AGENCY FOR INTERNATIONAL DEVELOPMENT
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Batch #26

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2. TITLE AND SUBTITLE

Improving the nutritive value of cereal based foods,progress report 1968

3. AUTHOR(S)

(101) Kan. State Univ. Food and Feed Grain Inst.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1968	177p.	ARC 664.72.K16a

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Kan. State

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

(Research summary)

9. ABSTRACT

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	14. CONTRACT NUMBER: CSD-1586 Res.
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Improving the Nutritive Value of Cereal Based Foods

Progress Report No. 1

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Improving the Nutritive Value of Cereal Based Foods

Progress Report No. 1

Jan. - Dec., 1968

Final authorization for initiation of this research project was received in January, 1968. This report constitutes essentially the progress made during the first year under the contract.

The general objective of this research project is designed to improve the nutritional value of wheat-based food by supplementation and process modification without decreasing the food acceptability to the consuming people in North Africa and Pakistan. The studies were to be conducted in two parts. One deals with wheat product supplementation with lysine or protein concentrates and vitamins and minerals to determine the best nutritionally economical blends which will result in highly acceptable finished foods. The other part deals with process modifications to maximize the recovery of the nutritionally valuable constituents of wheat.

Both specific objectives are to be carried out in three phases; i.e., a survey phase, an experimental phase, on a field testing phase. The survey phase has been essentially completed although a follow-up trip may be needed as more information is developed as the experimental phase progresses.

This report will cover the progress made in the survey phase and experimental phase of the project.

PHASE I - THE SURVEY PHASE

The purposes of the survey phase were as follows:

1. To gain first-hand knowledge about North Africa and Pakistan including:

    a. geography
    b. agriculture
    c. economy
    d. characteristics of the population
    e. history

2. To learn as much as possible about couscous and chapatis

    a. composition
    b. preparation
    c. consumption
    d. commercial processing

3. To determine dietary patterns and food consumption data

    a. average
    b. typical daily diets and intakes

4. To obtain information about the nutritional status of the population segments

5. To evaluate grain production, marketing and processing

    a. production, current and potential
    b. marketing and prices
    c. milling
    d. commercial processing of milled food products

6. To determine potential indigenous sources of nutrients

7. To obtain samples of grains, nutrient sources, and sample foods for analysis and evaluation

8. To determine pertinent research groups and research in each country

9. To establish contacts for cooperative in-country testing and development

To carry out these objectives, a trip was made by Dr. Charles Deyoe, Dr. William Hoover, and Prof. Arlin Ward during March, 1968, to Morocco, to FAO headquarters in Rome, Italy, and to Pakistan. It would be impractical to detail the mass of knowledge and information accumulated on this trip. It was felt that we had accomplished to varying degrees the nine purposes previously listed.

One finding is worthy of special mention. From information about typical daily food intakes, it became obvious that couscous, while important in the Moroccan diet, no longer represents the basic food position of bread. For this reason, we decided to include Arab bread along with couscous in the supplementation studies to be carried out in the experimental phase.

However, to give an indication of the extent of the information gathered on the pages immediately following will be found:

1. Informational materials acquired

   a. Morocco
   b. Pakistan
   c. Food and Agricultural Organization

2. Samples and process information obtained. (Actual samples not attached to sheets in this report. These sheets are duplicates of those appearing in our project master files which do have the samples mounted in the small squares on the sheets.) Enough of each sample was acquired for chemical and physical analysis.

   a. Morocco
   b. Pakistan

3. Pertinent contacts established

A number of photos were taken to tell the story to the team working on this project. Slides and movies were also made to show the techniques used in Morocco and West Pakistan in producing and processing their grain and grain products.

INFORMATIONAL MATERIALS ACQUIRED IN MOROCCO

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2. Simplified Handbook on Nutrition for Personnel Conducting Feeding Programs Overseas, Melvin B. Myers (2 copies)
3. L'Economie Cerealiere au Maroc, Etude Statistique, Abd el Khalek Kebbaj (French)
4. Geographie du Maroc, J. Martin, H. Jouer, J. Le Coz, G. Maurer, and D. Noin (French)
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6. Les Cultures Oleagineuses (French)
7. Bureau d'etudes et de participations industrielles (French)
8. Morocco Tourism, Jean Delage, Editor
9. Cereal Production and Marketing Procedures in Morocco, Floyd L. Corty, Agricultural Economist, USAID (2 copies)
10. Morocco - Role of Fertilizer in Agricultural Development with special emphasis on wheat, Thurman M. Kelso, Ralph E. McKnight, John L. Nevins, and Darrell A. Russell
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13. Le concentre de proteines (French)
14. Senegal Project 170
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17. La production industrielle d'aliments enrichis en proteines dan les pays en cours de developpement by Aldo Buffa (French)
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20. Rapport d'une enquete par sondage sur l'etat de nutrition d'enfants Marocains de 1 jour a 14 ans inclus, Professeur Andre Raoult (French)

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27. Chemical Composition of "Morocco Sunflower Flour" (2 copies)

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29. Breve etude comparative entre marine proteine concentrate (farine de sardine comestible) Ichlhyoproteolyte (Proleolysat de sardines) et les proteines provenant des diverses algues fermentation des microorganismes sur paraffine (French)

30. Mixed Feed Manufacturers

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34. American Consulate General Fact Sheet, Casablanca, Morocco

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36. Country Report--Morocco--IFYE Program, 1966-67

37. Fez Cookbook, recipes of Moraccan dishes

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39. Map of Morocco

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4. Long Range Assistance Strategy, Pakistan Agriculture, 1965-85

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16. Requirements to get Self-Sufficiency in Wheat from 1968 Onward

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18. Pakistan Council of Scientific and Industrial Research (2 copies)

19. Brief Note on the History and Activities of the Department of Agricultural Economics, West Pakistan Agricultural University (2 copies)

20. Production of Protein Flour and Concentrates from Oil Seeds for Human Consumption

21. Data on Oil Seeds: West Pakistan

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31. Letter from Norman Borlaug, Visiting Consultant in Wheat Improvement, International Center for Maize and Wheat Improvement to President Mohammad Ayub Khan summarizing a meeting at Lyallpur on March 13, 1967.

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37. Diversification of Agriculture in East Pakistan

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47. Telephone Director, Pakistan, Northern Telecommunication Region and Lahore

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3. Report of the Joint Symposium on Industrial Feeding and Canteen Management in Europe, Rome, Italy, 2-7 September 1963
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10. Legumes in Agriculture
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21. Evaluation of the Carcinogenic Hazards of Food Additives

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28. Human Nutrition in Tropical Africa

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37. Report to the Government of Yugoslavia on Production of Rice and Oil Bearing Crops

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41. The World Rice Economy, Vol. II: Trends and Forces

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MOROCCO SAMPLES

NA – I
PART I

CASABLANCA WHOLESALE MARKET MARCH 1968

SEE PHOTOS

	70 – 68	71 – 68	72 – 68	73 – 68
	BROKEN SPLIT PEAS	FOR BIRDS	MILLET	HARICO BEAN
DIRHAM/KILO (¢/LB)				
WHOLESALE	0.70 (6.4¢)	1.30 (11.8¢)	0.70 (6.4¢)	1.50 (13.6¢)
RETAIL	0.80–0.85 (7.3–7.7¢)	1.50 (13.6¢)	0.80 (7.3¢)	1.70 (15.4¢)

	74 – 68	75 – 68	7[illegible] – 68	77 – 68
	AMERICAN [illegible]ORN	MOROCCAN BEANS	TO MAKE OI[illegible] [illegible]	WHITE CORN FROM FEZ
DIRHAM/KILO (¢/LB)				
WHOLESALE	[illegible]	1.40 (12.7¢)	[illegible]	[illegible]
RETAIL	[illegible]	1.60–1.65 (14.5–15¢)	[illegible]	[illegible]85 (7.7¢)

