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The Distribution of Nicotinic Acid in the Grains of Wheat, Rye, Barley, and Oats

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The nicotinic acid content of cereals and cereal products has not drawn the attention of the investigators to such an extent as the aneurin content but, nevertheless, some information of it is already available. A common feature and at the same time the chief motive of the research work is probably the well-known fact that the white flour contains both of these vitamins, as well as others, less than the whole grain, owing to the low vitamin content of the interior of the endosperm. Many differences are, however, easy to note. Apart from the fact that the absolute quantities of these vitamins are very different, it may be mentioned that the niacin content of various kinds of cereals is not so even as the aneurin content, *e. g.* the grains of rye and oats are poor in niacin compared with wheat and barley.

The germ region and, in particular, scutellum and the tissues near it contain, as known, unexceptionally much aneurin. No corresponding accumulation of niacin has been noted, at least not in wheat, which has been dealt with in many publications. In the literature appeared in the 1940's values have been reported on the niacin content of the different parts of germ and of different germ-containing milling products, varying within the range 0.5—1.8 times the total content of the whole grain [1, 2].

On the basis of the information published on the niacin content of the milling products of wheat it can be concluded that the major part of this vitamin is located in the outer layers of grain or in their proximity. So, for instance, Andrews, Boyd, and Gortner [3], Moran and Drummond [1], and Jones and Moran [4], have obtained for coarse bran niacin values which are approximately five times that of the whole grain. By analyzing the products of a commercial mill it is not possible to decide definitely in which outer layer of grain niacin is chiefly localized. Nevertheless, the fact that the high-fibre

coarse bran invariably contains this substance appreciably more than does the fine bran easily gives rise to the assumption that it would be located mostly in the outermost coverings. For instance, Jones and Moran [4] report for coarse bran the value 296.0 μg/g and for fine bran 188.0 μg/g (13 % moisture basis), while the aneurin contents of the same mill products are 4.95 and 10.38 μg/g, hence the relation of aneurin and niacin is very different.

The authors proved as early as 1941 that the aneurin content of the outer pericarp tissues of wheat is lower than the average content of grain [5, 6]. Later we have made the same finding also in regard to rye [7]. In these experiments, a technique was successfully employed where the material was gradually removed from the grains, beginning from the surface, by means of emery scouring. Principally on account of the fact that the shape of the grain deviates from that of a ball the layers of grain cannot be completely separated in this way, but in examining the experimental data both in the previous works and in the present paper it is easy to see that this technique gives a truer picture, in particular, of the composition of the outer layers of the grain than does the analysis of the products of an industrial mill. As also the distribution of the nicotinic acid in grains, especially in the layers near surface interested the authors, the above technique was adopted to investigation of this vitamin, too. The results obtained in the experiments with wheat, rye, barley, and oats are recorded in the following.

MATERIAL AND METHODS

For the experiments were used the imported wheat Manitoba No. 2 and in addition the following cereals grown in Finland: rye, Toivo (Jokioinen); barley, Binder (Abed); oats, Guldregn II (Svalöf). The material was the same as used in the experiments on the location of aneurin [7].

The samples selected from normally developed pure lots of cereals were freed from foreign substances and broken grains. However, they were not washed owing to the nature of the experiment, although in the light of the previous experiments concerning aneurin it could be presumed that the loss of nicotinic acid in washing would remain fairly negligible [6]. The scouring experiments on oats were performed by using kernels from which the hulls were removed. The grains of other cereals were intact.

A simple machine specially designed for the purpose was used in the scouring. Its construction has been earlier described [7].

The determination of nicotinic acid was performed by the cyanogen bromide method according to the instructions of A.A.C.C. [8]. Instead of Lloyd's reagent, a preparation »Montana B» had to be used as the adsorption substance. This proved to be very suitable. For determination of colour Pulfrich-photometer with filter S 43 was employed.

Crude fibre was determined according to the modification worked out by Puranen and Tomula [9]. It gives very similar results as the ordinary so-called Weende-method (*cf. e. g.* instructions of A.O.A.C. [10]) but is more rapid and convenient.

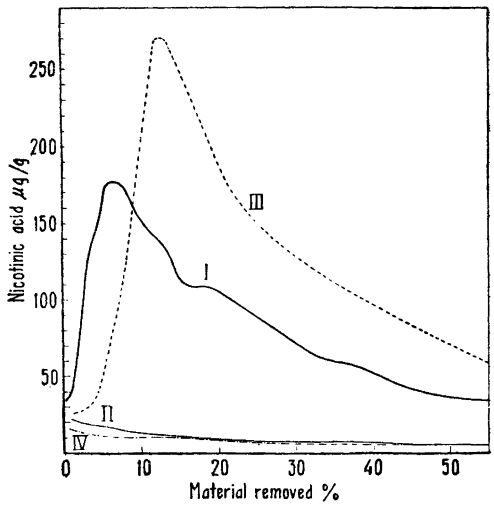

Fig. 1. Effect of scouring treatment on wheat (I), rye (II), barley (III), and hulled oats (IV). Nicotinic acid content (µg/g dry matter) of the material removed in each successive phase.

RESULTS AND DISCUSSION

The curves in Fig. 1 show the niacin content of the substance removed at each stage of scouring, expressed in micrograms per gram of dry matter.

