Potassium

Common Acronyms

CNS	Chinese Nutrition Society
CRN	Council for Responsible Nutrition
DRI	dietary reference intake
EC SCF	European Commission Scientific Committee on Food
EFSA	European Food Safety Authority
EVM	Expert Group on Vitamins and Minerals
HOI	highest observed intake level
ICMR-NIN	Indian Council of Medical Research - National Institute of Nutrition
IOM	Institute of Medicine
IU	international unit
JECFA	Joint FAO/WHO Expert Committee on Food Additives
KNS	Korean Nutrition Society
LOEL	lowest observed effect level
NDA	EFSA Panel on Nutrition, Novel Foods and Food Allergens
NIH	National Institute of Health
NOEL	no observed effect level
RCT	randomized clinical trial
SUL	safe upper level
UF	uncertainty factor
UL	tolerable upper intake level

Introduction

Potassium is an essential mineral in the human diet that is required for several physiological processes in the body including: osmolar regulations, distribution of fluids inside and outside cells, acid-base balance regulation, establishing membrane potential in nerve fibers and muscle and cell metabolism, energy transduction, hormone secretion, and protein and glycogen synthesis regulation (EFSA 2016; NIH 2021). Potassium is widely available in foods including fruits, whole grains, starchy root vegetables, dairy products, and coffee (EFSA 2016; NIH 2021). Potassium is also found in multivitamins or supplements in many different forms, such as

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potassium chloride, potassium citrate, potassium phosphate, potassium bicarbonate, and potassium gluconate (NIH 2021).

Supplemental potassium is readily available in standard, immediate-release form. Extended-release forms have also been developed, which are intended to mitigate potential gastrointestinal side effects associated with intake (see *Safety Considerations*). This chapter focuses on deriving a supplemental UL for immediate-release potassium in adults. Studies conducted with extended-release forms were also reviewed; however, data were insufficient at this time to derive an UL for supplementation with these forms.

Bioavailability

Approximately 90% of dietary potassium is absorbed in the small intestine and is regulated between dietary intake and renal excretion. Once absorbed, potassium is primarily distributed to the muscle, but is also found in bone, liver, skin, and red blood cells (EFSA 2016; NIH 2021). The primary route of potassium excretion is in urine, while a small amount is eliminated in the feces and to a lesser extent in sweat (EFSA 2016; NIH 2021).

Safety Considerations

The 3rd edition of this chapter summarized two older trials that reported no adverse effects following potassium supplementation (Siani et al. 1991; Fotherby and Potter 1992). Siani et al. (1991) found no adverse effects of potassium chloride at daily doses of 1,900 mg, while Fotherby and Potter (1992) found no adverse effects at 2,340 mg per day. The updated literature search for this chapter identified 58 human intervention studies published since CRN's 3rd edition based on title and abstract screening.[1] Upon full-text review, only eleven[2] studies were identified with immediate-release potassium that met the inclusion criteria for the current update; doses ranged from 1,173 to 4,329 mg per day and are discussed within the relevant sections below. No serious adverse effects of any type were reported across these eleven studies, with the exception of a non-statistically significant increase in incidence of hyperkalemia in one

[1] Literature search conducted September 2025.
[2] Reported in twelve total publications. Two studies in sensitive populations for potassium (chronic kidney disease or kidney stone patients) that otherwise met the inclusion criteria were excluded (Gritter et al. 2018, 2022; Solak et al. 2021).

study (see *Hyperkalemia*). In addition, gastrointestinal side effects considered to be a *nuisance* by CRN are also discussed to provide recommendations on maximum individual dose levels (see *Gastrointestinal Effects*). No side effects were reported in five studies following immediate-release potassium supplementation with doses ranging from 2,280 to 3,519 mg per day that are not discussed further in this chapter (Banarjee et al. 2023; Frings-Meuthen et al. 2018; Conen et al. 2016; Gijsbers et al. 2015; Shi et al. 2018).