	78 – 68	79 – 68	80 – 68	81 – 68
	LENTILLE	HORSE BEANS (BROAD BEANS)	CHICK PEAS (BIG & CLEAN)	MOROCCAN NYLON LENTILLE
DIRHAM/KILO (¢/LB)				
WHOLESALE	1.20 (10.9¢)	0.85 (5.9¢)	[illegible]	[illegible]
RETAIL	1.40 (12.7¢)	0.80 (7.3¢)	[illegible]	1.70–1.75 (15.4–15.9¢)

	82 – 68	83 – 68	84 – 68	85 – 68
	CHICK PEAS	GOOD HORSE BEANS (BROAD BEANS)	HALBA-EAT IN MORNING WITH OIL AS SOUP COURSE	P[illegible] HORSE BEANS (BROAD BEANS)
DIRHAM/KILO (¢/LB)				
WHOLESALE	0.85 (7.7¢)	0.70 (6.4¢)	1.20 (10.9¢)	0.50 (4.5¢)
RETAIL	1.00–1.05 (9.1–9.5¢)	0.85 (7.7¢)	1.35–1.40 (12.3–12.7¢)	0.70 (6.4¢)

NA – 2 PART II

MOROCCO SAMPLES

CASABLANCA WHOLESALE MARKET — MARCH 1968

SEE PHOTOS

	86 - 68	87 - 68	88 - 68	89 - 68
	EILLAN – GIVEN TO A BOY WHO IS NOT HEALTHY, OR BREAKS A BONE, OR TO MOTHER WHO IS GIVING NO MILK.	COCO BEANS CASABLANCA	WHITE CORN	YELLOW CORN (2ND SAMPLE)
DIRHAM / KILO (¢ / LB)				
WHOLESALE	2.25 (20.4¢)	2.00 (18.2¢)	0.70 (6.4¢)	0.60 (5.4¢)
RETAIL	2.50 (22.7¢)	2.30 (20.9¢)	0.85–0.90 (7.7–8.2¢)	0.85 (7.7¢)

	90 68	91 – 68	92 – 68	93 - 68
	OATS	#1 DURUM	#2 DURUM	DURUM
DIRHAM / 100 KILO	50.00	75.00	70.00	[illegible] 00
DIRHAM / KILO (¢/LB) WHOLESALE	0.50 (4.5¢)	0.75 (6.8¢)	0.70 (6.4¢	[illegible].60 (5.4¢)

	94 – 68	95 – 68
	BARLEY	CORN
DIRHAM / 100 KILO	37.00	40.00
DIRHAM / KILO (¢/LB) WHOLESALE	0.37 (3.4¢)	0.40 (3.6¢)

MOROCCO SAMPLES

NA-3
MARCH 1968

SAMPLES COURTESY DR. EDWARDS AID AND INSTITUTE NATIONAL DE LA RESEARCH AGRONOMIQUE RABAT

307-68 2777	308-68 3225	309-68 3424
310-68 BT 2306	311-68 BT 2511	312-68 BT 908
313-68 BT 3597	314-68 INRHM 383 HYBRID DOUBLE	315-68 D117 HYBRID DOUBLE
316-68 Tx21 TOP CROSS	317-68 Tx23 TOP CROSS	318-68 SH 20 HYBRID MAWCAIN

MOROCCO SAMPLES

NA-4
MARCH, 1968

SAMPLES COURTESY DR. EDWARDS AID AND INSTITUTE NATIONAL DE LA RESEARCH AGRONOMIQUE RABAT

319-68
VAR. ROUGEDE TAZA
SORGHUM VULGARE PEIS

320-68
VAR. TISSA SORGHUM
VULGARE PEIS

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MOROCCO SAMPLES
FEZ MEDINA MARKET

NA—5
MARCH 8 1968

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BARLEY-COARSE PARTICLES FOR SOUP

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SPLIT-GREEN PEAS

40-68
BARLEY-MEDIUM PARTICLES FOR BREAD

41-68
COW - PEAS

42-68
LENTIL

43-68
PEANUTS ROASTED

44-68
HORSE-BEANS (BROAD BEANS

45 68
[illegible] PEAS

46-68
CHICK-PEAS TOASTED

47-68
SUNFLOWER SEED

48 68
PUMPKIN SEED

49-68
PUMPKIN SEED

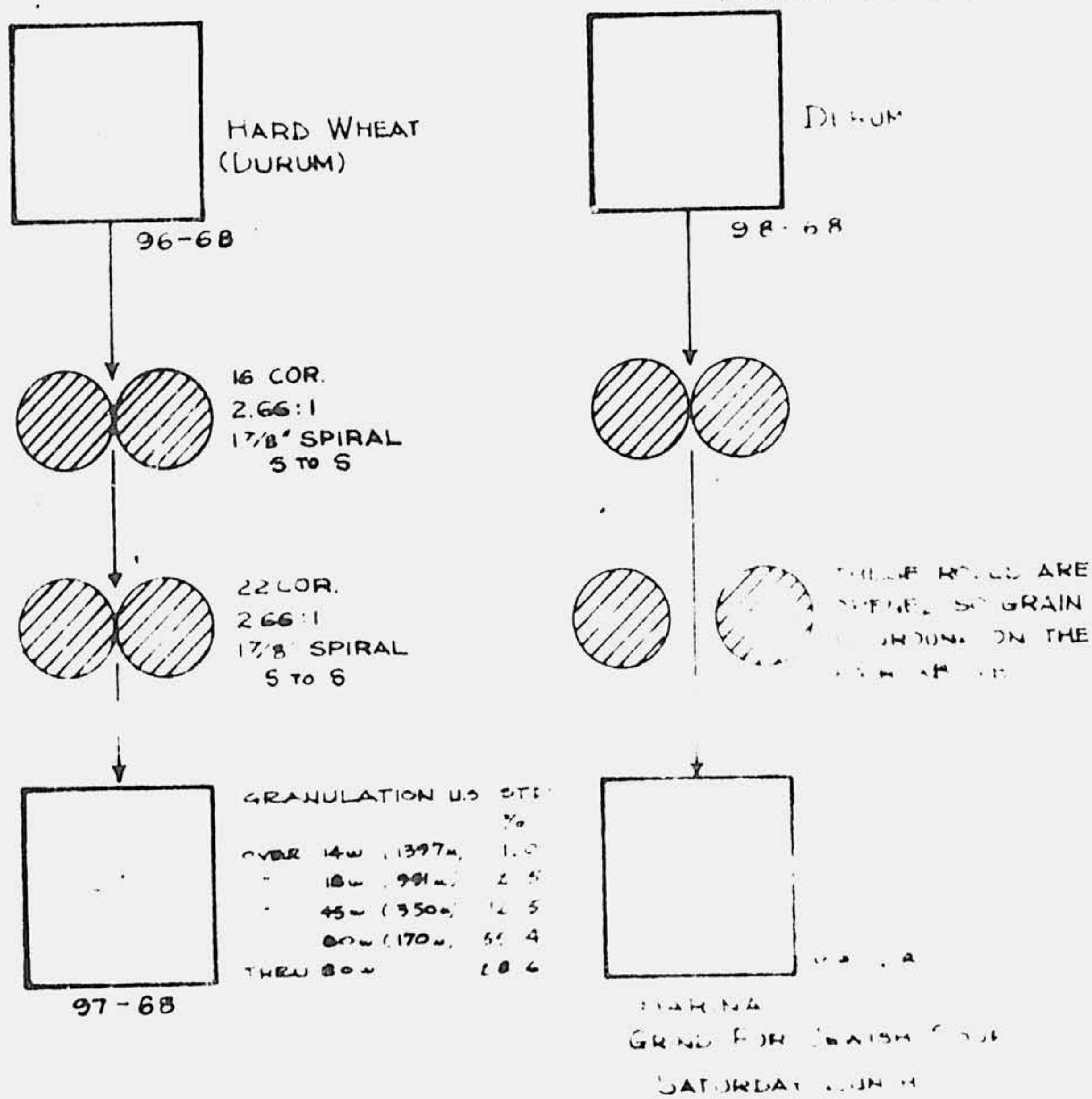
50-68
DEHULLED HORSE BEANS (BROAD BEANS)