The total niacin contents of the grains used for scouring experiments were: wheat 61 µg/g (calculated from the scouring fractions 58 µg/g); rye 7.8 µg/g (7.4); barley 66 µg/g (65); oats, kernel 6.6 µg/g (6.1).

Furthermore, it should be mentioned that for fairly pure oat hulls removed by hands a value of 5.6 µg/g was obtained. The nicotinic acid contents of the whole oat grains varied from 5.4 to 6.6 µg/g.

In examining the results there are noted at the first glance great differences between different kinds of cereals. This applies as well to the total quantity of nicotinic acid as its distribution in different parts of grain. The niacin content of the grains of wheat and barley is roughly ten times that of rye and oats. In the scouring treatment there is segregated from the outermost layers of wheat (Fig. 1, curve I) and barley (III) material whose niacin content is lower than the average content of grains. The pericarp tissues of rye (II) and oats (IV) contain, again, this substance comparatively more than the tissues in the interior of the kernel. This latter fact is, however, of no great value from the nutrition chemical point of view because the absolute quantities of niacin in rye and oats are so small.

It is interesting to compare the distribution of niacin and aneurin in the grains, in particular, in their outer layers. The results previously reported by the authors on the distribution of aneurin are without any difficulty compa-

rable with those given here, since the material analyzed has been for the major part the same [7, 11]. Other values, too, concerning the composition of the tissues separated at the corresponding phase of scouring, as, for instance, ash, fat, and fibre contents, might well be used in connection with the niacin contents given in the present paper.

It can be seen at the first glance that the distribution of niacin in the grain of rye is very different from that of aneurin. The same applies to oats, too, although the low total quantity of niacin is striking. On the contrary, in wheat and barley the curves for aneurin and niacin markedly resemble each other in shape [11]. The content of both these vitamins in the outer layers is lower than average rising rapidly towards the interior. The nicotinic acid content reaches its maximum much earlier than aneurin, in wheat after removal of about 6 % of the weight of grain, and in barley after removal of about 13 %. The respective figures for aneurin are about 21 % and 18 % [11].

Since the niacin content of the outer layers of both wheat and barley is lower than the average it is possible to prepare by means of a deliberate scouring treatment products whose niacin content is as great or slightly smaller than that of the whole grain. As the outer layers on account of their high fibre content are the least digestible part their removal ought to be advantageous both from the standpoint of baking quality and nutrition physiology. This of course with the proviso that the high fibre content is not desirable for

Table 1. Effect of scouring treatment on wheat, rye, barley, and hulled oats. Relative contents of nicotinic acid and fibre in the kernel after the scouring (niacin and fibre content of the whole kernel = 100).

Material removed %	Wheat		Rye		Barley		Oats (hulled)
	Niacin	Fibre	Niacin	Fibre	Niacin	Fibre	Niacin
1	100.3	94	98.0	95	100.6	97	98.5
2	100.4	87	95.9	89	101.3	92	97.2
3	99.8	81	94.3	84	101.8	86	96.1
4	98.4	76	92.7	79	102.4	81	95.2
6	95	70	90	69	102.0	70	93
8	90	64	87	62	101.0	59	92
10	86	60	85	58	100.0	49	90
15	77	52	81	53	82	31	86
20	70	46	77	51	65	25	82
30	58	35	73	49	42	22	75
40	50	27	68	46	—	—	72
50	45	19	67	45	—	—	69

some special reason and that the outer layers of the grain do not contain certain specially valuable nutrients.

Table 1 gives the relative contents of nicotinic acid and fibre in the bulk of grain after each stage of scouring, expressed in per cent of the content of untreated grain designated as 100.

The crude fibre content does not of course *per se* express the total quantity of the indigestible substance but it may serve as a ratio. It appears from Table 1 that if, for instance, 10 % of the weight of barley grain is carefully removed by scouring, the nicotinic acid content of the remaining bulk of grain is the same as that of the original whole grain, but the crude fibre content only half the original and accordingly, the digestibility much better. The treatment of wheat does not regularly give equally good results but even that may, however, considerably promote the materialization of the hopes the physiologists have fixed to the so-called graham meal. The figures pertaining to rye grain and oat kernel are in this sense of less interest, the total quantity of nicotinic acid being so slight. Reference is made to the previously reported results concerning aneurin.

SUMMARY

The distribution of nicotinic acid in the grains of wheat, rye, barley, and oats has been investigated by means of the scouring method developed by the authors. Niacin was determined colorimetrically according to the cyanogen bromide method. The following contents of niacin were found (all data are expressed on dry matter basis).

The outer pericarp layers of wheat contain niacin less (34 μg/g) than the kernel on the average (58—61 μg/g). Higher concentrations were met in the interior of the bran coverings (maximum 175 μg/g). For other kinds of cereals the following niacin contents were found respectively: Rye, outer pericarp 22 μg/g, whole kernel 7.4—7.8 μg/g; barley, outer layers (chaff) 26 μg/g, whole grain 65—66 μg/g (max. 270 μg/g); hulled oats, outer pericarp 16 μg/g, whole groats 6.1—6.6 μg/g (hulls removed by hand 5.6 μg/g).

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