



DOSSIER · SUBSTANCE

Whole Grain

Whole grain is not a substance, but a food group — and from this follows the most important finding of this evaluation: The most cited works are reviews and mechanism studies, not controlled human trials. Robust statements concern markers such as blood glucose, gut hormones and inflammatory values, not disease progression.

166

STUDIES IN
TOTAL

60

IN HUMANS

17

OF WHICH
CONTROLLED

11

IN ANIMALS

2

IN THE LAB

Figures from the IHR study database · Last updated 2026-10-15

How to Read This Dossier

ESTABLISHED

measured in humans, with a comparison group

PLAUSIBLE

supported by mechanism, animal studies or observation

HYPOTHESIS

a likely connection that still needs to be tested

Whole Grain at a Glance

ORIGIN:

Whole grain is not a substance, but a food group: cereals processed as whole kernels — flour and baked goods from the complete grain rather than from refined flour. The evaluated studies examine its constituents, especially dietary fibres and phenolic compounds such as arabinoxylans. As a subject of investigation, whole grain appears in very different forms, from quinoa through whole kernels to baked goods.

EVIDENCE BASE:

166 evaluated studies · 17 controlled human studies · 43 observational studies · 40 reviews · 11 animal studies · 2 cell-culture studies

STRONGEST EVIDENCE:

- Metabolism: A 2024 review pools ten cohort studies and 37 randomised controlled trials; 50 g whole grain per day was associated with a risk ratio for type 2 diabetes of 0.761 ²⁸.
- Metabolism: A meta-analysis of 30 randomised studies with 1140 participants showed that intrinsic arabinoxylans lowered fasting glucose (SMD -0.44) and systolic blood pressure (MD -2.86) ¹.
- Metabolism: In a randomised parallel study over 12 weeks, weight change in 115 adults with obesity was -2.0 kg (50 g whole grain per day) and -1.7 kg (100 g) ¹².
- Cardiovascular and oncology: A scoping review for the Nordic Nutrition Recommendations 2023 describes dose-response relationships between high whole-grain intake and lower risk of cardiovascular disease and colorectal cancer ²⁹.
- All-cause mortality: An umbrella review screened 41 meta-analyses with over one million participants; higher consumption of nuts, whole grain, fruit, vegetables and fish was associated with lower mortality rates ¹⁹.

LIMITATIONS:

- Controlled human studies are clearly in the minority — fewer than twenty — small, short and measure predominantly markers such as postprandial values and gut hormones, not disease progression.
- Intake is usually self-reported, blinded feeding is hardly feasible; assignment of individual biomarkers to whole grain is not yet established.
- Whole grain is only one component of a dietary pattern in many highly cited studies; the oncological data also include risk of colorectal cancer.

CLASSIFICATION:

Whole grain is a preparation form of cereals whose marker effects are well studied, but whose effect on disease progression remains open.

1. What Whole Grain Is

Whole grain denotes cereals processed as whole kernels — flour and baked goods from the complete grain rather than from refined flour. The evaluated studies deal with the constituents of this kernel: dietary fibres and phenolic compounds, notably arabinoxylans, are the focus of several reviews. As a subject of investigation, whole grain appears in very different forms — quinoa alongside other cereals, whole kernels alongside baked goods, meals in kindergartens alongside individual foods. This is precisely the peculiarity of the topic: whole grain is not a substance with a dose, but a preparation form of cereals. Studies record intake via the diet, not administration of a preparation.

Decisive for understanding all studies is how intake is measured. Most observational studies rely on self-reported data; a randomised feeding trial is currently comparing whole-blood and urine biomarkers with reported amounts. Equally important is the form: some studies test fibres as they occur in the kernel, others test isolated arabinoxylans. These are not the same. In addition, whole grain is only one component of a dietary pattern in many highly cited studies — Mediterranean diet, plant-based diet, DASH variants. Anyone seeking a statement on whole grain alone must check whether the study tested whole grain as the sole variable. This is the question on which most of the literature turns.