TWO-HIGH MILL

MILL = TAHOUNA (ARABIC)

CASABLANCA MOROCCO

RABAT ZRAA CEREAL
MARCH 12 1968



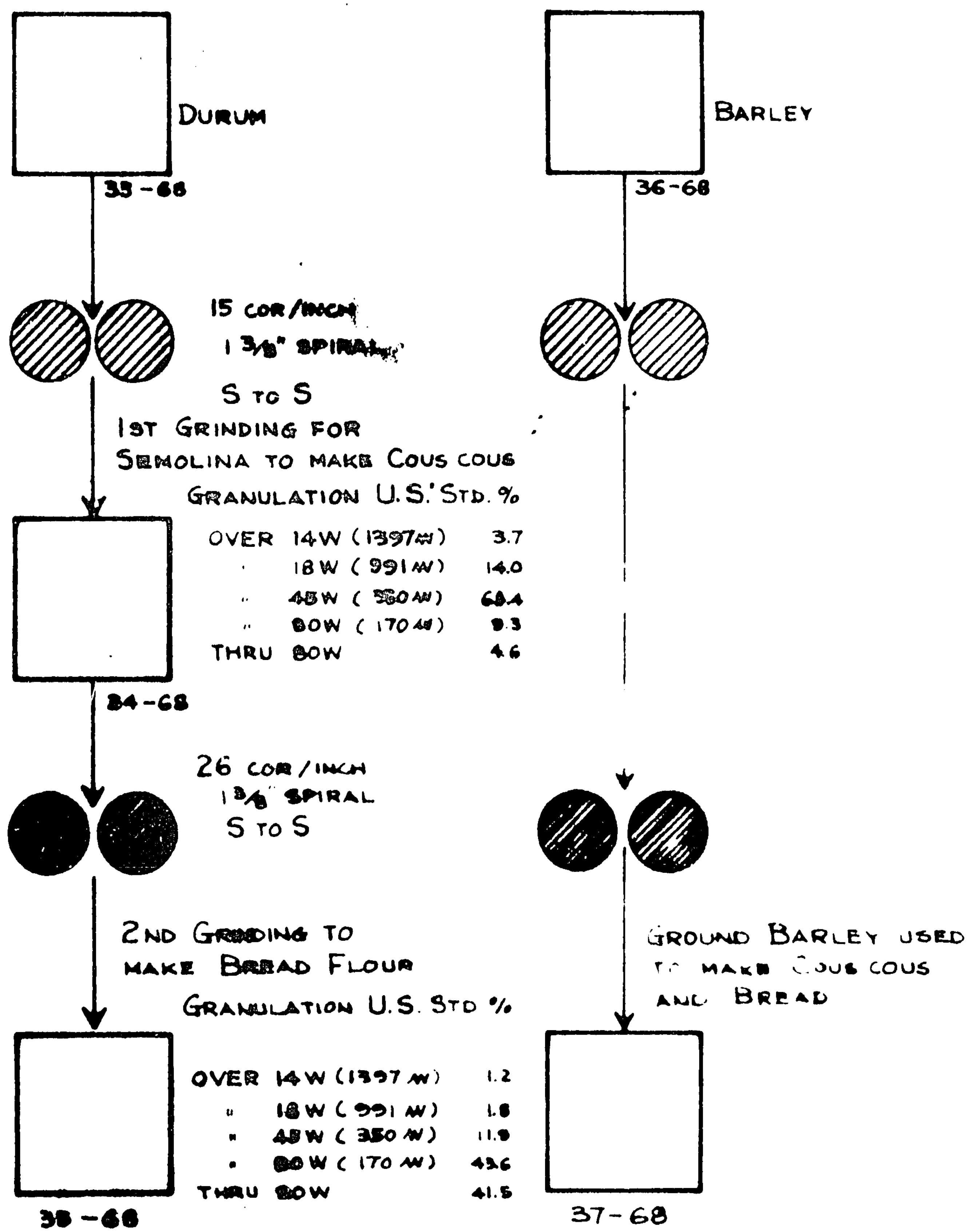
ROLLER MILL MANUFACTURED BY
TEISSET - ROSE - BRAULT
POISSY - PARIS
CHARTES

SEE PHOTOS

MOROCCO SAMPLES

TWO-HIGH MILL

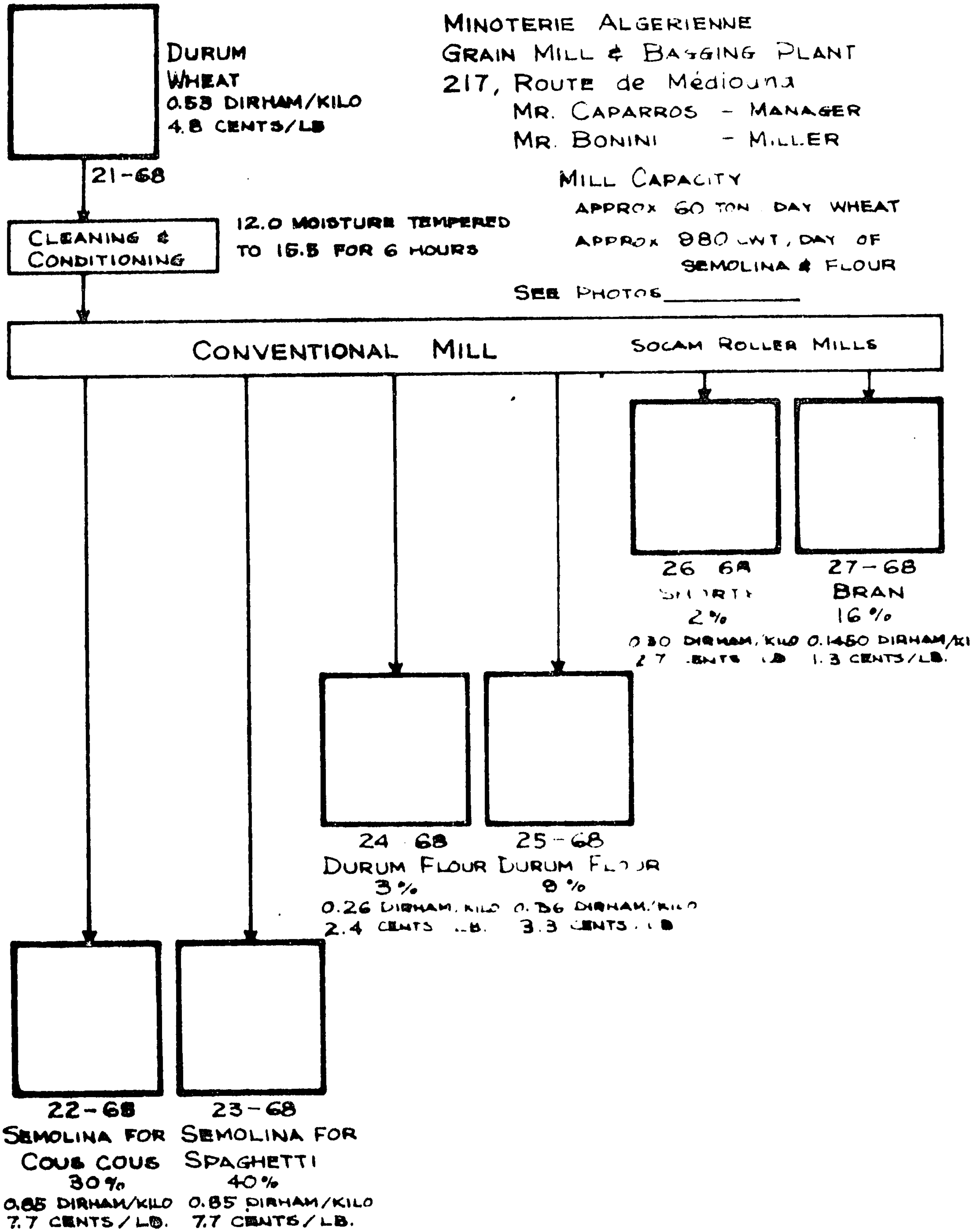
MARCH 1968
FEZ, MOROCCO
NEAR AINELKADOUSE AREA



