and is composed majorly of macromolecules (carbohydrates and protein), minerals, and amino acids; the major carbohydrates in GA are rhamnose, arabinose, galactose, and glucuronic acid [3]. It is rich in amino acids such as hydroxyproline, serine, threonine, proline, leucine, and histidine [4], GA is a valuable source of four antioxidant minerals like copper, iron, manganese, and zinc [5]. Studies demonstrated GA to be a successful prebiotic [6]. GA belongs to the class of nondigestible fibers, as it ferments with bacteria to convert into short-chain fatty acids in the digestive system [7]. The natural characteristics of GA associated with qualitative and quantitative indicators include moisture, ash content, volatile compounds, and inner energy, which exactly represents the world standards [8]. Recent studies have shown the therapeutic action of GA [9]. GA is used to treat many diseases as it improves the performance of the digestive system and improves the appetite [10]. As for patients with kidney failure, it helps them obtain sufficient energy from their food [11].

Chronic kidney failure is often associated with a lack of dietary fiber consumption, excessive utilization of antibiotics, edema of the intestinal wall, and iron intake [12]. Patients with renal disorders suffer from a state of inflammation originating from the gastrointestinal tract; and uremia is associated with a steady increase in the bacteria count in the large intestine and the jejunum, which results in the presence of bacteria in the stool [13].

Many studies have been conducted on the importance of GA for treating kidney diseases and kidney failure, adding GA to drinking water contributes significantly to alleviating kidney problems regardless of its effect on the metabolism of intestinal bacterial ammonia [14-16]. The daily addition of 10-40 g of GA to the diet of ongoing kidney failure patients, substantially decreased the amount of C-reactive protein (CRP) level which could positively affect death of these patients [17]. In addition, 90 g GA/day was able to decrease the hyperglycemia in chronic renal disease [18]. Ali *et al.* hypothesized that addition of GA to patients with hemodialysis would decrease oxidative stress and thus decrease the state of hemodialysis-related chronic inflammatory activation [19]. Al-Mosawi announced that implementation with GA might be an option in contrast to renal substitution treatment to enhance the personal satisfaction and lessen the requirement

for dialysis in kids in some countries [20]. The customary admission of GA notwith-standing a low-protein/high-calorie diet candelay the requirement for hemodialysis or peritoneal dialysis in kids'. Further, the impact of GA oral therapy on the metabolic profile of renal failure (RF) patients was evaluated, they found that oral intake of GA could possibly reduce antagonistic impacts of CRF [21]. RF which is the outcome of broadly contrasting illnesses of the kidney is an overwhelming clinical, social, and economic issue for patients and their families. Most patients with RF will in the long run arrive at the state of ESRD, become suggestive, and require replacement of their renal capacity [22].

The initial search for literature reviews on the effectiveness of GA on the metabolic profile of chronic kidney patients did not show any previous reviews. This systematic review was carried out to show the utilization of GA in healing and mitigating the side effects of chronic kidney disease and preserving the lives of kidney patients.

2. Materials and Methods

2.1. Study selection

Based on the methodology of search and data extraction conducted previously [23], we searched PubMed, Web of Science, Scopus and the Cochrane Library for data from 1980 to 2020. All the studies before 1980 were omitted from the search, using the keywords "Gum Arabic" or "Sudani Gum" or "Acacia Gum" or "Gum Acacia" or "Acacia" or "Senegal Gum" or "Indian gum" AND "chronic kidney disease" or "CKD" or "chronic renal failure" or "CRF" or "renal insufficiency" or "hemodialysis" or "peritoneal dialysis" or "dialysis". We made some restrictions on RCTs, Human, and English language only studies.

To ascertain the efficacy and safety of the GA for the treatment of patients with renal failure, we included controlled randomized trials examining the impact of GA on patients with renal failure. We excluded trials that used GA in the therapy of patients with renal failure for other purposes such as uric acid, fiber diet duration, controlled feeding, and non-English language publications.

2.2. Data extraction

Each article was independently reviewed and had relevant data extracted by two independent reviewers (SS and EG). Extracted data included information on study