2. What the Studies Show in Detail

The key human studies and the most important reviews — by application area, with population, duration, preparation, measure and result as reported in the original studies. Numbers appear only where the study states them.

Distribution of **controlled human studies** by application area — the numbers are not additive, as one study may be assigned to several areas:

APPLICATION AREA	CONTROLLED STUDIES
Metabolism	12
Cardiovascular	5
Gut and microbiome	3
Inflammation	2
Oncology	2
Immune system	2

APPLICATION AREA	CONTROLLED STUDIES
Safety and tolerability	1

Metabolism

The 2024 review pools ten prospective cohort studies and 37 randomised controlled trials²⁸. In the cohorts, an intake of 50 g whole grain per day was associated with a risk ratio for type 2 diabetes of 0.761 (95 % CI 0.700 to 0.828; $I^2 = 72.39$ %; $P < 0.001$), with a monotonic inverse relationship. In the randomised studies, whole grain lowered fasting glucose (MD = -0.103 mmol/L). The umbrella review of 13 food groups evaluated 67 studies, including 46 meta-analyses on type 2 diabetes risk with half a million participants; 25 of the 67 studies reached high quality according to AMSTAR-2. High whole-grain intake was associated with lower risk of type 2 diabetes and metabolic syndrome; the meta-evidence for type 2 diabetes is rated moderate¹⁸. A further review of plant foods and healthy plant-based diets describes that replacement of animal with healthy plant foods in randomised studies led to cardiometabolic improvements in people with type 2 diabetes or high risk; it covers many plant foods and not whole grain alone⁶.

On the question whether whole grain acts via gut hormones, a meta-analysis summarises 19 randomised studies³. Acute intake did not significantly change the area under the curve of GLP-1 and GIP. The GIP area fell more strongly in unhealthy participants (SMD -1.08; 95 % CI -2.07 to -0.10; $I^2 = 75.9$ %) and in those with fasting glucose of at least 99 mg/dL at baseline (SMD -0.71; 95 % CI -1.30 to -0.11; $I^2 = 74.4$ %). A second meta-analysis compared 30 randomised studies with 1140 participants on intrinsic and isolated arabinoxylans¹: intrinsic arabinoxylans lowered fasting glucose (SMD -0.44; 95 % CI -0.75 to -0.13; $p = 0.005$; $I^2 = 60$ %) and systolic blood pressure (MD -2.86; 95 % CI -5.45 to -0.27; $p = 0.03$; $I^2 = 0$ %). In people with overweight and obesity the reduction in fasting glucose was more pronounced (SMD -0.25; 95 % CI -0.48 to -0.03; $p = 0.03$; $I^2 = 0$ %). Isolated arabinoxylans lowered fasting glucose (SMD -0.19; 95 % CI -0.36 to -0.02; $p = 0.03$; $I^2 = 0$ %) and total cholesterol (MD -0.14; 95 % CI -0.27 to -0.01; $p = 0.03$; $I^2 = 0$ %) and increased lymphocyte count (MD 3.52; 95 % CI 0.75 to 6.29; $p = 0.01$; $I^2 = 28$ %).

Compared with the control diet, DASH4D lowered mean glucose (MD = -11.1 mg/dL; $P < 0.001$) and increased time in range (MD = +5.2 percentage points; $P < 0.001$); the coefficient of variation remained unchanged ($P = 0.52$). The entire dietary pattern was tested, not whole grain alone. In 207 people with impaired glucose tolerance, a one-year randomised study compared 100 g quinoa per day with 100 g multigrain and a control⁵: the quinoa group showed longer time in range, higher conversion rate to normal glucose tolerance and lower values for 2-hour glucose, fasting insulin, HOMA-IR, 14-day mean glucose and diabetes development ($P < 0.05$); HbA1c improved in both intervention groups ($P < 0.05$).