MOROCCO SAMPLES NA-8

DURUM MILL UNIT I (REFERRED TO AS HARD WHEAT) TWO UNIT MILL

MARCH 1968



MOROCCO SAMPLES — NA-9

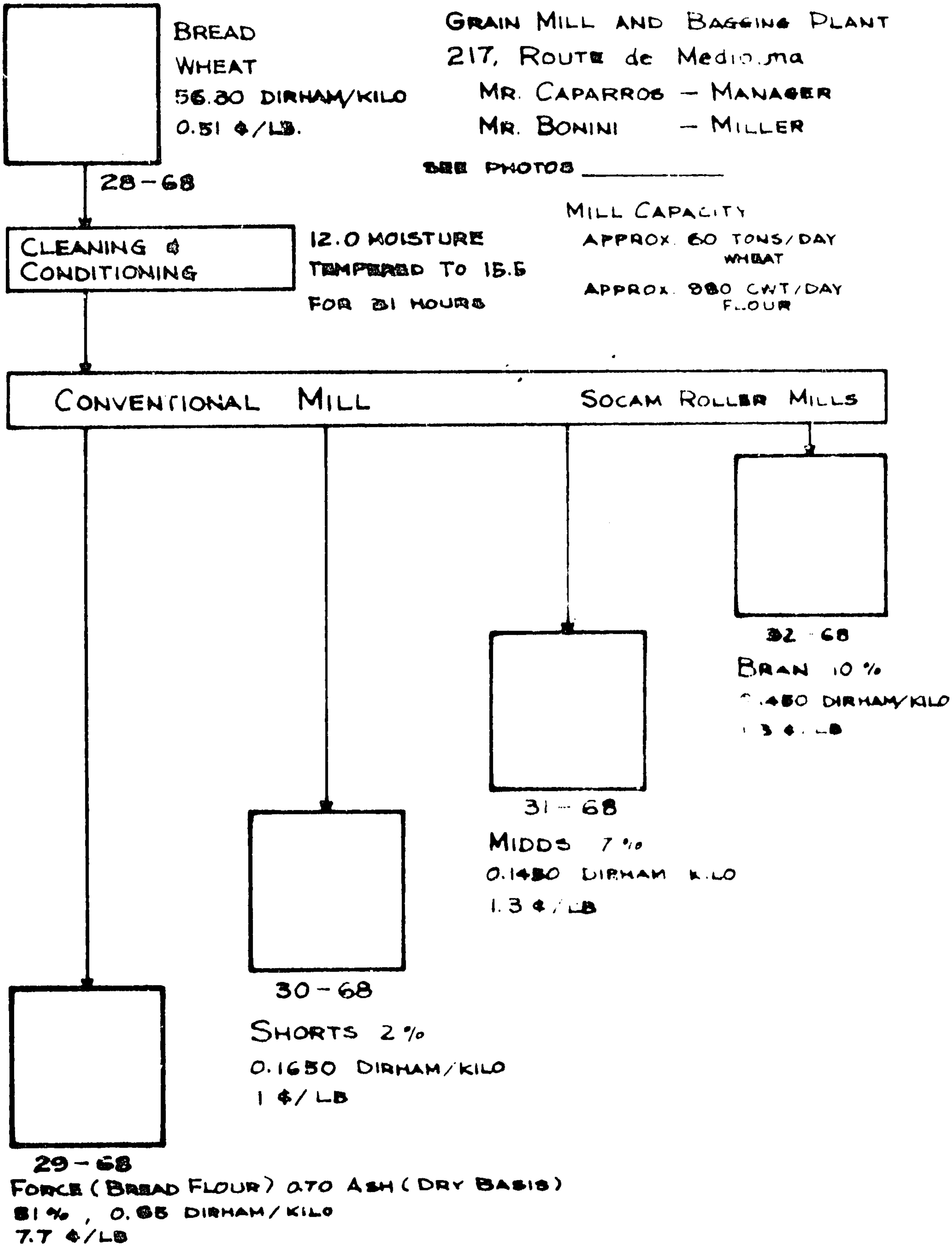
BREAD WHEAT MILL UNIT 2 — MARCH 1968

(REFERRED TO AS SOFT WHEAT)