setting, design, randomization, blinding, sample size, and participant characteristics; dose of the GA and comparator, follow-up, and funding. Mean and standard deviation data on serum urea and serum creatinine for end of treatment were extracted as priori end points. The preferred reporting items of systematic review and meta-analysis (PRISMA) flow diagram of the studies screened and selected for the present systematic review is mapped on Figure **1**.
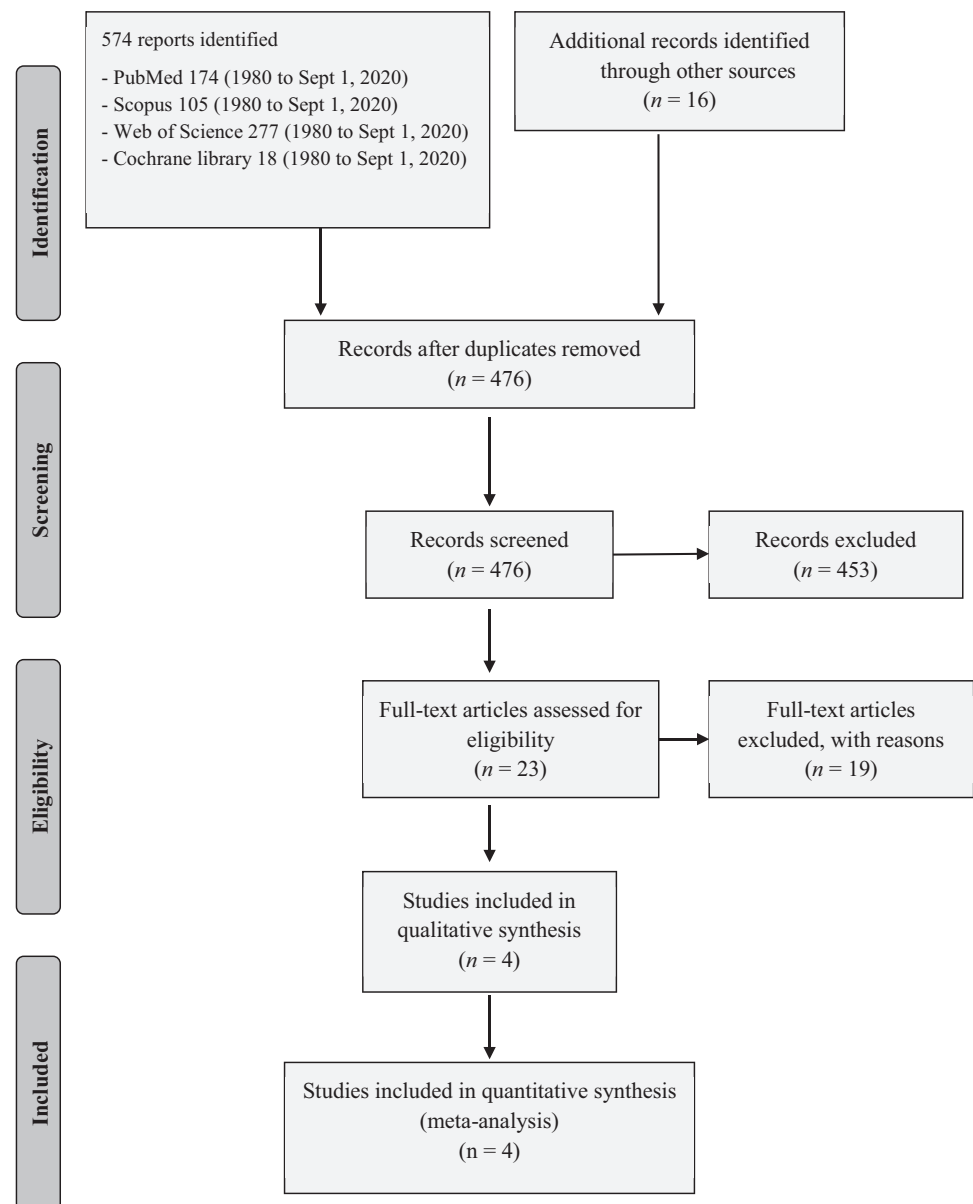

Figure 1: The PRISMA flow diagram of the studies' screened and selected.

2.3. Statistical Analysis

Data were analyzed using Review Manager (RevMan) version 5.4.1. Data were pooled using the generic inverse variance method with random-effects models and data were expressed as mean differences (MDs) with 95% confidence intervals (CIs). Inter-study heterogeneity was assessed by the Cochran Q statistic ($\chi2$), with the significance at P value = 0.10 and quantified by the I^2 statistic, where a value of $\geqslant$ 50% indicates substantial heterogeneity. Potential sources of methodological heterogeneity were investigated by sensitivity analysis in which each individual trial was removed systematically and the pooled effect estimates were recalculated. We assessed and interpreted heterogeneity according to the recommendations in the Cochrane Handbook of Systematic Reviews and Meta-analysis [24].

2.4. Creatinine

For creatinine analysis, four studies were used in Figure **3**-A, B, C, and D. The four studies showed high-heterogeneity test, as evidenced by the P value > 0.1 of I^2 = 99%, and the total effect of the pooled effect estimated a probability value of 0.08. This effect was significant at a confidence interval of 90% but not effective at the level of 95%. To reduce the effect of the heterogeneity, we conducted a sensitivity analysis and used the leave-one-out method. The study of Farman *et al*., 2020, deviated the most from the rest of the studies based on the forest funnel plot, so it was removed and the pooled effect estimates were recalculated; the new results are shown in Figures 3-C and D. The decrease in the level of heterogeneity (I^2) was recorded as 21% in the three studies, Ali *et al*., 2008, Bliss *et al*., 1996, and Elamin *et al*., 2017, and the hypothesis of homogeneity of the studies with a P value = 0.28 was accepted. The analysis of the pooled effect of GA on the decrease in creatinine despite the presence of the diamond shape left of the null line showed obvious, non-significant results (P value = 0.58). The funnel plot estimated that the three studies 1996, 2008, and 2017 were all within the confidence level, while the study of Elamin *et al*., 2017 recorded 41% higher weighted value compared to the other two studies.

2.5. Urea

The Forest plot of the studies included in the analysis of the efficacy of GA intervention on the serum level of urea is displayed in Figures 4-E, F, G, H, I, and J. Because the P

value was 0.05 and the level of heterogeneity was high (I2 = 97%), the four studies Ali *et al.*, 2008; Bliss *et al.*, 1996; Elamin *et al.*, 2017; and Farman *et al.*, 2020 revealed a significant effect on the decrease of urea by GA intervention. By using the leave-one-out method and omitting the study of Farman *et al.*, 2020, the heterogeneity decreased to I^2 = 72%, but the heterogeneity remained present (*P* value = 0.03). Results illustrated in Figure **4**-G showed that the diamond shape is located on the left side of the null line, but without significant effect on the decrease of urea due to the doses of GA used during intervention periods. Additionally, when the study of Ali *et al.*, 2008 was removed, the homogeneity occurred leading to the disappearance of variance, where the *P* value recorded was 0.14 and the overall effect of GA on the high level of urea was not significant (*P* value = 0.23).

2.6. Sodium

Analysis of sodium was done based on three studies, Elkarib *et al.*, 2016, Elamin *et al.*, 2017, and Farman *et al.*, 2020 using Forest Plot (Figures 5-K, L, M, and N). Analysis suggested that no overall significant decrease was recorded in serum level of sodium during GA intervention. Also, there was a high heterogeneity in the three studies analyzed. Therefore, the study of Farman *et al.*, 2020 was removed resulting in reduction in the heterogeneity produced (*P* value = 0.16) despite the appearance of significant decrease in the blood sodium level during GA supplementation (*P* value = 0.001). The studies analyzed revealed clinically significant reduction rate of 2.21 m/mol in 95% confidence intervals of mean difference UCI = 3.54 and LCI = 0.87 m/mol as illustrated in Figure **5**-M.