In a randomised parallel study, 115 adults with obesity received 50 g or 100 g whole grains per day or the control condition over 12 weeks¹². The weight change from baseline was -2.0 kg (95 % CI -3.1 to -0.8) for 50 g and -1.7 kg (95 % CI -2.7 to -0.6) for 100 g; BMI, body fat and visceral fat decreased, fasting glucose and insulin resistance improved, triglycerides, total cholesterol and the triglyceride-glucose index declined, as did uric acid and homocysteine. A dose-response meta-analysis on quinoa included seven randomised studies with 258 adults (mean age 31 to 64 years), 15 to 50 g quinoa per day over 28 to 180 days²: For fasting glucose, a non-linear association was found ($P = 0.027$) with a steeper curve from about 25 g/day; no significant effect was shown on BMI (MD -0.25; 95 % CI -0.98 to 0.47; $I^2 = 0$ %). It remains open which whole grain types and which minimum duration carry the effects on fasting glucose and weight; direct comparative studies with uniform dose are pending.

Gut and Microbiome

Two identical reviews classify whole grains and pseudocereals (quinoa, amaranth, buckwheat) as well as cereals (wheat, rice, maize)^{7,9}. Both describe that higher consumption of whole grains instead of refined grains was repeatedly associated with lower risk for type 2 diabetes and cancer, and cite as one mechanism the alteration of the gut microbiota with an increase in beneficial bacteria. The bran layer of the grain contains the majority of the fibre, essential amino acids and phenolic acids. A review on the Mediterranean diet names whole grains as substrate for the formation of short-chain fatty acids that modulate the immune response, maintain the gut barrier and regulate energy metabolism²⁵.

The Dietary Index for Gut Microbiota lists whole grains among the favourable components. A higher index value was associated with lower constipation prevalence (OR = 0.82; 95 % CI 0.75 to 0.90), as was a higher score for favourable gut microbiota (OR = 0.77; 95 % CI 0.67 to 0.89). Constipation was defined as fewer than three bowel movements per week. The study is cross-sectional and cannot establish temporal sequence.

A pilot trial with 45 healthy adults who reported low whole-grain intake themselves provided whole-grain or refined-grain products for household use for six weeks⁸. Intake was recorded via consumption and a daily protocol. At the beginning and end, participants completed an Implicit Association Test that captured the strength of the association of whole-grain and refined-grain images with pleasant or unpleasant taste words via reaction times as a D-score; analysis was performed with ANCOVA. The study examined whether the mere availability of whole-grain products alters the implicit association. It remains open which fibre and phenolic acid fractions of whole grains shift the microbiota in what way; intervention studies with measured composition would be required for this.

Further Investigations

Four kindergartens received a five-day prototype meal plan with regulated portions of vegetables, fruit, whole grains and nuts; two kindergartens retained their usual plan. 57 children completed the study, 40 from the prototype group and 17 from the control group. A seven-day dietary protocol was recorded inside and outside the kindergarten and evaluated with the Dietary Assessment Tool OPEN. Average daily consumption of vegetables (54 % vs. 28 %), whole grains (100 % vs. 47 %) and nuts (104 % vs. 4 %) was significantly higher in the prototype group relative to the recommendations ($p < 0.05$); fruit, meat, dairy products and refined grains did not differ.

A randomised crossover trial with three 48-hour interventions tested a panel of proposed dietary intake biomarkers¹⁴. 21 participants (mean age 24.8 years, SD 6.0; BMI 24.1, SD 4.0) completed the study. Each study day contained three food groups, including whole grains, and omitted three other groups. Fasting whole blood and 24-hour urine were examined by liquid chromatography-mass spectrometry for previously proposed biomarkers; urine sodium was additionally measured. Pairwise correlations and generalised linear models were evaluated.