TWO UNIT MILL

MINOTERIE ALGERIENNE
GRAIN MILL AND BAGGING PLANT
217, ROUTE de Medio.ma
MR. CAPARROS – MANAGER
MR. BONINI – MILLER

SEE PHOTOS ____________

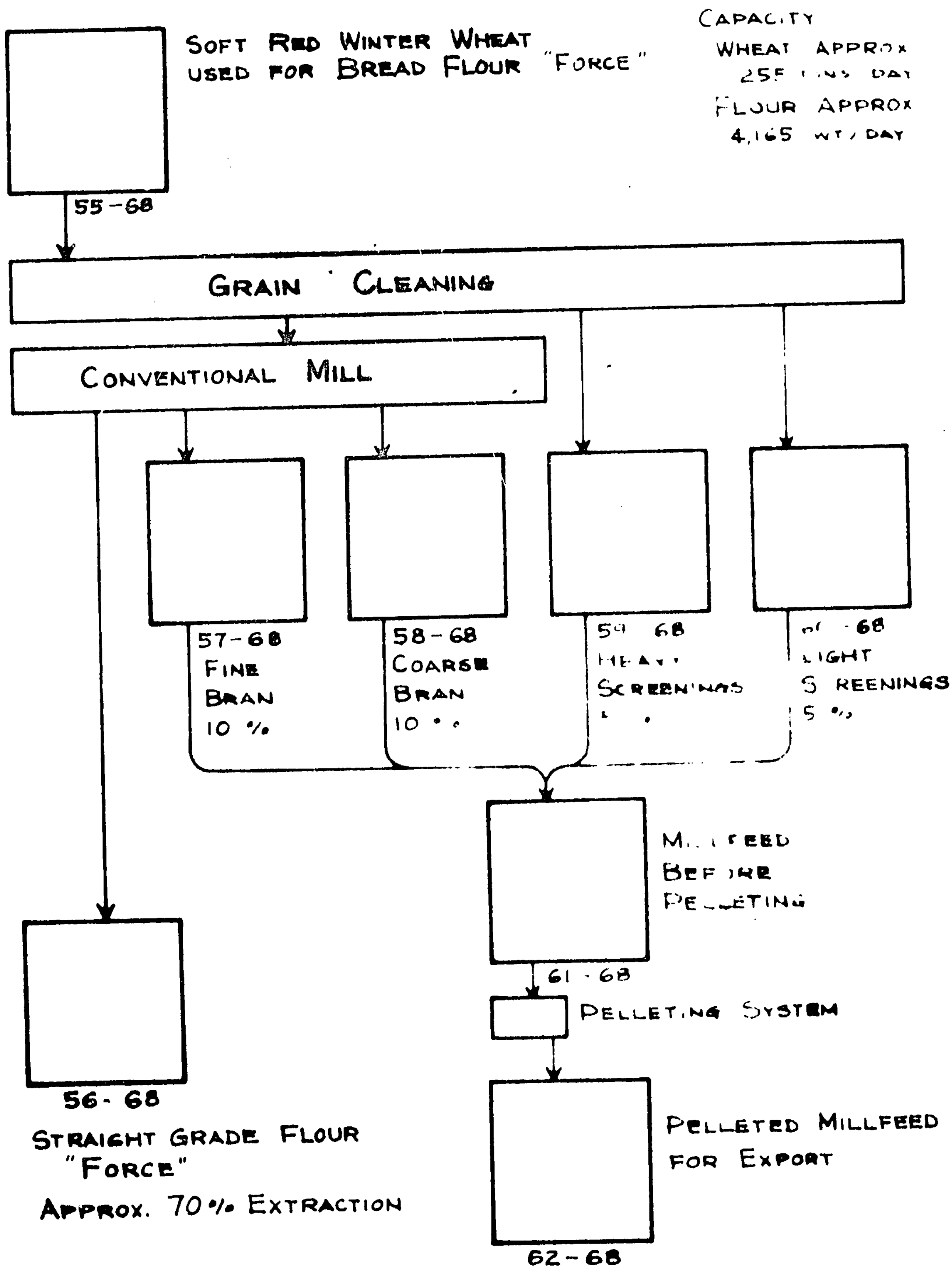


NA – 10

MOROCCO SAMPLES

COMMERCIAL FLOUR MILL — SALE, MOROCCO

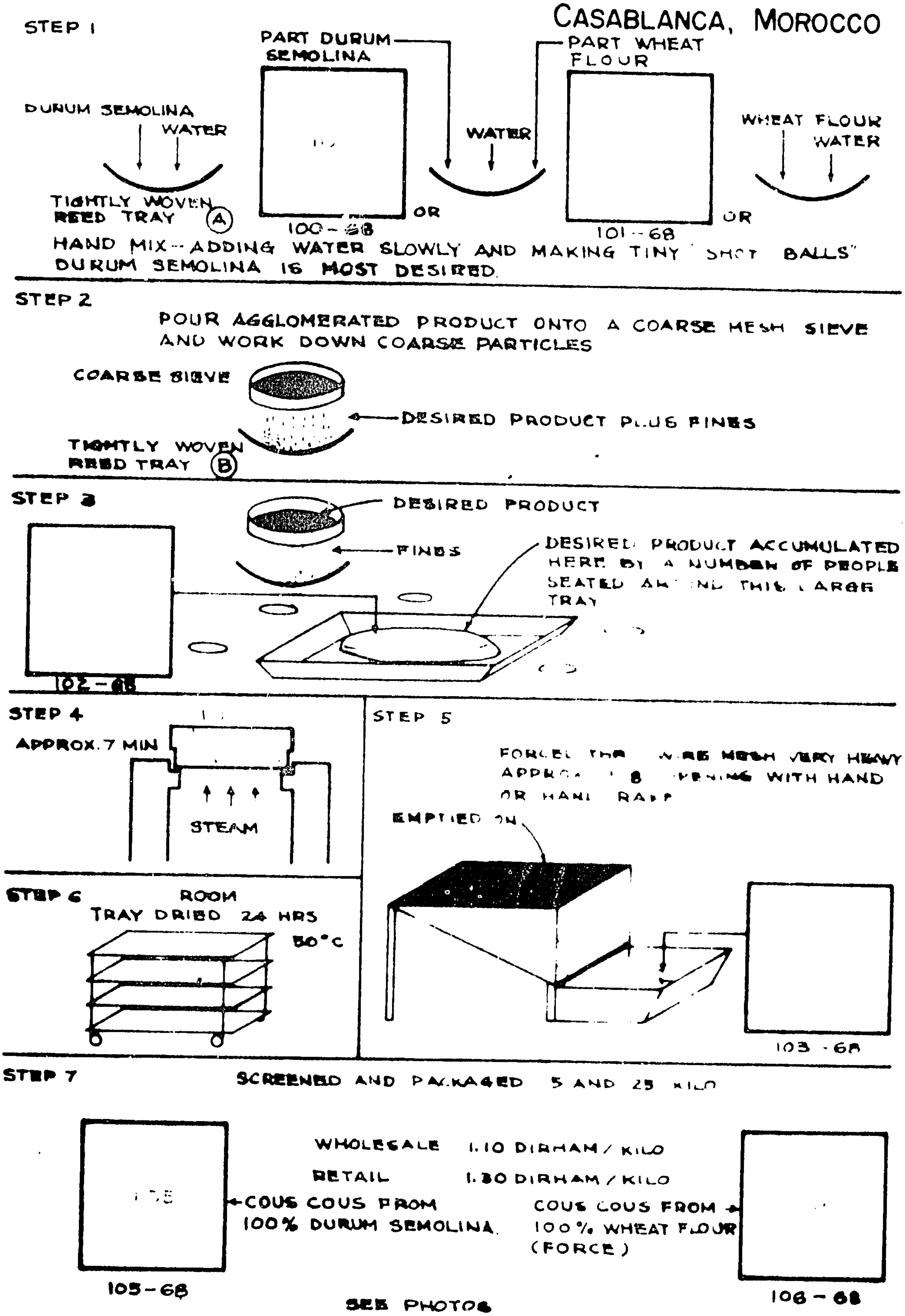
MILL USED TO GRIND BREAD WHEAT AND ALSO DURUM WHEAT — MARCH 1968



NA-11

COMMERCIAL HAND MADE COUS COUS

MARCH 1968
CASABLANCA, MOROCCO

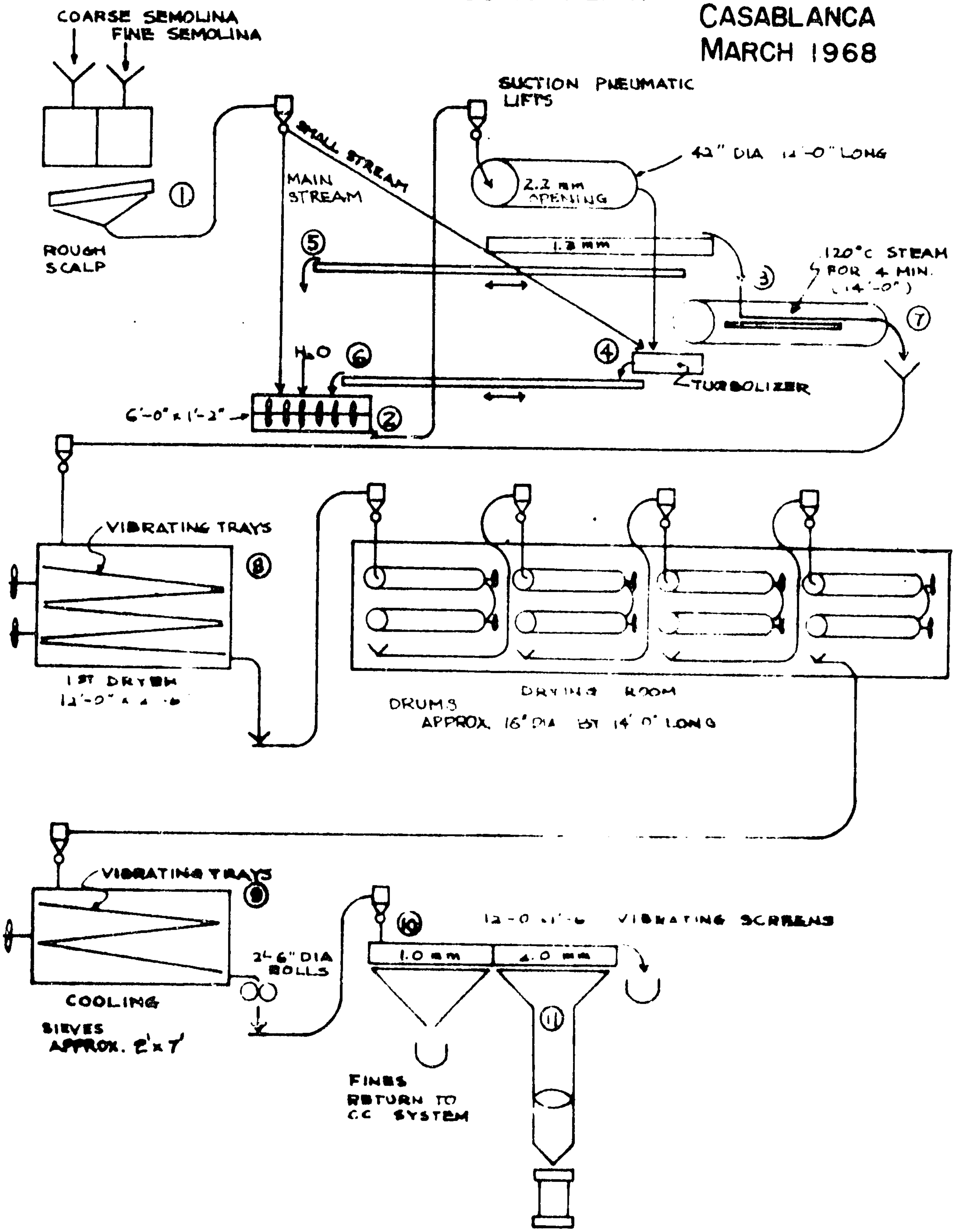


SEE PHOTOS

COUS COUS PROCESSING PLANT

NA-12

CASABLANCA
MARCH 1968



○ INDICATES SAMPLE NO.
SAMPLES ARE MOUNTED ON NA-13

NA—13

MOROCCO SAMPLES
COUS COUS PROCESSING PLANT
CASABLANCA MARCH 1968

1-68
SEMOLINA TO COUS COUS PLANT

2-68
FROM MIXER BLENDER

3-68
GOING TO STEAM COOKER

4-68
OVENS OF REEL

5-68
AFTER TURBOLIZER

6-68
FINES THR. REEL (THR. SHAKER) BACK TO MIXER

7-68
AFTER STEAM COOKING

8-68
AFTER 1ST DRYING ON VIBRATING TRAYS

9-68
COOLED PRODUCT TO ROLLS

10-68
TO REBOLT-SIZING SIEVE

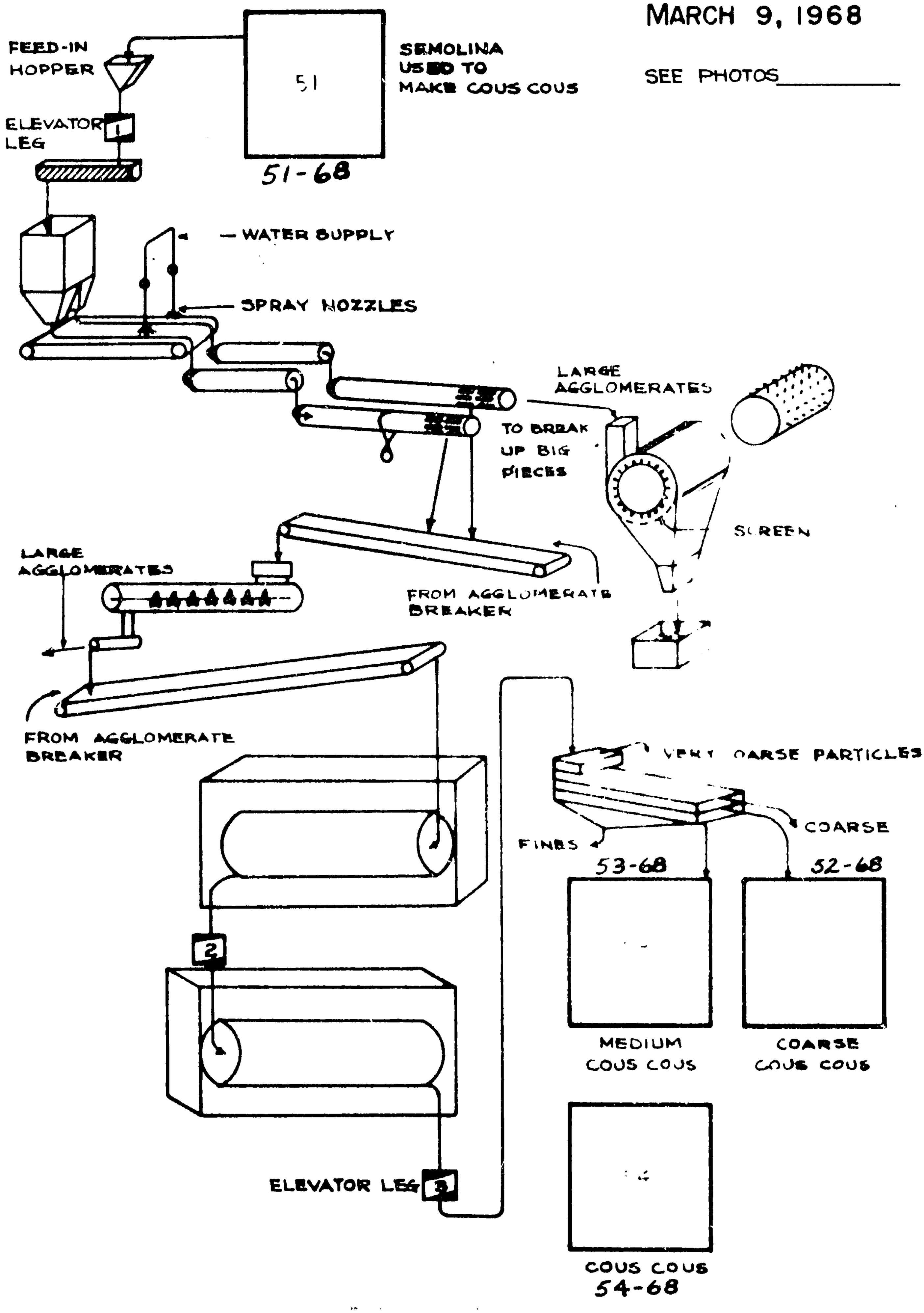
NA-14

CONTINUOUS COUS COUS PLANT

SALE, MOROCCO

MARCH 9, 1968

SEE PHOTOS________



MOROCCO SAMPLES
MISCELLANEOUS

300-68
FAMO COUS COUS
CARTON 500 GRAMS
1 LB 1 $\frac{2}{3}$ OZ.

301 68
BARUK COUS COUS
PACKAGE 500 GRAMS

[illegible] 8
BAR[illegible] [illegible]US COUS
PA[illegible]KAGE

30[illegible] 8
COU[illegible]S
PA[illegible]KAGE

304 6[illegible]
COUS COUS
PARTIAL PACKAGE