2.7. Potassium

Analysis for potassium was based on three studies, as shown in Figures 6-O, P, Q, and R. All the studies included gave high heterogeneity and not significant increase in the serum level of potassium in the treated patients (Figure **5**-Q), even after the removal of the study of Farman *et al.*, 2020 that recorded decrease in potassium during intervention period. It is true that the studies of Elkarib *et al.*, 2016 and Elamin *et al.,* 2017 showed increase in the potassium level as the diamond shape moved to the right side of the null line, but this increase was still not significant (*P* value = 0.23).
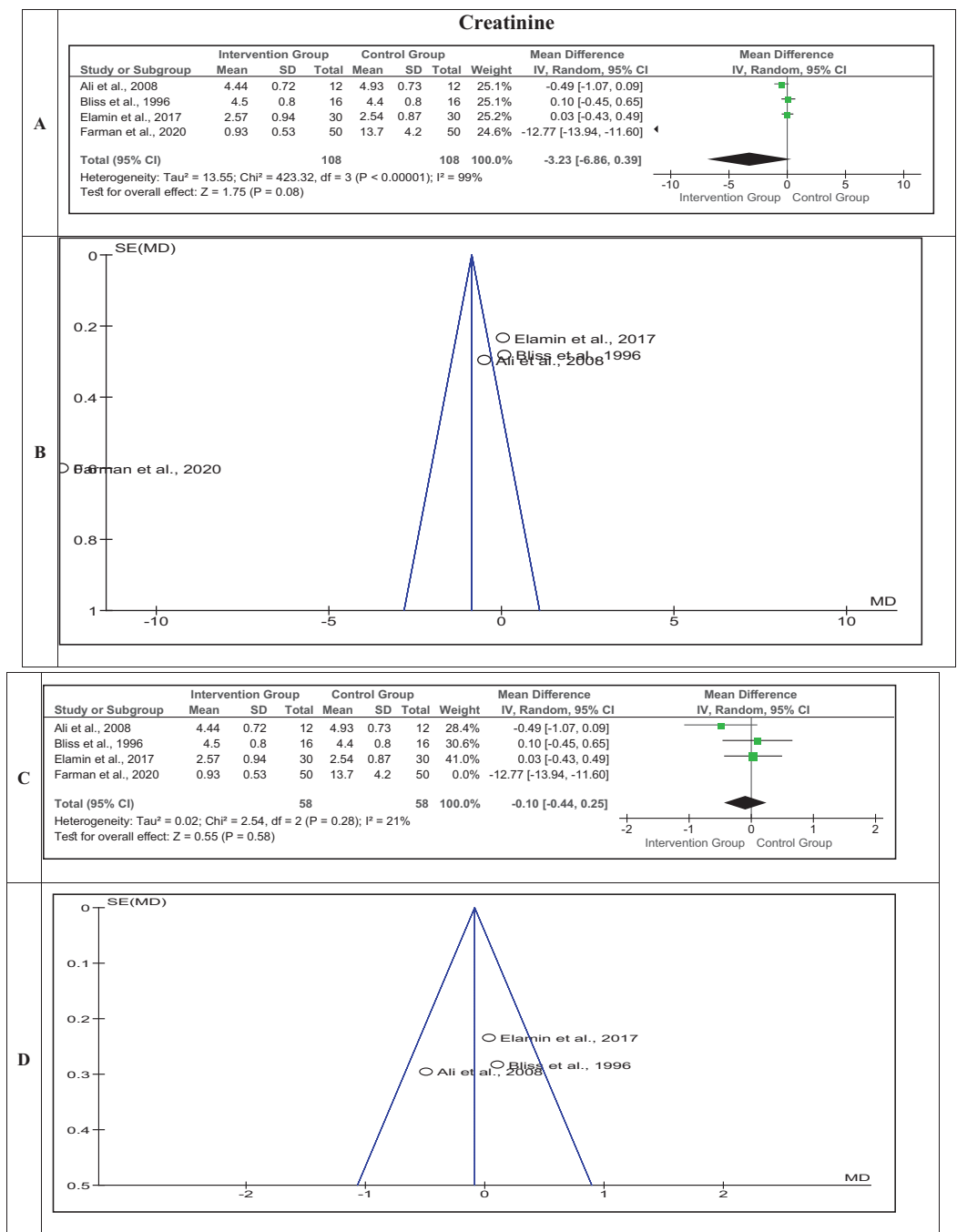
Figure 2: Forest Plot in the meta-analysis of the studies included in the efficacy of GA intervention on serum level of creatinine.