Most clinical trials report the dose of potassium in mmol or mEq. One milliequivalent (mEq) or one millimole (mmol) corresponds to approximately 39 mg of potassium (Delage 2019). For the purposes of this assessment, all oral doses of potassium reported from studies have been converted to a mg potassium per day dose to ensure consistency in dose reporting and interpretation.

Hyperkalemia

Normal serum potassium levels are between approximately 3.5 and 5.0 mmol per L. Potassium deficiency (i.e., hypokalemia) can occur and is identified as serum potassium concentrations below approximately 3.5 mmol per L (NIH 2021). Hypokalemia is more likely to be brought on by impaired renal function, or increased potassium losses due to diarrhea or vomiting, than by insufficient intake. More severe symptoms of hypokalemia include increased urination, decreased brain function, high blood sugar, muscle paralysis, difficulty breathing, and irregular heartbeats (EFSA 2016; IOM 2004; NIH 2021).

The primary adverse effect associated with excess potassium consumption is hyperkalemia, identified as serum potassium exceeding normal levels, i.e., greater than approximately 5.0 to 5.5 mmol per L (NIH 2021). Potassium is a positively charged electrolyte, as such, very high serum potassium levels (e.g., above 6.0 mmol per L) can result in serious cardiac arrythmias and cardiac arrest (NIH 2021). However, such hyperkalemic states depend heavily on factors such as water consumption and kidney function (Delage 2019; IOM 2004). Hyperkalemia is more likely to result from renal insufficiency (due to decreased kidney function or decreased water intake) or use of certain medications such angiotensin converting enzyme (ACE) inhibitors and some diuretics than from excess consumption (NIH 2021). For the purposes of deriving a

supplemental UL for the general population, individuals with known risk factors related to kidney impairment or those taking drugs that impair potassium excretion (e.g., ACE inhibitors) are excluded from the target population. As noted in the previous edition of this chapter (CRN 3rd edition), the risk of hyperkalemia is small through normal dietary or supplemental intake of potassium in healthy adults.

These considerations are consistent with authoritative review findings from multiple case and controlled studies, which demonstrated that hyperkalemia following potassium supplementation varies (EVM 2003; IOM 2004; EFSA 2005). While the EFSA (2005) reported that long-term supplemental intake of approximately 3,000 mg potassium per day had not been associated with adverse effects, the Panel noted that adverse effects on heart function[3] in "apparently healthy individuals" were identified in a few case studies at doses ranging from of 5,000 – 7,000 mg per day (see *Official Reviews*). The IOM (2004) noted that, in otherwise healthy individuals (that is, individuals without impaired urinary potassium excretion from a medical condition or drug therapy), there have been no reports of hyperkalemia resulting from acute or chronic ingestion of potassium naturally occurring in food.

The occurrence of hyperkalemia, defined as serum potassium above 5 mmol per L, following intervention was assessed in six[4] of the clinical trials identified as part of this chapter update (Dawson-Hughes et al. 2015; Shea et al. 2018; Moseley et al. 2013; Margolis et al. 2017, 2018; Gregory et al. 2015; Granchi et al. 2018). However, while two of these studies administering potassium at levels >3,000 mg per day assessed hyperkalemia by measuring serum potassium concentrations, they did not report the corresponding results (Margolis et al. 2017, 2018). One study in healthy individuals reported hyperkalemia (serum potassium levels not defined) occurred in 1/78, 1/79, and 5/75 individuals after potassium bicarbonate supplementation for three months at doses of 0 (placebo), 2,886, and 4,329 mg potassium per day, respectively (Dawson-Hughes et al. 2015). While incidence in this study appears to have increased with increasing potassium dose, the differences were not statistically significant[5] when compared to

[3] Presumably from hyperkalemia
[4] Reported in seven total publications
[5] As reported by the study author(s), where relevant. For studies in which statistical analysis was not performed, standard statistical analysis was conducted according to the methodology included in CRN's Methodology for 4th Edition Nutrient Chapter Updates.

the control group. The study authors noted that, "There were no safety concerns with the lower dose…The higher dose did cause a few more episodes of hyperkalemia." In another study, 0 (placebo), 2,346, or 3,519 mg potassium per day (as potassium citrate) was given to healthy men and women over the age of 55. One person developed hyperkalemia (defined as 5.0 mmol per L) with a serum potassium level of 5.4 mmol per L and withdrew from the study (Moseley et al. 2013). It is unclear what dose of potassium the individual was taking (i.e., 2,346, or 3,519 mg per day). However, the authors noted that serum potassium did not increase significantly between groups for six months.

