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Cereal products are generally produced using purified flours extracted from the wheat grain endosperm by the milling industry. However, whole grains contains appreciable concentrations of micronutrients, phytochemicals and fibres that are mostly eliminated with the bran. These nutritionally interesting compounds are distributed within the peripheral layers of the grain (i.e. pericarp, testa and aleurone layer as the major tissues) which show distinct structure and mechanical properties. New dry fractionation processes were investigated in order to recover these compounds while keeping a matrix effect (in contrast with wet extraction processes). Starting material was either whole grain to partially incorporate the peripheral tissues into "enriched" flours or milled bran to produce specific "functional" cereal-based ingredients. A multi-scale approach, from grain batches to specific molecules, was used to find out the key factors which govern the grain fractionation and their genetic variability and further develop the new processes. Grains were dissected into their main constitutive tissues which were individually characterised in terms of composition, structure, mechanical properties and micro-milling behaviour. This approach allowed to determine the involvement of each of the main peripheral tissue in the bran rigidity, elasticity and extensibility and gave informations on the way to dissociate them. Biochemical markers were also identified and could be used to track each of the different tissues in the different milling fractions produced from complex processes. On the basis of the knowledge acquired from model studies, combinations of conventional (milling, grinding, sieving) and advanced technologies (pre-treatments, debranning, abrasion, attrition, jet-milling, air-classification) demonstrated the possibility to produce flours containing selected peripheral compounds or to prepare different fractions of contrasted composition from brans.