3. Discussion

Chronic renal disease (CRF) is a long-term disease that appears as gradual decrease in the renal function progressing to end-stage renal failure. The leading reasons of the disease can be referred to many factors including glomerular and tubular diseases, renal stones, and nephrotic disorders [4]. One of the important demands that has been
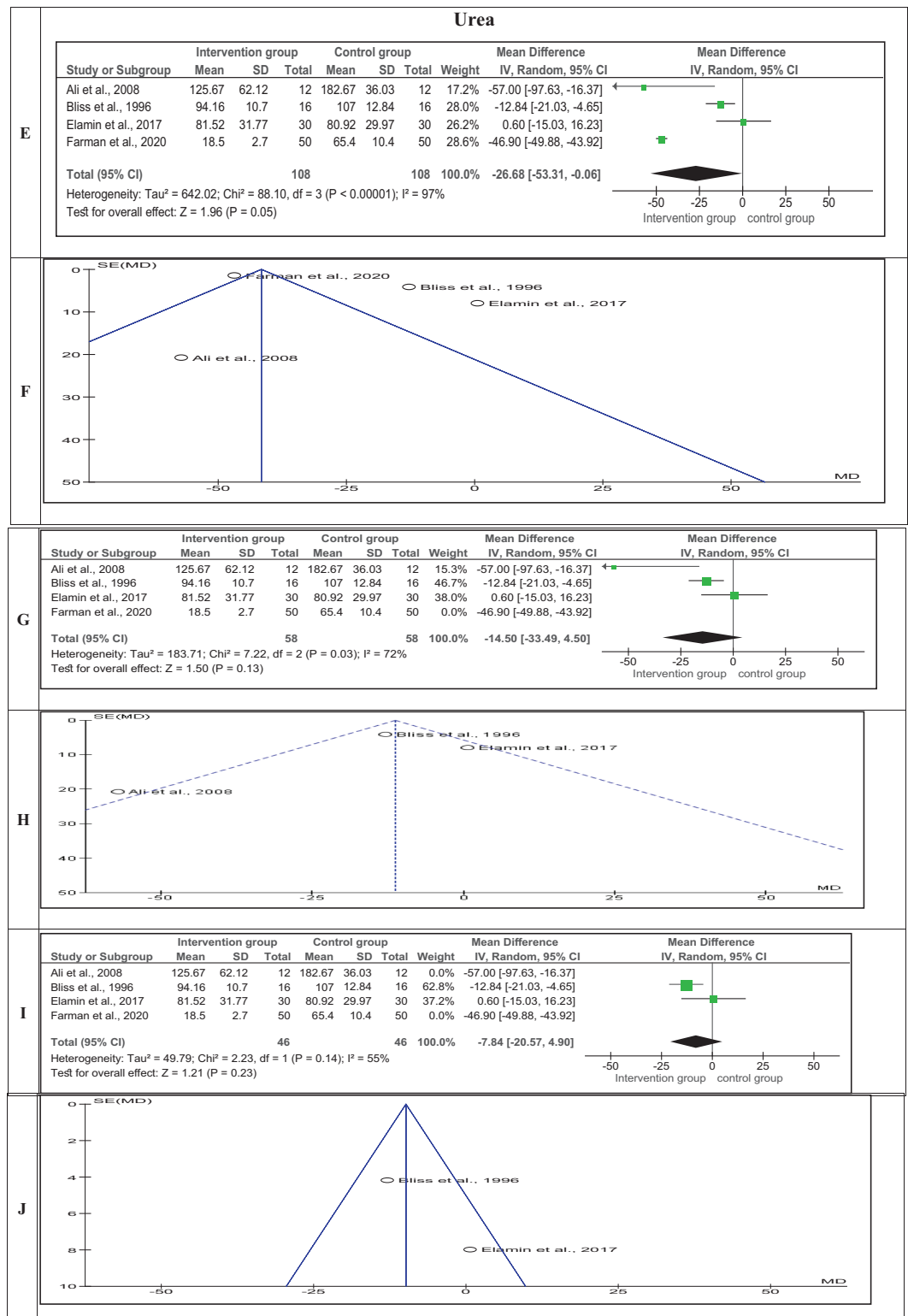
Figure 3: Forest Plot in the meta-analysis of the studies included in the efficacy of GA intervention on serum level of urea in CRF disease.

focused by healthcare organizations in both developed and developing countries is chronic renal failure (CRF) disease due to the high incidence of the disease, especially in
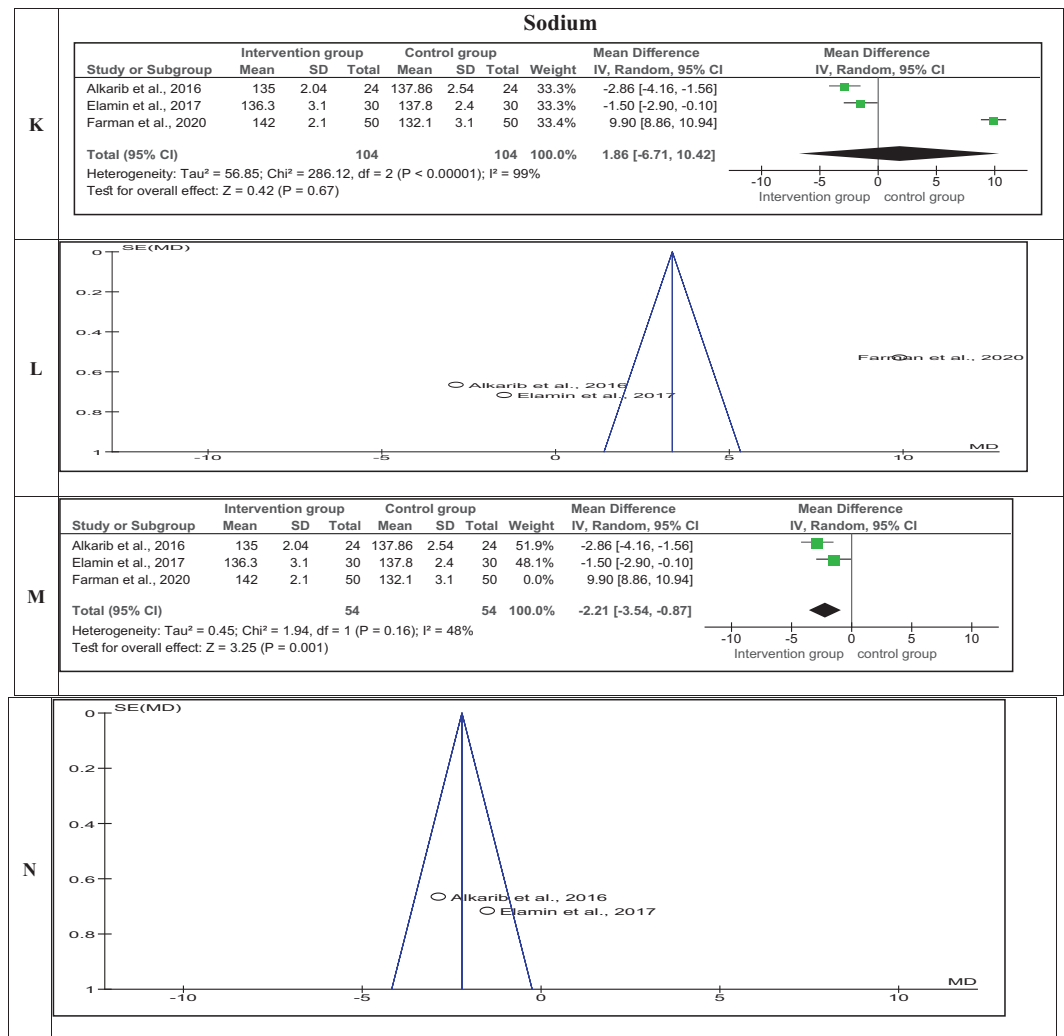
Sodium