An umbrella review on food groups and all-cause mortality screened 41 meta-analyses with over one million participants¹⁹. 18 studies reached high, 8 moderate, 5 low and 10 critically low quality according to AMSTAR-2. Higher consumption of nuts, whole grains, fruit, vegetables and fish was associated with lower mortality rates, both in comparisons of high versus low intake and per serving. Many of the included studies showed considerable heterogeneity. It remains open how whole-grain intake can be measured objectively; the biomarker panel is a first step for this, and the assignment of individual markers to whole grains is not yet confirmed.

Inflammatory Processes

An umbrella review of randomised controlled trials searched five databases up to March 2025 and included 25 publications with 113 endpoints⁴. 43 % of the endpoints concerned diabetes, 21 % lipid metabolism, 12 % anthropometric measures, 9 % blood pressure, 10 % inflammatory markers and 5 % appetite and energy intake. The authors report favourable changes in diabetes-related endpoints, blood lipid values, blood pressure, body measures and inflammatory markers as well as an improvement in appetite.

A crossover trial with 20 healthy participants aged 19 to 24 years tested four types of pancakes in 100 g portions: steamed buns as control, maize, buckwheat and oat pancakes¹³. Blood samples were taken at 0, 0.5, 1, 2 and 3 hours; after a one-week washout period, participants crossed over. For glucose, insulin, CRP, triglycerides and HDL-C, no significant differences were found between control and the three whole-grain groups; for total cholesterol and LDL-C, the study reports differences between oat pancakes and control. The acute test in 20 persons does not permit any statement on longer-term inflammatory courses.

A review on the composition of whole-grain fibre and phenols describes arabinoxylan and β -glucan as well as hydroxycinnamic acids and hydroxybenzoic acids, which are predominantly located in the bran layer²⁶. Fibre and phenolic acids are linked to an inverse association with inflammatory risk. The authors note that the biological mechanisms behind the reported association between whole-grain consumption and lower disease risk are not fully understood; part of the effect occurs via the gut microbiota, which converts bioactive substances into more potent metabolites. It remains open which inflammatory markers decline measurably at which whole-grain amount and duration; the available studies partly test individual meals or bundle heterogeneous endpoints.

Oncology

For whole grains, no significant associations with liver cancer were shown. 277 liver cancer cases (median follow-up 15.6 years) and 165 cases (16.0 years) were recorded. As a comparison, fibre in the PLCO was inversely associated with liver cancer risk (HR per 10 g/day 0.69; 95 % CI 0.55 to 0.86). Intake was estimated via validated food frequency questionnaires.

The study estimated how replacement of potatoes by whole grains affects diabetes risk. As a comparison, it considered potato consumption: for every three additional servings of potatoes per week, the rate rose by 5 % (HR 1.05; 95 % CI 1.02 to 1.08), for French fries by 20 % (HR 1.20; 95 % CI 1.12 to 1.28). Boiled, baked or mashed potatoes were not significantly associated with risk.

Meta-analyses with three to ten observational studies each were calculated, among others for whole grains. The evidence was overall rated as limited. A scoping review for the Nordic Nutrition Recommendations 2023 identified five qualified systematic reviews and describes clear dose-response relationships between high whole-grain intake and lower risk for cardiovascular diseases and colorectal cancer²⁹. It remains open whether whole grains after a cancer diagnosis influence the course; the available analyses are observational and the level of evidence remains limited.

Cognition and Psyche

A systematic review screened four databases up to August 2021 and included 23 studies, of which four randomised controlled trials and 19 observational studies²⁷. Twelve studies examined the association of whole-grain intake and cognitive decline, nine mood outcomes and two both. Risk of bias was assessed with the Nutrition Quality Evaluation Strengthening Tools, strength of evidence per endpoint with GRADE. For cognition, the overall evidence is inconclusive. For mood, randomised studies, prospective cohorts and case-control studies suggest better outcomes with higher intake. It remains open which cognitive tests and which observation duration could capture whole-grain effects; four randomised studies stand against 19 observational studies, and the authors rate the evidence for cognition as inconclusive.