In addition to the clinical studies identified, one systematic review and meta-analysis of twenty[6] RCTs (published 1982-2015) on the effects of potassium supplementation reported that potassium intake ranging from 858 to 5,460 mg per day (with an average of 1,755 mg per day) is safe and void of the risk of hyperkalemia or renal deterioration in healthy individuals (Cappuccio et al. 2016). These findings are similar to those of a meta-analysis discussed in the previous edition of this chapter which assessed clinical trials on potassium (mostly potassium chloride) for possible lowering of blood pressure and indicated that this mineral "appeared to be well tolerated in all studies included" (Whelton et al. 1997). The potassium dosages in those clinical trials ranged from 1,876 to 7,820 mg per day. As noted above, one 2015 clinical study reported a non-significant increase in incidence of hyperkalemia. As such, additional data should be monitored as they become available.

Gastrointestinal Effects

The 3rd edition of this chapter discussed the occurrence of gastrointestinal symptoms with excess potassium intake, noting that these effects seem more likely if the daily total is ingested all at once, especially on an empty stomach. In addition, the EFSA (2005) stated that gastrointestinal symptoms have been reported in healthy individuals taking some forms of potassium supplements with doses ranging from 1,000 to 5,000 mg per day. As defined by CRN's methodology, gastrointestinal symptoms are considered by CRN to be a *nuisance* rather than a *true hazard*. As such, CRN's previous UL was not based on this endpoint but included

[6] Only two studies from 2014-2015 were included in the meta-analysis (Graham et al. 2014; Gijsbers et al 2015), both of which are also included in CRN's review.

division of the daily UL into smaller doses to minimize gastrointestinal symptoms.

Of the eleven studies identified in the update for this chapter, five studies provided information related to gastrointestinal symptoms (Dawson-Hughes et al. 2015; Gregory et al. 2015; Granchi et al. 2018; Margolis et al. 2018; Shi et al. 2018). One study reported that the incidence of unspecified gastrointestinal symptoms following potassium supplementation at doses of 782 mg twice per day (1,564 mg per day) was 19.0% versus 9.8% in the placebo group; however, this difference was not statistically significant (p=0.23) (Gregory et al. 2015). While incidence data were not provided, Shi et al. (2018) reported that no participants left their study due to gastrointestinal complaints at a total dose of 2,280 mg per day administered as 760 mg three times per day. In another study, no significant differences in reported effects occurred following a single dose of 1,173 mg per day as potassium citrate (Granchi et al. 2018). Two studies reported that participants were allowed to gradually increase the number of capsules taken daily until the total daily dose was reached to better tolerate any gastrointestinal symptoms (Dawson-Hughes et al. 2015; Margolis et al. 2018). The remaining studies identified did not report information related to or assess gastrointestinal effects.

In one set of older studies, potassium doses of 1,250 mg administered 3 times per day (for a daily total of 3,750 mg) produced only minor and infrequent adverse effects as revealed by endoscopy (McMahon et al. 1982). In a follow-up study, the wax-matrix formulation was administered in dosages ranging from 900 to 3,700 mg per day (McMahon et al. 1984). Endoscopically evident erosions of the upper gastrointestinal tract were evident in a few subjects supplemented with 1,560 to 3,120 mg potassium per day for 21 months. Gastrointestinal symptoms were mild and did not correlate with lesions shown by endoscopic evaluation. While not considered by CRN to be a *nuisance*, these effects were attributed to the specific formulation (i.e., wax matrix) and enteric coating used only in this set of studies. Similar effects have not been reported in other clinical trials or case studies and are therefore not expected to be a concern for formulations currently available to consumers.