305-68
TEA
BROWN BOX

306-[illegible]8
VERMICILLI PASTA PRODUCT
YELLOW BOX

104-68
WHEAT FLOWER "FORCE"
TO MAKE PASTA PRODUCTS

MOROCCO SAMPLES — NA-16

PASTA PLANT CASABLANCA MARCH 1968

2-68
FAM[illegible] BISCUIT
[illegible] (COOKIES)

13-68
FAMO "FORCE"
BREAD TYPE
FLOUR PUT
WITH SEMOLINA

14-68
DURUM
SEMOLINA

[illegible]
[illegible]
S[illegible]LINA

16-68
FAMO
VERMICILLI

7-68
FAMO
NOVILLES

8-68
[illegible]

[illegible]

[illegible]
[illegible]NGE

FAMO	DIRHAM/KILO	[illegible]
PASTA PRODUCTS		
COUS COUS		

300-68
FAMO COUS COUS

WEST PAKISTAN SAMPLES

WP-1

MARCH 1968

COURTESY CENTRAL LABORATORY, P.C.S.I.R. KARACHI

107-68 SYNTHETIC RICE 10% F.P.C. & 90% RICE FLOUR EXTRUDED ON ITARIAN EQUIPMENT	108-68 FISH(ELASMOBRANCHII) CLASS 95% DIGESTABLE-SHARK ETC F.P.C. 85% PROT. 25% YIELD OF FISH	109-68 FAO ASTRA FISH FLOUR NO 180
110-68 MOONG BARI 50% MOONG 50% F.P.C.	111-68 GUAR SEEDS	112-68 GUAR RESIDUE OF GUAR KERNEL (INSIDE OF KERNEL) 40%-TOXIC
113-68 GUAR DETOXIFIED	114-68 GUAR GUM 60% LABORATORY PRODUCED	115-68 BISCUIT CONTAINING SHARK MEAT F[illegible] F.P.C AND [illegible] WHEAT FLOUR
116-68 RICE POLISHINGS	117-68 TWO-MINUTE RICE-FORTIFIED RICE WITH VIT B. 5 mcg/gr EXTRA VIT FROM POLISHINGS	118-68 RESIDUE-WASTE OF RICE POLISHINGS SHARK PROCESS POULTRY FEED BROILERS ONLY
119-68 FISH GLUE FROM FISH SCALES	120-68 SHRIMP POWDER 81% PROTEIN 5% FAT 8% MOIST.	121-68 FISH SCALES DELMOR

