LXV. THE SUPPLEMENTARY RELATIONSHIPS BETWEEN THE PROTEINS OF WHEAT AND RYE BREADS AND THOSE OF THE PEA (*PISUM SATIVUM*).

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It has been reported by Kon and Markuze [1931] that a supplementary relation exists between the proteins of soya bean flour and those of wheat and rye flour. The present paper deals with the effect of an addition of pea meal (from *Pisum sativum*) to the two latter substances on the biological value of their proteins.

EXPERIMENTAL.

The biological values of the proteins of pea meal, rye bread (baked from 70 % rye flour by the Municipal Bakeries in Warsaw), of two mixtures of wheat rolls and pea meal and of two mixtures of rye bread and pea meal have been determined by the method of Osborne *et al.* [1919].

The bread was dried at 35° and the dry product ground in a mill. The peas were boiled, dried and ground. The following mixtures were used: wheat-pea mixture I; wheat rolls 80 %, pea meal 20 %; wheat-pea mixture II; wheat rolls 60 %, pea meal 40 %; rye-pea mixture I; rye bread 80 %, pea meal 20 %; rye-pea mixture II; rye bread 60 %, pea meal 40 %. The nitrogen contents of the above products are given in Table I. The composition of the diets is given in Table II. The biological values of the proteins were, in most cases, estimated at

Table I.

Product examined	Protein content (calculated on dry wt.) N × 6.25 (%)	Ratio of bread- to pea-proteins
Rye bread from 70 % rye flour	7.4	—
Pea meal	26.2	—
Wheat-pea mixture I	14.0	1.8 : 1
Wheat-pea mixture II	16.8	1 : 1.5
Rye-pea mixture I	11.2	1.1 : 1
Rye-pea mixture II	14.6	1 : 2.4

several levels of protein intake. Albino rats bred in the laboratory were used in the experiments. The technique of the tests was as described by Kon and Markuze [1931]. The results will be found in Table III.

It will be seen from the tables that for the pea-meal-proteins alone a biological value of from 1.2 to 1.4 was found at 3 levels of protein intake. On the other hand the values found for the wheat-pea mixture I were from 1.6 to 1.9, while

Table II.

All values refer to dry weights

Source of protein	Composition of diets			
	Level of protein intake ($N \times 6.25$)			
Rye bread from 70% rye flour		7.1%		
	Bread	95		
	Salts*	5		
Pea meal		Level of protein intake ($N \times 6.25$)		
		6.2%	8.2%	12.5%
	Pea meal	22.9	30.5	45.8
	Butter fat	10.0	10.0	10.0
	Salts	5.0	5.0	5.0
	Potato starch	62.1	54.5	39.2
Wheat-pea mixture I		Level of protein intake ($N \times 6.25$)		
		6.1%	8.8%	11.2%
	Mixture	42.8	57.1	80.0
	Butter fat	10.0	10.0	10.0
	Salts	5.0	5.0	5.0
	Potato starch	42.2	27.9	5.0
Wheat-pea mixture II		Level of protein intake ($N \times 6.25$)		
		6.3%	8.1%	11.0%
	Mixture	35.7	47.6	65.5
	Butter fat	10.0	10.0	10.0
	Salts	5.0	5.0	5.0
	Potato starch	49.3	37.4	19.5
Rye-pea mixture I		Level of protein intake ($N \times 6.25$)		
		6.2%	8.2%	10.5%
	Mixture	53.5	71.4	95.0
	Butter fat	10.0	10.0	—
	Salts	5.0	5.0	5.0
	Potato starch	31.5	13.6	—
Rye-pea mixture II		Level of protein intake ($N \times 6.25$)		
		6.3%	8.5%	11.8%
	Mixture	41.0	55.0	75.5
	Butter fat	10.0	10.0	10.0
	Salts	5.0	5.0	5.0
	Potato starch	44.0	30.0	9.5

* Steenbock and Nelson's [1923] salt mixture No. 40.

the second wheat-pea mixture gave at all three levels a value of at least 2.0, *i.e.* twice that found by Kon and Markuze [1931] for the proteins of wheat rolls. In all cases the biological value of the proteins of the mixtures exceeds that of the proteins of the separate constituents.

A similar supplementary relation was also found for the rye-pea mixtures. In the case of the rye-pea mixture I the biological value was 2.0 and 2.1 for the two lower levels and 1.6 for the highest level; it varied from 1.5 to 1.6 for all three levels of the second mixture. Rye bread alone gave a definitely lower value of 1.1. Owing to its low nitrogen content this bread could be fed only at one level of protein intake.

Results similar to those found in the case of wheat-pea mixtures have been observed when wheat gluten was fed to rats either as the sole source of protein or combined with pea meal. The mixture was composed of 80 % of pea meal and 20 % of wheat gluten (containing 84.2 % of protein). The two diets were fed

Table III.