Extended-Release Potassium

While not included in this evaluation to derive an UL for immediate-release potassium, three[7] studies conducted with extended-release potassium chloride were identified in the updated literature search that are discussed here for comparison (Drier et al. 2020, 2021; Graham et al. 2014; Chaterjee et al. 2017, 2020). Two studies reported minor adverse gastrointestinal effects (nausea, abdominal pain, flatus, diarrhea, irritation, and/or acid reflux) following supplementation with "slow potassium" (2,496 mg per day) or "Kaleroid" (3,519 mg per day as 1,173 mg three times daily) (Drier et al. 2020, 2021; Graham et al. 2014). In the Drier et al. (2020) study, symptoms were resolved with a reduction in dose to 1,872 mg per day. No gastrointestinal effects were reported in the third study, which administered 1,564 mg per day (782 mg twice daily) (Chaterjee et al. 2017; 2020). These studies also reported a lack of hyperkalemia throughout the duration.

Official Reviews

Expert Group on Vitamins and Minerals (EVM 2003). The United Kingdom (UK)'s EVM 2003 review concluded that the evidence was not sufficient to establish a safe UL but could support a guidance level for potassium. The EVM noted that the available data that reported adverse effects were variable and depended on factors which included formulation (McMahon et al. 1982; McMahon et al. 1984; Grimm et al. 1988, 1990). The EVM concluded that "supplemental doses of up to 3,700 mg potassium per day appear to be without overt adverse effects but may be associated with gastrointestinal lesions diagnosed by endoscopy." No uncertainty factor for inter-human variation was applied since this was based on data from several human studies. Since the effect was reported following ingestion of potassium supplements rather than potassium in food, a guidance level for total potassium intake was not calculated.

IOM (2004) and NASEM (2019). The IOM (2004) reviewed potassium, the other electrolytes,

[7] Reported in five total publications, as cited.

and water to establish new dietary reference intakes (DRIs). At that time, the IOM concluded that there was no evidence of chronic excess intakes of potassium in healthy individuals and thus no UL was established. However, they noted caution is warranted given concerns about adverse effects when consuming excess amounts of potassium from supplements while on drug therapy or in the presence of undiagnosed chronic disease. The DRI for potassium was updated by the National Academies of Sciences, Engineering, and Medicine (NASEM) in 2019 following its review of the available data from RCTs, meta-analyses of RCTs, systematic reviews, and case reports (NASEM 2019). The Committee found that the available clinical trials did not provide a specific "indicator" to serve as the basis of an UL for potassium and noted the lack of variability in doses across supplemental studies. The NASEM concluded that short-term[8] supplemental potassium of approximately 2,500 mg per day "appears to be safe for generally healthy individuals" and adding that this level would "likely be below the UL for individuals without kidney disease, diabetes, heart failure, adrenal insufficiency, or individuals using ACE-Is, ARBs, or other medications that may raise blood potassium concentrations to levels that could lead to adverse effects." The Committee stated that "very high levels"[9] of supplemental potassium can lead to serious adverse events but that an UL could not be established due to the lack of a "specific indicator" of a toxicological effect.

European Food Safety Authority (EFSA 2005). The EFSA has not yet derived an UL for potassium. The ESFA (2005) concluded that the available data were insufficient[10] to establish a UL for potassium but noted that potassium intakes from foods in healthy individuals (up to 5,000 to 6,000 mg per day), as well as long-term intakes of supplemental potassium (as potassium chloride) of about 3,000 mg per day, have not been associated with adverse effects. The Panel noted that a few case studies reported that supplemental potassium in doses of 5,000 – 7,000 mg per day can cause adverse effects on heart function in apparently healthy individuals and gastrointestinal symptoms have been reported in healthy individuals taking some forms of potassium supplements with doses ranging from 1,000 to 5,000 mg per day. The EFSA noted that certain groups (particularly those with impaired kidney excretion of potassium) are