		Intervention group			Control group				Mean Difference	Mean Difference
	Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
K	Alkarib et al., 2016	135	2.04	24	137.86	2.54	24	33.3%	-2.86 [-4.16, -1.56]	
	Elamin et al., 2017	136.3	3.1	30	137.8	2.4	30	33.3%	-1.50 [-2.90, -0.10]	
	Farman et al., 2020	142	2.1	50	132.1	3.1	50	33.4%	9.90 [8.86, 10.94]	
	Total (95% CI)			104			104	100.0%	1.86 [-6.71, 10.42]	

Heterogeneity: Tau² = 56.85; Chi² = 286.12, df = 2 (P < 0.00001); I² = 99%
Test for overall effect: Z = 0.42 (P = 0.67)

Intervention group   control group

L

		Intervention group			Control group				Mean Difference	Mean Difference
	Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
M	Alkarib et al., 2016	135	2.04	24	137.86	2.54	24	51.9%	-2.86 [-4.16, -1.56]	
	Elamin et al., 2017	136.3	3.1	30	137.8	2.4	30	48.1%	-1.50 [-2.90, -0.10]	
	Farman et al., 2020	142	2.1	50	132.1	3.1	50	0.0%	9.90 [8.86, 10.94]	
	Total (95% CI)			54			54	100.0%	-2.21 [-3.54, -0.87]	

Heterogeneity: Tau² = 0.45; Chi² = 1.94, df = 1 (P = 0.16); I² = 48%
Test for overall effect: Z = 3.25 (P = 0.001)

Intervention group   control group

N

Figure 4: Forest Plot in the meta-analysis of the studies included in the efficacy of GA intervention on serum level of Sodium in CRF disease.

some developing countries. Earlier studies on the incidence of CRF prevalence in Sudan had recorded a yearly average increase in CRF patients of about 100 cases per million population, most of them were below the age of 40 [25]. Studies attributed the reasons of incident CRF cases in Sudan to stone diseases, hypertension, and diabetes mellitus [26]. Lameire *et al*., 2005 reported that new patients treated with renal replacement therapy in 25 countries of the European Union due to end-stage renal failure was estimated to be 36,000 per year according to the report issued by the European Renal Association/European Dialysis and Transplant Association Registry 2001 [27].

3.1. Effect of GA on serum creatinine and urea

Recent studies exposed the positive effects of low-protein diet (LPD) and prebiotic activity of nutrients in managing the renal function of CRF patients [28]. In chronic renal
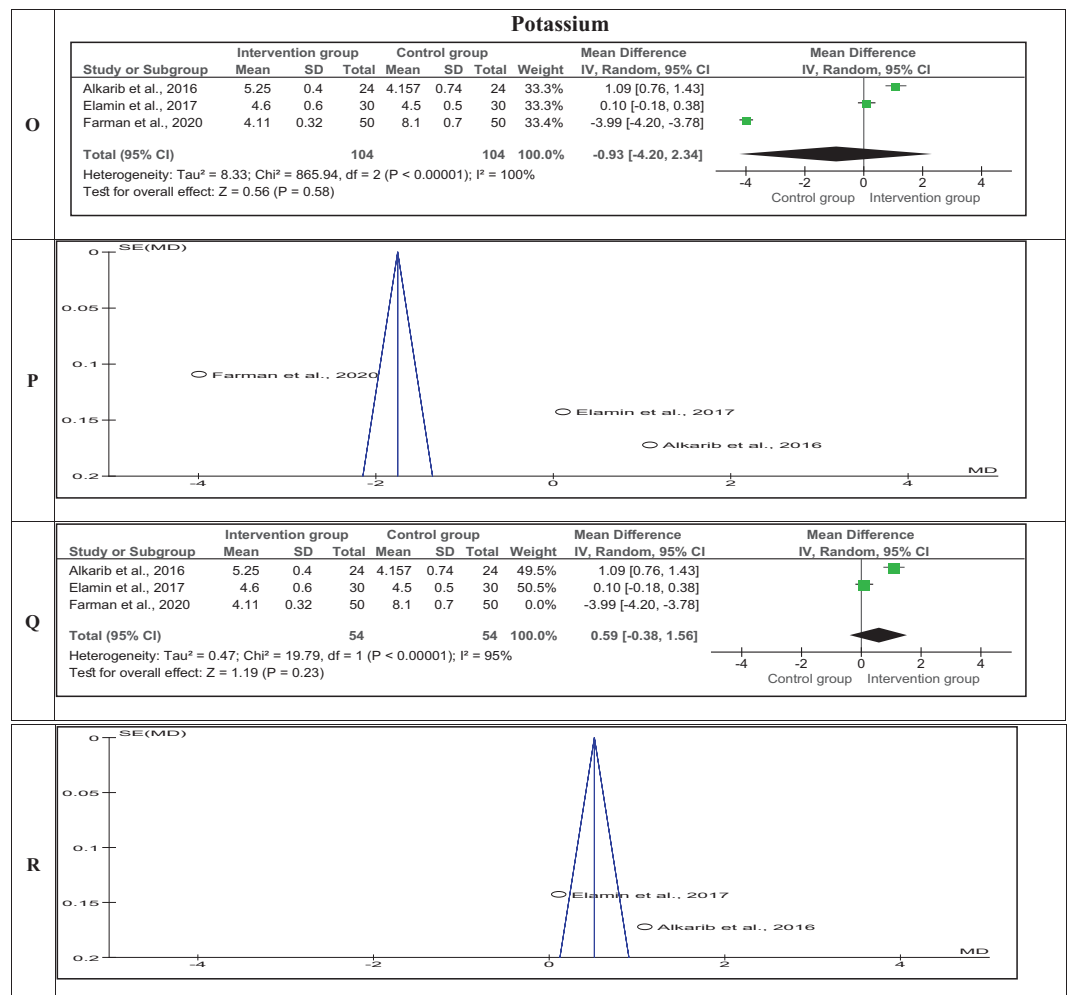
Figure 5: Forest Plot in the meta-analysis of the studies included in the efficacy of GA intervention on serum level of Potassium in CRF disease.