Overall Picture

Across the areas, the reviews carry the strongest statements: an intake of 50 g whole grains per day was associated in cohorts with lower type 2 diabetes risk (RR = 0.761; 95 % CI 0.700 to 0.828)²⁸, and the umbrella review on 13 food groups rates the meta-evidence for type 2 diabetes as moderate¹⁸. For all-cause mortality, higher whole-grain consumption was associated with lower rates¹⁹. Randomised studies support improvements in fasting glucose, with the reduction at MD = -0.103 mmol/L being moderate²⁸.

Where the evidence stands at the beginning: For cognition, the evidence is rated inconclusive by the authors²⁷, for metabolic health the umbrella review bundles heterogeneous endpoints⁴, and for liver cancer no significant association was found for whole grains¹⁶. Most randomised studies test individual meals or short periods; dose comparisons between whole-grain types are rare. The question of which constituents — fibre, arabinoxylans, phenolic acids — account for what share of the observed effects remains open^{1 26}.

Methodology of the evidence base

The studies range from cross-sectional analyses and prospective cohorts through randomised crossover and parallel studies to systematic reviews, dose-response meta-analyses and umbrella reviews. Typical interventions last five weeks to one year; individual tests measure postprandial courses over three hours. Endpoints are fasting glucose, HbA1c, HOMA-IR, insulin, weight, BMI, body fat, lipids, blood pressure, incretin levels, inflammatory markers, stool frequency, biomarkers in blood and urine as well as cognitive and mood values. Frequently missing are data on dose per whole-grain type, origin of the means and long-term courses; many meta-analyses report high heterogeneity.

Whole grains as part of a dietary pattern says nothing about whole grains alone

The most cited works in the evaluation deal with plant-based dietary patterns, Mediterranean diet, an index for the gut flora and DASH variants. Whole grain is a component therein alongside vegetables, pulses, nuts and oil. Such studies contribute substantially to the question of how dietary patterns affect metabolism and risk. However, they cannot show what proportion is attributable to whole grain. If a work on a dietary pattern is cited as evidence for whole grain, the statement becomes larger than the study provides. The citation numbers reflect the interest in the pattern, not in the individual food.

The reverse error is equally widespread. Part of the mechanism literature examines isolated arabinoxylans or individual fibre fractions. No statement about whole grain as a food can be derived from such works, because the matrix in which these substances are present in the grain is missing. What would decide the question is a manageable group of studies in which whole grain is the only changed variable, the intake is confirmed via biomarkers and not only a marker but a course is recorded. Individual newer randomised studies go in this direction; they have so far rarely been cited.

3. How Reliable the Research Is

The evaluation is broad, yet unevenly distributed. The largest block consists of basic research and reviews on mechanisms of action; human observational data follow closely behind. Controlled human studies, by contrast, are markedly in the minority — there are fewer than twenty. Within these controlled works, metabolism dominates by a wide margin; cardiovascular and gut follow, while inflammation, oncology, immune system and safety are represented by only single studies. Animal and cell studies play a minor role; one agricultural or environmental work is added. Notably, among the most cited works, reviews and meta-analyses rank highest, not individual randomised studies.

The methodological strength of the field lies in synthesis: systematic reviews, dose-response meta-analyses, an overview of reviews and a work that jointly evaluates cohort studies with randomised studies. Prospective observational data with long follow-up are also included. The weakness lies in the primary data. Controlled studies are small, short and predominantly measure markers — postprandial values, gut hormones, glucose variability — not disease course. Blinded nutrition is scarcely feasible, and intake is usually self-reported. The oncological data concern prevention, not prognosis after diagnosis. The decisive open question remains whether these markers translate into a measurable course.