WP — 2

WEST PAKISTAN SAMPLES

SAMPLES OF SUPPLEMENTS BEING ADDED TO NAN

WEST PAKISTAN AGRIC. UNIVERSITY, LYALLPUR

MARCH 1968

SEE PHOTOS ________

182-68 RED KIDNEY BEANS	183-68 DEFATTED CORN GERM	184 68 [illegible]ORN [illegible]ERM
185-68 CORN MILL	186 68 GROUND N[illegible]T (PEANUT[illegible]	18[illegible] 68 [illegible]S [illegible] [illegible]R

NAN

a) WATER
WHEAT FLOUR (MAIDA)
NATURAL SOURING
SODA

b) WATER
WHEAT FLOUR
NATURAL SOURING
SODA
SALT

c) WATER
WHEAT FLOUR
NATURAL SOURING
SODA
SALT
YEAST

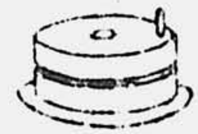
WEST PAKISTAN SAMPLES   MARCH, 1968   WP-3

GRANULATION US STD	%
OVER 14W(1397µ)	8.1
" 18W(991µ)	15.6
" 45W(350µ)	5[illegible] 1
" 80W(170µ)	11 [illegible]
THRU 80W	5 [illegible]

122-68
DOMESTIC
WHITE WHEAT

123-68
STONE GROUND DOMESTIC
WHITE WHEAT.
ATTA

WEST PAKISTAN UNIV.
OF AGRIC LYALLPUR



CHAKKI
MANUAL GRINDING MILL
PHOTO NO

124-68
WHITE WHEAT

125-68
SOFT RED
WINTER WHEAT

126-68
SORGHUM

GRAIN STORED IN
SACKS
IN GO-DOWN
(ELEVATOR)

LYALLPUR, W PAKISTAN

GRANULATION U.S STD	%
OVER 14W(1397µ)	0.0
" 18W(991µ)	2.8
" 45W(350µ)	18.4
" 80W(170µ)	42.8
THRU 80W	36.0

CHAK (VILLAGE NO 6
DAROR
NEAR LYALLPUR

127-68
WHITE WHEAT

128-68
STONE GROUND
WHITE WHEAT
ATTA

GRANULATION U.S STD	%
OVER 14W(1397µ)	[illegible]
" 18W(991µ)	[illegible]
45W(350µ)	[illegible]
" 80W(170µ)	[illegible]
THRU 80W	21.1

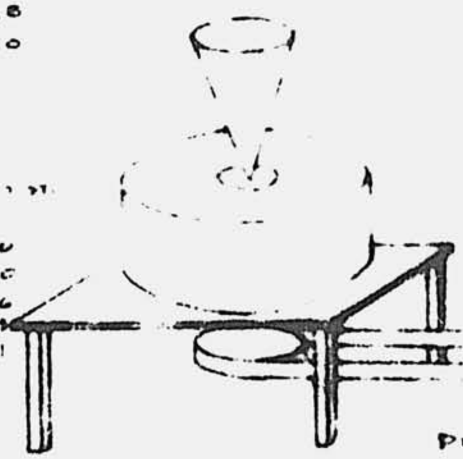


PHOTO NO.

129-68
DOMESTIC CORN.

130-68
STONE GROUND
DOMESTIC CORN

CHAKKI
POWER DRIVEN GRINDING MILL

131-68
MUNG

132-68
DEHULLED
MUNG

133-68
DEHULLED
CHICK PEAS

134-68
MASH
(BEAN)

135-68
MOTH

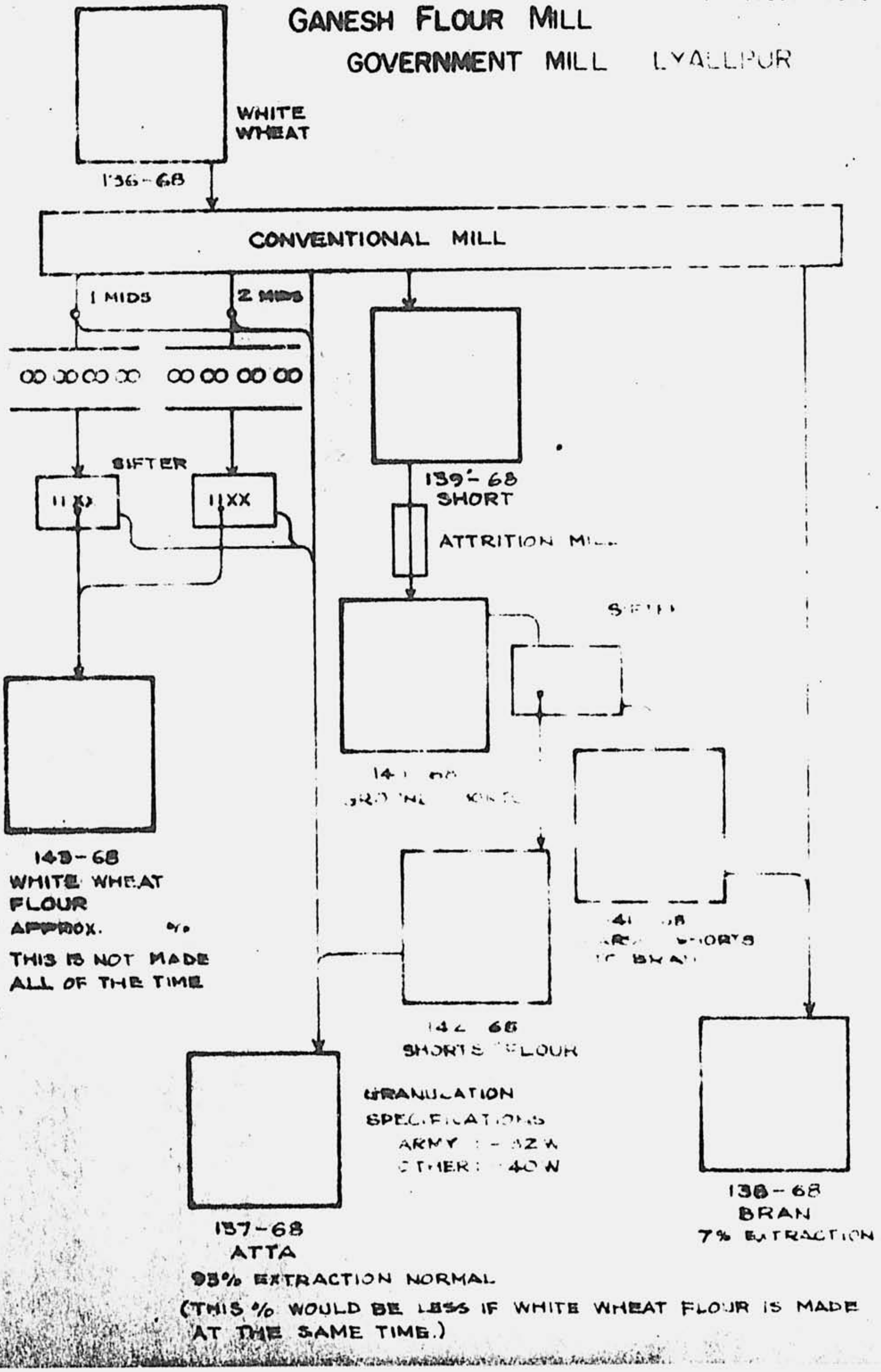
CHAK NO. 6
DAROR
VILLAGE
STORE
PHOTO NO

WEST PAKISTAN SAMPLES

MARCH 1968

GANESH FLOUR MILL

GOVERNMENT MILL LYALLPUR



WP-5

WEST PAKISTAN SAMPLES

WHOLESALE MARKET — LYALLPUR MARCH 1968

BULK PRICES PHOTOS______

MAUND [illegible] 82 LBS

RUPEE [illegible]