[8] Duration not specified. However, the studies in the NASEM review were typically 4 to 16 weeks with some trials lasting one year or longer.
[9] Levels not defined but are presumed to be much higher than the 2,500 mg per day noted in the Committee's conclusions.
[10] No additional information was provided by the EFSA regarding its inability to set an UL.

sensitive to adverse effects such as heart function associated with increases in potassium intakes. In addition, the Panel noted that elderly people may be more vulnerable to adverse effects of potassium due to reduced kidney function or due to concomitant use of drugs affecting potassium balance. The EFSA has not evaluated potassium for the purposes of deriving an UL since its 2005 assessment.

The EFSA has since published reviews of potassium safety as it pertains to specific uses and use levels (not intended to develop an UL). The EFSA (2010) Panel on Food Additives and Nutrient Sources Added to Food (ANS) was asked by the European Commission to deliver a scientific opinion on the safety of potassium sulfate (maximum of 100 mg potassium per day for adults) and of sodium sulfate when added for nutritional purposes in food supplements as sources of, respectively, potassium and sodium. The EFSA concluded that the proposed use and use levels of potassium sulfate as sources of potassium were not a safety concern. Most recently, the EFSA (2024) evaluated potassium in a novel food evaluation of a mineral salt containing potassium and magnesium (i.e., potassium magnesium chloride hydrate). The EFSA determined that the anticipated daily intake of potassium from this salt was 335.2 mg per day in adults and that it represents limited additional intake as compared to the observed potassium intakes in the EU population reported in its earlier EFSA (2016) evaluation. The Panel determined that the additional intake of potassium from this novel food does not present a safety concern.

Chinese Nutrition Society (CNS 2023). When setting its dietary reference intake (DRI) value for potassium, the CNS did not derive an UL.

Indian Council of Medical Research - National Institute of Nutrition (ICMR-NIN 2020). The ICMR-NIN did not derive an UL value for potassium when determining recommended intakes.

Korean Nutrition Society (KNS 2020). The KNS published its general approach to evaluating data for setting DRI values. The KNS did not derive an UL value for potassium.

CRN Recommendations

The goal of this chapter was to determine whether more recent human clinical trial data are available that might impact the conclusions published in the 3rd edition, which derived a supplemental UL value for potassium of 1,500 mg per day (up to 500 mg, 3 times per day to minimize potential gastrointestinal effects).

CRN's safety methodology for deriving supplemental UL values prioritizes data from human studies, when available. As with any assessment in which not all available data are reviewed, inherent uncertainties with the risk assessment and selection of the UL are recognized. The table below summarizes the key human clinical studies considered in deriving the supplemental UL value for immediate-release potassium by CRN according to its principal points of departure for risk assessment (as described in the Methods).[11] These studies were limited to those that assessed and reported data specific to the critical endpoint (i.e., hyperkalemia).

Key Studies Considered for the CRN UL for Immediate-Release Potassium in Adults

Reference	Study Design	Participant Description	No. of Subjects	Total Dose(s) (mg/day)	Duration	NOAEL (mg/day)	Hyperkalemia Incidence[a]
Dawson-Huges et al. 2015	Randomized placebo-controlled	Men and Women aged 55 and older	233	0, 2886, 4329	3 months	4329[b]	Increased with dose but not statistically different between groups (1/78, 1/79, and 5/75)
Moseley et al. 2013	Randomized, double-blind, placebo-controlled	Men and women	52	0, 2346, 3519	6 months + 9-week dose escalation	3519	Not statistically different between groups
Gregory et al. 2015	Randomized, double-blind, placebo-controlled	Women with postmenopausal osteopenia	83	0, 1565	12 months	1564	Not statistically different between groups
Granchi et al. 2018	Randomized, double-blind, placebo-controlled	Women with postmenopausal osteopenia	40	0, 1173	6 months	1173	No incidence of hyperkalemia in either group