Source of protein in diet	Protein (N × 6.25) content*	Rat no.	Days	Total intake		Initial wt. g.	Gain in wt. g. = <i>b</i>	Bio- logical value of protein <i>b/a</i>	Mean
				Food* g.	Protein* g. = <i>a</i>				
Rye bread from 70% rye flour	7.1	827 ♀	31	236.8	16.8	66	14	0.83	1.14
		902 ♀	31	346.5	24.6	61	30	1.22	
		903 ♀	31	329.6	23.4	64	27	1.15	
		830 ♀	31	303.1	21.5	69	29	1.35	
Pea meal	6.2	786 ♀	31	183.1	11.3	46	14	1.24	1.21
		789 ♂	31	177.3	11.0	45	13	1.18	
	8.2	785 ♀	31	200.0	16.4	45	20	1.22	1.21
		788 ♂	31	223.3	18.3	49	22	1.20	
	12.5	784 ♀	31	242.0	30.2	40	41	1.36	1.38
		787 ♀	31	245.8	30.7	41	43	1.40	
Wheat-pea mixture I	6.1	745 ♀	31	302.5	18.4	55	35	1.90	1.92
		746 ♀	31	235.7	14.4	60	28	1.94	
	8.8	747 ♀	31	306.7	27.0	60	45	1.67	1.57
		749 ♂	31	285.8	25.1	58	37	1.47	
	11.2	748 ♀	31	349.8	39.2	63	66	1.68	1.77
		750 ♂	31	264.4	29.6	68	55	1.86	
Wheat-pea mixture II	6.3	752 ♀	31	285.9	18.0	54	39	2.17	2.11
		755 ♂	31	294.3	18.5	60	38	2.05	
	8.1	753 ♀	31	319.5	25.9	53	49	1.89	2.08
		754 ♀	30	330.8	26.8	53	61	2.27	
	11.0	740 ♀	31	330.8	36.4	59	80	2.20	2.00
		751 ♀	31	401.5	44.2	68	84	1.90	
Rye-pea mixture I	6.2	829 ♀	31	256.1	15.9	55	40	2.51	1.99
		833 ♂	31	250.3	15.5	75	25	1.61	
		881 ♀	31	304.8	18.9	49	35	1.85	
	8.2	831 ♀	31	311.2	25.5	62	55	2.16	2.07
		832 ♂	31	337.3	27.7	76	55	1.98	
	10.5	826 ♀	31	322.9	33.9	72	54	1.59	1.56
837 ♂		31	299.2	31.4	56	48	1.53		
Rye-pea mixture II	6.3	840 ♀	31	288.5	18.2	56	30	1.65	1.56
		843 ♂	31	368.1	23.2	68	34	1.46	
	8.5	841 ♀	31	356.0	30.3	64	47	1.55	1.52
		844 ♂	31	355.0	30.2	71	45	1.49	
	11.8	842 ♀	31	341.8	40.3	74	56	1.39	1.47
		845 ♂	31	349.0	41.2	79	64	1.55	

* Calculated on dry weight.

Table IV.

Source of protein	Composition of diet* %		Protein (N × 6.25) content* %	Rat no.	Days	Total intake		Initial weight g.	Gain in weight g. = b	Biological value of protein b/a	Mean
						Food* g.	Protein* g. = a				
Wheat gluten	Gluten	14.2	11.8	966 ♂	31	195.6	23.1	46	22	0.95	1.00
	Butter fat	10.0		967 ♂	31	187.2	22.1	43	20	0.90	
	Salts	5.0		968 ♂	31	244.0	29.0	47	33	1.14	
	Potato starch	70.8									
Gluten-pea mixture	Mixture	34.2	11.6	983 ♀	31	264.0	30.6	58	57	1.86	2.24
	Butter fat	10.0		984 ♀	31	294.2	34.1	57	78	2.29	
	Salts	5.0		985 ♂	31	285.0	33.1	56	85	2.57	
	Potato starch	50.8									

* Calculated on dry weight.

only at one level of protein intake; their composition and the results of the animal tests are given in Table IV. The biological value of the gluten proteins was found to be 1·0, which corresponds closely with the value obtained by Kon and Markuze [1931] for wheat roll proteins. The biological value of the proteins of the gluten-pea mixture is 2·2, *i.e.* about twice as great as in the case of wheat gluten alone and almost double that of the proteins of pea meal.

SUMMARY.

1. The biological values of the proteins of wheat gluten, of rye bread baked from 70 % rye flour, of pea meal and of mixtures in various proportions of pea meal with wheat rolls, rye bread and wheat gluten have been determined by the method of Osborne, Mendel and Ferry.
2. A supplementary relation exists between the proteins of wheat rolls and rye bread and those of pea meal.
3. The same is true in the case of a mixture of wheat gluten and pea meal.

REFERENCES.

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