4. What Is Frequently Claimed — and What the Data Provide

STATEMENT	RESEARCH STATUS
Whole grain lowers blood sugar	Dose-response meta-analyses on glycaemic control and a review of randomised studies support an effect on markers. Controlled single studies mostly measure
Whole grain protects against bowel cancer	The evaluation contains a systematic review on prognosis after diagnosis, not on prevention. Observational data, no tested effect.
Whole grain aids weight loss	A randomised parallel trial in obesity with body weight as the outcome measure is available and is new. Angaben zum Body-Mass-Index stammen vor allem aus I
Whole grain lifts mood and protects cognition	A systematic review summarises observational data on cognition, mood and anxiety. Associations, no tested effect; controlled studies in this field are still pendin

5. The Most Reliable Studies

Ordered by strength of evidence, not by familiarity: overview articles and studies with many participants first. The complete evaluation comprises considerably more works; the most robust are listed here.

Controlled Human Studies

- ¹ The physiological effects of intrinsic and isolated arabinoxylans on human immunometabolic response: A systematic review and meta-analysis (2025) — Review, 1,140 participants
- ² Does Quinoa (<i>Chenopodium quinoa</i>) Consumption Improve Blood Glucose, Body Weight and Body Mass Index? A Systematic Review and ... (2024) — Review, 258 participants

- ³ Effects of whole grain intake on glucagon-like peptide 1 and glucose-dependent insulintropic peptide: a systematic review and meta-analysis (2023) — Review
- ⁴ The impact of whole grain consumption on metabolic health: an umbrella review of systematic reviews and meta-analyses of randomized controlled trials (2025) — Review
- ⁵ Quinoa is more effective than other whole grains in the management of impaired glucose tolerance: a randomized controlled trial (2025) — 207 participants
- ⁶ Plant foods, healthy plant-based diets, and type 2 diabetes: a review of the evidence (2024)
- ⁷ Grains in a Modern Time: A Comprehensive Review of Compositions and Understanding Their Role in Type 2 Diabetes and Cancer (2024)
- ⁸ Initial implicit association between whole grains and taste does not predict consumption of whole grains in low-whole grain consumers: a pilot ... (2024)
- ⁹ Grains in a Modern Time; A Comprehensive Review on Compositions and Understanding their Role in Type 2 Diabetes and Cancer (2024)
- ¹⁰ Can Kindergarten Meals Improve the Daily Intake of Vegetables, Whole Grains, and Nuts among Preschool Children? A Randomized Controlled Evaluation (2023) — 57 participants
- ¹¹ DASH4D diet for glycemic control and glucose variability in type 2 diabetes: a randomized crossover trial (2025) — 89 participants
- ¹² Effectiveness of whole grain to body weight and cardiometabolic risk in adults with obesity: a parallel randomised controlled trial (2026)
- ¹³ Effect of whole grain pancakes on postprandial cardiometabolic risk factors in healthy subjects: A randomized crossover trial (2026)
- ¹⁴ Comparing a diet-wide panel of biomarkers of food intake in whole blood and 24-hour urine and self-reported with known dietary intakes: randomized ... (2026)
- ¹⁵ Kindergarten Meals Improve Daily Intake of Vegetables, Whole Grains, and Nuts in Pre-School Children: A Randomized Controlled Evaluation (2023) — 4 participants