[a] Defined as serum potassium levels above normal (e.g., <5.0 mmol per L).
[b] The NOAEL was based on non-statistical significance of reported hyperkalemia incidence in the high dose group

[11] Where numerous relevant studies were identified, those most pertinent to the UL derivation are included in the table as representative studies. Prioritization was given to studies at dose levels informing the UL and studies with higher weighting based on CRN's Methods (e.g., duration, number of participants, randomization, etc.).

compared to controls. While statistical analysis for trend was not conducted, incidence increased with increasing potassium dose.

There is limited evidence that large quantities of immediate-release oral potassium are associated with any serious adverse effects in healthy individuals. However, as noted by the EFSA (2005), case studies have previously reported that supplemental potassium in doses of 5,000 – 7,000 mg per day can cause adverse effects related to hyperkalemia on heart function in apparently healthy individuals. Hyperkalemia is the primary adverse effect associated with excess potassium consumption and is identified as the critical effect from which to derive the CRN supplemental UL.

Based on the data reviewed from human clinical trials, 3,519 mg potassium per day from the Moseley et al. (2013) study is identified as the NOAEL for immediate-release potassium for healthy adults following the CRN process. While none of the studies reviewed reported a statistically significant increase in incidence of hyperkalemia compared with placebo groups, results of the clinical trial by Dawson-Hughes et al. (2015) suggest an increase in incidence with increased dose at higher doses of potassium (1/78, 1/79, and 5/75 individuals at doses of 0 (placebo), 2,886, and 4,329 mg potassium per day, respectively). The selected NOAEL of 3,519 mg per day for healthy individuals is supported by the NASEM (2019) conclusion that 2,500 mg per day "appears to be safe" and is likely below the UL for individuals without risk factors such as kidney disease. In addition, the German Federal Institute for Risk Assessment (BfR) (2021) recent assessment for a proposed maximum level for the addition of potassium to foods including supplements concluded that 3,000 mg of potassium per day does not appear to result in adverse health effects based on the current data. In further support of the NOAEL, available meta-analyses of randomized controlled trials reported that potassium intake using supplements ranging from 858 to 5,460 mg per day were not associated with risk of hyperkalemia in healthy individuals (Cappuccio et al. 2016) and 1,876 to 7,820 mg per day were well tolerated (Whelton et al. 1997).

As described in CRN's Methods, if the supplemental intake dose-response relationship is identified from the strongest data and assessed conservatively, no additional uncertainty factor is needed (that is, the implicit UF is 1.0). Consistent with CRN's methodology, an UF of 1 is

applied to yield an UL of 3,500 mg per day (rounded down from 3,519) for adults for supplemental immediate-release potassium, with the provision that it should be divided into doses no larger than 700 mg each to minimize gastrointestinal discomfort. This provision is based conservatively on non-significant increases in gastrointestinal symptoms from the Gregory et al. (2015) study.

CRN notes that data on extended-release forms are not sufficient at this time to derive an UL for supplementation.

The available data suggest individuals with known risk factors related to kidney impairment are excluded from the target population for the UL. Individuals with impaired kidney function or individuals who are taking drugs that impair potassium excretion, such as ACE inhibitors, should consult with their healthcare provider before taking potassium supplements.

Quantitative Summary for Immediate-Release Potassium in Adults

CRN (2025) UL, supplemental intake	3,500 mg/day (not to exceed 700 mg at one time)[a]
NASEM (2019)[b]	Not determined[b]
EFSA (2005)	Not determined
EVM (2003), guidance level, supplemental intake	3,700 mg/day
CNS (2023) UL, total intake	Not determined
ICMR-NIN (2020), total intake	Not determined
KNS (2020), total intake	Not determined

[a] Excludes those with known risk factors related to kidney impairment or taking drugs that impair potassium excretion; such individuals should consult with their healthcare provider.
[b] Supersedes IOM (2005)

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