disease patients, the advantageous intestinal bacteria, that produces the important short-chain fatty acids, are damaged leading to increase in the toxic bacteria that generate uremic toxic substances [29]. Additionally, studies showed that the prebiotic ingredients in food supplements play crucial role in removing uremic toxins from blood *via* growth and stimulation of beneficial intestinal bacteria [30]. World Health Organization and Food and Drug Administration have approved the prebiotic activity of GA (Obaid, 2020). In the current systematic review and meta-analysis, the study of Bliss *et al.*, 1996 suggested insignificant effect in the serum level of creatinine together with significant reduction in the serum level of urea in the CRF patients examined during the one-month intervention period of 50 g GA. The study attributed the decrease of blood urea in the intervention period to the low-protein diet and high-fiber content of GA that enhanced nitrogen excretion in the stool. Additionally, the fermentation of colon bacteria to the dietary fibers of GA and their increased utilization of the resulting nitrogen with growth had decreased urea during intervention compared to baseline.

On the other hand, the non-significant effect of GA intervention to creatinine level was due to the short period of intervention [31]. Ali and his colleagues, 2008 reported that supplementation of CRF patients with 50 g GA for 3 months intervention had significantly decreased the serum levels of creatinine and urea. The study explained the decrease of intervention creatinine due to the high activity of colonic bacteria that utilized nitrogen from the nitrogenous human wastes. In addition, the decrease of blood urea was referred to the fiber content of GA that enhanced nitrogen excretion in the stool and decreased nitrogen content of blood urea [21]. Elamin *et al.*, 2017 reported the non-significant effect of the dose tested (10 g) for GA on the serum creatinine and urea of all CRF patients in the trial study due to the short period of intervention (1 month), lack of low-protein diet (LPD) taken, and the advanced stage of renal insufficiency/dialysis dependency of patients subjected to the study [17]. The study of Farman *et al.*, 2020 showed significant decline in the serum levels of creatinine and urea due to the long period of intervention dose (30 g of GA/6 months) as well as the prebiotic activity of GA [5]. Although the study of Farman *et al.*, 2020 suggested clear evidence for the efficacy of long-term intervention (6 months) of GA on the high-blood level of creatinine and urea in CRF patients, but the study was removed from the meta-analysis of creatinine because of the heterogeneity caused with the inclusion of the study (I2 = 99%, *P* value = 0.08). Additionally, studies of Ali *et al.*, 2008 and Farman *et al.*, 2020 were removed to reverse the heterogeneity caused with their inclusion on the meta-analysis of urea (I2 = 97%, *P* value = 0.05) reaching homogeneity (I2 = 55%, *P* value = 0.14). The factors affecting the efficacy of GA supplementation on serum creatinine and urea in CRF patients are illustrated in Figure **6**.
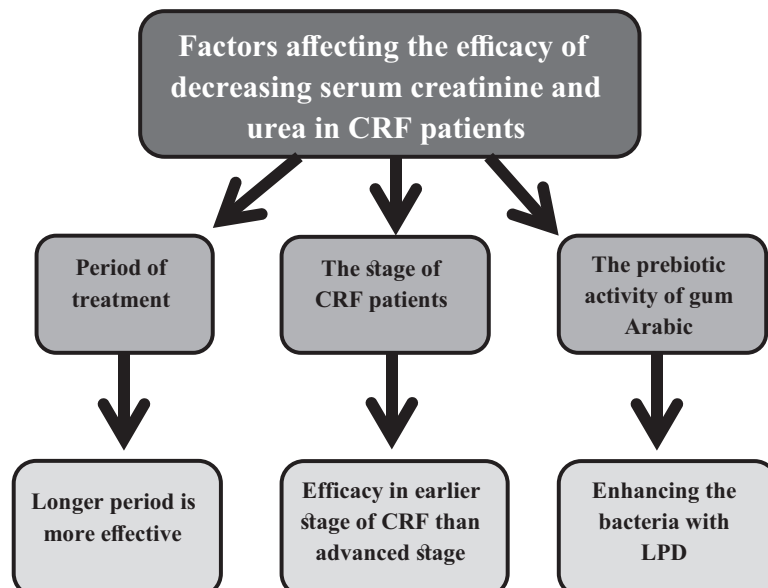

Figure 6: Factors affecting the role of GA supplementation on patients with chronic renal failure (CRF).

3.2. Effect of GA on serum sodium and potassium

Researches on the effect of GA supplementation has reported that the addition of GA to the diet decreased the serum level of sodium and potassium in experimentally-induced chronic renal failure [32]. Another study published that treatment experimental animals with GA did not show significant effect on the plasma level of sodium and potassium in Gentamycin-induced renal damage [33]. Alkarib *et al.*, 2016 showed that gradual increase of intervention dose of GA (10 g – 25 g) for 4 months had significantly lowered the serum level of sodium and elevated the level of potassium in the CRF patients subjected to the trial study [34]. Elamin *et al.*, 2017 reported that supplementation of CRF patients with 10 g of GA for one month showed a significant decrease in the blood level of sodium without affecting the blood level of potassium [17]. Farman *et al.*, 2020 exposed that the intake of 30 g of GA on daily basis for 6 months caused significant increase in sodium and decrease in potassium level of blood in CRF patients. The study referred these reversed effects of GA on the blood level of sodium and potassium due to the high-calcium content of GA that stimulated the calcium receptor leading to inhibition of the sodium and potassium co-transport in the thick ascending limb [5, 35]. Accordingly, the meta-analysis study excluded the study of Farman *et al.*, to reduce the heterogeneity caused from I^2 = 99% to 48%, *P* value = 0.16. Regarding the high heterogeneity appeared (100%) in the meta-analysis of potassium with the inclusion of the three studies, the exclusion of the study of Farman *et al.*, 2020, did not reduce the heterogeneity that remained very high (99%) indicating overall non-significant efficacy of gum Arabic intervention on the serum level of potassium in CRF patients.