Observational Studies in Humans

- ¹⁶ Fiber and whole grain intakes in relation to liver cancer risk: An analysis in 2 prospective cohorts and systematic review and meta-analysis of ... (2024) — Review, 111.396 participants
- ¹⁷ Consumption of whole and refined grains and the risk of gastric cancer: a pooled analysis within the Stomach cancer Pooling (StoP) Project (2026) — Review, 7.943 participants
- ¹⁸ Umbrella Review of Systematic Reviews and Meta-Analyses on Consumption of Different Food Groups and Risk of Type 2 Diabetes Mellitus and Metabolic ... (2025) — Review
- ¹⁹ Umbrella Review of Systematic Reviews and Meta-analyses on Consumption of Different Food Groups and Risk of All-cause Mortality (2025) — Review
- ²⁰ Total and specific potato intake and risk of type 2 diabetes: results from three US cohort studies and a substitution meta-analysis of prospective ... (2025) — Review
- ²¹ Postdiagnosis dietary and lifestyle factors and mortality outcomes among colorectal cancer patients: a meta-analysis (2025) — Review
- ²² Association of the newly proposed dietary index for gut microbiota and constipation: a cross-sectional study from NHANES (2025) — 11.405 participants
- ²³ Bread, wholegrain consumption and weight change from middle to late adulthood: a prospective cohort study (2025) — 1.764 participants
- ²⁴ Exploring the relationship between dietary quality, eating behavior, and mental health among young adults (2025) — 520 participants

6. Summary

Evidence is mainly for marker effects. The 2024 review pools ten cohort studies and 37 randomised controlled trials: 50 g whole grain per day was associated with a risk ratio for type 2 diabetes of 0.761; in the randomised studies fasting glucose decreased (MD -0.103 mmol/L) ²⁸. An umbrella review of 13 food groups evaluated 67 studies, including 46 meta-analyses on type 2 diabetes risk with half a million participants; the meta-evidence for type 2 diabetes is rated as moderate ¹⁸. For liver cancer, no significant associations were shown for whole grain, whereas fibre was inversely associated with the risk.

Plausible is a mechanism via the gut microbiota: The bran layer of the grain contains the majority of the fibre, essential amino acids and phenolic acids; whole grain is considered a substrate for the formation of short-chain fatty acids that modulate the immune response and maintain the intestinal barrier ^{25 26}. **Hypothesis:** If these mechanistic findings are confirmed in longer-term courses, the marker level could be the actual point of action and not the individual meal. The authors note that the biological mechanisms behind the reported association are not fully understood.

What remains to be clarified is whether the markers translate into a measurable disease course. Open is which whole grain types and which minimum duration carry the effects on fasting glucose and weight; direct comparative studies with uniform dose are pending. Equally open is how whole grain intake can be measured objectively — the biomarker panel from whole blood and urine is a first step for this, the assignment of individual markers to whole grain is not yet secured ¹⁴. For the inflammatory process, the question remains which markers decrease measurably at which whole grain amount and duration.

7. What Remains Open

- **Dose and Form:** Which amount, which grain type and which processing carry the measured effects is not uniformly defined across the studies presented.
- **Measurement:** Whether biomarkers in whole blood and 24-hour urine can replace self-reported intake is tested by a randomised feeding trial; confirmation in larger groups is pending.

- **Individual grains:** A randomised trial in impaired glucose tolerance found quinoa more effective than other whole grain types; whether this can be reproduced is open.

Frequently Asked Questions

Can whole grain be treated like a fibre supplement in counselling?

No. The evaluated studies explicitly distinguish between fibres as they occur in the grain and isolated arabinoxylans. Individual fractions cannot stand for the food because the matrix in which they occur in the grain is missing. When speaking about whole grain, one speaks about the cereal as a whole — and about intake via the diet, not about the supplied amount of a substance.

How robust are the data on glycaemic control?

They belong to the best-studied area of the evaluation. Several reviews and dose-response meta-analyses summarise prospective cohorts and randomised trials. However, the primary studies are small and short and predominantly measure markers such as postprandial values, gut hormones or glucose variability. For the course of diabetes these works still carry no statement.

Why do so many reviews and so few controlled studies appear in the evaluation?

Nutrition is difficult to randomise and hardly possible to blind. Reviews and meta-analyses therefore bundle what observational and interventional data are available and carry the main statements. Controlled human studies remain in the minority, which describes the research status of this field and not the value of the food. Newer randomised works on body weight, baked goods and intake measurement show where the next steps are heading.

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