4. Limitations

The present systematic review and meta-analysis showed significant heterogeneity in the analysis performed due to the few clinical studies conducted on the efficacy of GA in chronic renal failure. More clinical case studies are required to be conducted on this topic to resolve the heterogeneity of the study and confirm the results analyzed. Also, complicated scientific terms were avoided in English language writing of the current study to be easy for all readers to understand the analysis performed.

5. Conclusion

The efficacy of GA supplementation on the serum creatinine, urea, sodium, and potassium of chronic renal failure (CRF) patients depends on the period of treatment where a longer period of treatment is applied, the more significant reduction was obtained on serum urea and creatinine but not on sodium and potassium. In addition, the CRF stage of the patient plays a role in the efficacy of intervention where the efficacy of GA treatment in early stage is more significant than the advanced stage. Moreover, the intake of LPD shows obvious enhancement to the prebiotic activity of colon bacteria and subsequently significant reduction in the blood level of creatinine and urea. However, based on the studies collected and used in the present systematic review and meta-analysis, it can be confirmed that GA is effective in the early stages of renal failure more than late stages. More clinical trials are required to confirm the factors mentioned.

Acknowledgements

Ethical Considerations

None.

Competing Interests

Authors declare no conflict of interest.

Availability of Data and Material

Data is available with corresponding author upon request.

Funding

References

[1] Satti, N. M. E., AFA, M., Bawadekji, A., & Eltahir, S. H. (2020). Gum Arabic (Acacia Gum): A review. *Journal of the North for Basic and Applied Sciences, 5*(1), 15–29.

[2] Dashtdar, M., & Kardi, K. (2018). Benefits of gum arabic, for a solitary kidney under adverse conditions: A case study. *Chinese Medicine and Culture, 1*(2), 88–96. https://doi.org/10.4103/CMAC.CMAC_22_18

[3] Ma, J., Xu, C., Yu, H., Feng, Z., Yu, W., Gu, L., Liu, Z., Chen, L., Jiang, Z., & Hou, J. (2020). Electro-encapsulation of probiotics in gum arabic-pullulan blend nanofibres using electrospinning technology. *Food Hydrocolloids*. Advance online publication. https://doi.org/10.1016/j.foodhyd.2020.106381

[4] Babiker, M., Abbas, T., & Mohammed, M. (2017). Effect of gum arabic on liver function and antioxidant enzymes of sprague-dawley rats. *IOSR Journal of Pharmacy and Biological Sciences, 12*(2), 29–33. https://doi.org/10.9790/3008-1202032933

[5] Farman, M. S., Salman, M. I., & Hamad, H. S. (2020). Effect of gum arabic administration on some physiological and biochemical parameters in chronic renal failure patients. *Systematic Reviews in Pharmacy, 11*(6), 697–701.

[6] Elgazouly, H. M. M., Idris, Y. M. A., & Baraka, B. M. K. (2018). Prebiotication with gum arabic on growth of *Bifidobacterium longum* BB536 during fermentation of peanut milk. *Journal of Agricultural and Veterinary Sciences, 19*(2), 12–24.

[7] Kishimoto, A., Ushida, K., Phillips, G. O., Ogasawara, T., & Sasaki, Y. (2006). Identification of intestinal bacteria responsible for fermentation of gum arabic in pig model. *Current Microbiology, 53*(3), 173–177. https://doi.org/10.1007/s00284-005-0219-3

[8] Lelon, J., Jumba, I., Keter, J., Chemuku, W., & Oduor, F. (2010). Assessment of physical properties of gum arabic from *Acacia Senegal* varieties in Baringo District, Kenya. *African Journal of Plant Science, 4*(4), 95–98.

[9] Ibrahim, N. M., Ali, A. M., Khogali, N., & Bashir, H. S. (2017). Effect of gum arabic as dietary supplement for type II diabetes in Jabir Abu Aliz diabetic center-(Khartoum State). *Global Journal of Health Science, 9*(7), 168–176. https://doi.org/10.5539/gjhs.v9n7p168

[10] Bussmann, R. W., Paniagua-Zambrana, N. Y., Njoroge, G. N. (2020) *Acacia drepanolobium* Harmes ex Sjostedt *Acacia nilotica* (L.) Willd. ex Delile *Acacia senegal* (L.) Willd. *Acacia seyal* Delille *Acacia tortilis* (Forssk.) Hayne Fabaceae. Ethnobotany of the Mountain Regions of Africa. doi.org/https://doi.org/10.1007/978-3-319-77086-4_4-1

[11] Hammad, Z. M., & Mohammed, M. H. (2018). *Management practices of gum arabic–producing trees*. Gum Arabic: Elsevier.

[12] Al Khodor, S., & Shatat, I. F. (2017). Gut microbiome and kidney disease: A bidirectional relationship. *Pediatric Nephrology (Berlin, Germany), 32*(6), 921–931. https://doi.org/10.1007/s00467-016-3392-7

[13] Vaziri, N. D., Wong, J., Pahl, M., Piceno, Y. M., Yuan, J., DeSantis, T. Z., Ni, Z., Nguyen, T. H., & Andersen, G. L. (2013). Chronic kidney disease alters intestinal microbial flora. *Kidney International, 83*(2), 308–315. https://doi.org/10.1038/ki.2012.345

[14] Ali, B. H., Al Za'abi, M., Al Suleimani, Y., Manoj, P., Ali, H., Ribeiro, D. A., & Nemmar, A. (2020). Gum arabic reduces inflammation, oxidative, and nitrosative stress in the gastrointestinal tract of mice with chronic kidney disease. *Naunyn-Schmiedeberg's Archives of Pharmacology, 393*, 1427–1436. https://doi.org/10.1007/s00210-020-01844-y

[15] Mariod, A. A. (2018). *Gum arabic: Structure, properties, application and economics*. Academic Press.

[16] Rose, S. D., & Strombom, A. J. (2019). A plant-based diet prevents and treats chronic kidney disease. *Urology Nephrology, 6*(3), 1–28. https://doi.org/10.19080/JOJUN.2018.06.555687

[17] Elamin, S., Alkhawaja, M. J., Bukhamsin, A. Y., Idris, M. A., Abdelrahman, M. M., Abu-taleb, N. K., Housawi, A. A. (2017). Gum arabic reduces C-reactive protein in chronic kidney disease patients without affecting urea or indoxyl sulfate levels. *International Journal of Nephrology, 2017*, 6. doi.org/https://doi.org/10.1155/2017/9501470.

[18] De Rechter, S., Levtchenko, E., Evenepoel, P., & Mekahli, D. (2016). The case hypercalcemia in a child with chronic kidney disease. *Kidney International, 90*(1), 233–234. https://doi.org/10.1016/j.kint.2015.12.060

[19] Ali, N. E., Kaddam, L. A., Alkarib, S. Y., Kaballo, B. G., Khalid, S. A., Higawee, A., AbdElhabib, A., AlaaAldeen, A., Phillips, A. O., & Saeed, A. M. (2020). Gum arabic (*Acacia Senegal*) augmented total antioxidant capacity and reduced C-reactive protein among haemodialysis patients in phase II trial. *International Journal of Nephrology, 2020*, 7214673. https://doi.org/10.1155/2020/7214673

[20] Al-Mosawi, A. J. (2004). Acacia gum supplementation of a low-protein diet in children with end-stage renal disease. *Pediatric Nephrology (Berlin, Germany), 19*(10), 1156–1159. https://doi.org/10.1007/s00467-004-1562-5

[21] Ali, A. A., Ali, K. E., Fadlalla, A. E., & Khalid, K. E. (2008). The effects of gum arabic oral treatment on the metabolic profile of chronic renal failure patients under

regular haemodialysis in Central Sudan. *Natural Product Research, 22*(1), 12–21. https://doi.org/10.1080/14786410500463544

[22] Al Mosawi, A. J. (2009). Six-year dialysis freedom in end-stage renal disease. *Clinical and Experimental Nephrology, 13*(5), 494–500. https://doi.org/10.1007/s10157-009-0181-7

[23] Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., Stewart, L. A., & the PRISMA-P Group. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Systematic Reviews, 4*(1), 1–9. https://doi.org/10.1186/2046-4053-4-1

[24] Higgins, J. P., Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M. J., Welch, V., & Flemyng, E. (2019). *Cochrane handbook for systematic reviews of interventions*. John Wiley & Sons. https://doi.org/10.1002/9781119536604

[25] Suliman, S. M., Beliela, M. H., & Hamza, H. (1995). Dialysis and transplantation in Sudan. *Saudi Journal of Kidney Diseases and Transplantation, 6*(3), 312–314.

[26] Elnour, K. S., Mahgoub, A., Bahroun, S., & Elazomi, A. (2019). Evaluation of serum α-amylase activity in Sudanese patients with chronic renal failure. *Libyan Journal of Medical Research, 13*(1), 1–7.

[27] Lameire, N., Jager, K., Van Biesen, W., de Bacquer, D., & Vanholder, R. (2005). Chronic kidney disease: A European perspective. *Kidney International. Supplement, 68*, S30–S38. https://doi.org/10.1111/j.1523-1755.2005.09907.x

[28] Ondrussek-Sekac, M., Navas-Carrillo, D., & Orenes-Piñero, E. (2020). Intestinal microbiota alterations in chronic kidney disease and the influence of dietary components. *Critical Reviews in Food Science and Nutrition*. Advance online publication. https://doi.org/10.1080/10408398.2020.1761771

[29] Lau, W. L., Savoj, J., Nakata, M. B., & Vaziri, N. D. (2018). Altered microbiome in chronic kidney disease: Systemic effects of gut-derived uremic toxins. *Clinical Science (London, England), 132*(5), 509–522. https://doi.org/10.1042/CS20171107

[30] Gibson, G. R., Hutkins, R., Sanders, M. E., Prescott, S. L., Reimer, R. A., Salminen, S. J., Scott, K., Stanton, C., Swanson, K. S., Cani, P. D., Verbeke, K., & Reid, G. (2017). Expert consensus document: The International Scientific Association for Probiotics and Prebiotics (ISAPP) consensus statement on the definition and scope of prebiotics. *Nature Reviews. Gastroenterology & Hepatology, 14*(8), 491–502. https://doi.org/10.1038/nrgastro.2017.75

[31] Bliss, D. Z., Stein, T. P., Schleifer, C. R., & Settle, R. G. (1996). Supplementation with gum arabic fiber increases fecal nitrogen excretion and lowers serum urea nitrogen concentration in chronic renal failure patients consuming a

low-protein diet. *The American Journal of Clinical Nutrition, 63*(3), 392–398. https://doi.org/10.1093/ajcn/63.3.392

[32] Alla, F., & Sadeek, E. A. (2018). Effect of Arabic gum as prebiotics and lactobacillus casei Shirota (LcS) as probiotic on oxidative stress and renal function in adenine–induced chronic renal failure in rats. *European Journal of Nutrition & Food Safety, 8*(1), 29–46. https://doi.org/10.9734/EJNFS/2018/36022

[33] Tahir, E. E., Shaddad, S. A., Muddathir, A., & Agabna, N. M. (2016). Nephro-protective effect of *Acacia senegal* against genatmaycin-induced renal damage in rats. *World Journal of Pharmaceutical Research, 5*(5), 294–303.

[34] Alkarib, S. Y., Saeed, A. M., Khalid, S. A., Groun, E. A., & Ghalib, M. B. (2016). Gum Arabic role in high blood pressure among patients with stage III chronic kidney disease. *Journal of Pharmacological and Clinical Research, 1*(4), 1–6. https://doi.org/10.19080/JPCR.2016.01.555569

[35] Jung, J., Foroud, T. M., Eckert, G. J., Flury-Wetherill, L., Edenberg, H. J., Xuei, X., Zaidi, S. A., & Pratt, J. H. (2009). Association of the calcium-sensing receptor gene with blood pressure and urinary calcium in African-Americans. *The Journal of Clinical Endocrinology and Metabolism, 94*(3), 1042–1048. https://doi.org/10.1210/jc.2008-1861