	144-68 BARLEY	145-68 IMPORTED CORN	146-68 MUSTARD	147-68 [illegible]SEED
RUPEES/MAUND	17.0	11.5	3[illegible]	[illegible]
CENTS/LB.	4.4	2.9	[illegible]	5.6

	[illegible]48-68 FLAX	149-68 MUNG	[illegible]-68 [illegible]	[illegible]-68 [illegible]CBIA SIMILAR TO SOY BEAN
RUPEES/MAUND	40.0	[illegible]	[illegible]	[illegible]
CENTS/LB.	10.2	[illegible]	[illegible]	[illegible]

	152-68 RICE (ALSO EXPORTED)	153-68 RICE (ALSO EXPORTED)	[illegible]54-68 [illegible]E
RUPEES/MAUND	57.0	[illegible]	[illegible]
CENTS/LB.	14.6	14.[illegible]	[illegible]

WP— 5B

WEST PAKISTAN SAMPLES
WHOLESALE MARKET – LYALLPUR MARCH 196
BULK PRICES PHOTOS

	170-68 PAK. WHEAT MIXED 2734 C[illegible]	171-68 PAK. RED WHEAT MIXED PUNJAMO	172-68 MILLET (BAJRA)	173-68 PAK WHITE SORGHUM (JOWAR)
RUPEES/ MAUND	18-21	16-17.5	18.5	20.0
CENTS/ LB.	4.6-5.4	4.1-4.5	4.7	5.1

	174-68 GRAM CHICK PEA BLACK	175-68 WHITE GRAMS	[illegible] [illegible]	177-68 BLANK
RUPEES/ MAUND	26.0	30.0	[illegible]	[illegible]1.5
CENTS/ LB.	6.6	7.7		4.5

	178-68 OIL SEED	179-68 BLACK MASH	180-68 CORN
RUPEES/ MAUND	55.0	30.0	16.5
CENTS/ LB.	14.1	7.7	4.2

WEST PAKISTAN SAMPLES — MARCH 1968

RETAIL MARKET — BULK PRICES LYALLPUR

MAUND = 82 LB
[illegible] LB = 0.0476194

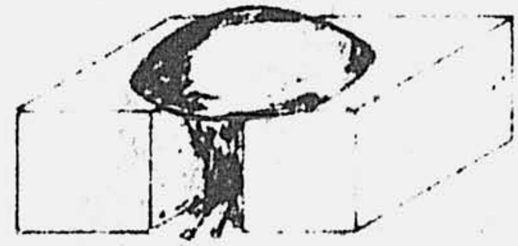
	155-68 WHITE FLOUR	156-68 SUJI (FARINA)	157-68 BAKING [illegible]	[illegible]-68 [illegible] PLANTS [illegible] HAIR [illegible]
RUPEES/MAUND	38.0	40.0	2[illegible]	[illegible]
CENTS/LB.	9.7	10.2	[illegible]	[illegible]

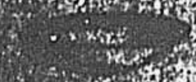
	159-68 [illegible]	160-68 ROASTED PEANUTS	[illegible]-68 [illegible]	[illegible]-68 TEA
RUPEES/MAUND	[illegible]	40.0	[illegible]	[illegible]
CENTS/LB	4[illegible]	10.2	[illegible]	[illegible]

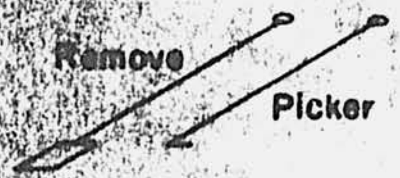
	163-68 TEA	[illegible]-68 DEHULLED [illegible] GRAM (CHICK PEA)	[illegible]	[illegible]-68 [illegible] GRAM ([illegible] PEAS)
RUPEES/MAUND	3[illegible]	[illegible]	[illegible]	37.[illegible] OR 31.[illegible]
CENTS/LB	[illegible].0	[illegible]9		9.5 OR 7.9

	167-68 LINTELS	[illegible]68-68 DEHULLED MASH	169-68 SPLIT MASH	181-68 GRAM (CHICK PEA)
RUPEES/MAUND	35.0	44.0	37.0	33.0
CENTS/LB.	9.0	11.3	9.5	8.4

2) LOH (LIKE TAWA)



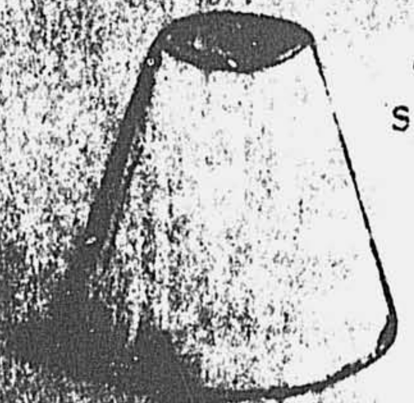




20-24"
Diameter
For big families or at time of marriages

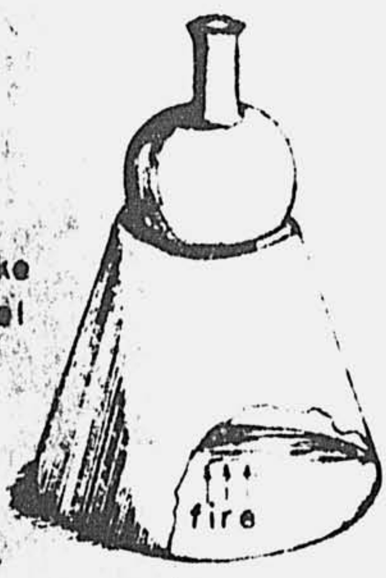
a. TANDOORI (LARGE)

b. TANDOOR (SMALL)



Sticking Pad

[illegible] to hold
and preserve heat



[illegible] families take
[illegible] ...ying fuel
for a common
tandoori

Some of these in old marketing areas of towns

WEST PAKISTAN INDEX

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PHASE II - THE EXPERIMENTAL PHASE

MATERIALS

The processing of grain and other food products is done in many different ways. A study of the present methods used in Morocco and West Pakistan was made. Samples of the grain and grain products were procured from the processing plants.

Grain and other available products that would be potential supplements for cereal based foods were procured. When possible simplified flow diagrams were made showing the procedures used in processing. The local market place--both wholesale and retail--were visited and samples were obtained wherever possible. The section of this report beginning on page 12 indicates the type of materials and process products obtained.

After identifying the samples obtained in Morocco and West Pakistan, we have been procuring similar materials in the United States with which to work. Some of these are depicted on the next two pages.

The potential nutrient supplements can be derived from fractions of the native materials, from protein concentrates, or from synthetic nutrients. The following supplemental materials have been obtained and are currently under study: Peanut flour; fish protein concentrate; soy isolate; soy flour; high lysine corn grits; corn-soy-milk (CSM); grain sorghum protein concentrate; wheat protein concentrate; glandless cottonseed flour; horsebean flour; chick pea flour; yeast concentrate; and L. Lysine-HCl.

AID-F-2
JUNE 1968

SAMPLES FROM
DOWNTOWN HEALTH AND FOREIGN FOODS
LAWRENCE, KANSAS

34- - 6

G .R A JZOS
(IC PEAS)

344-68
FEVEROLES

3 5 6
UNG BEA

346 68
LENTILS (RA ED)

347-68
HORSE (BRA. BE

PILLSBURY COMPANY
ATCHISON, KANSA

348-6
GROUND SHORT
PILLCO SP CIAL
CODE 4806

PRODUCTS FOR FORTIFICATION AID-F-7

391-68
BROWN GRAMS
PAKISTAN P[illegible]

392-68
WHITE GRAMS
PAKISTAN C727

393-68
CSM
[illegible]
[illegible]

394-68
PEANUT FLOUR

395-68
FISH FLOUR

MILLING AND PROCESSING OF PRODUCTS AND SUPPLEMENTS

Techniques have been worked out to produce materials similar to the native products in analytical properties as well as physical properties such as particle size. A considerable amount of material for couscous manufacture and also atta for making chapati and roti products has been produced. We are developing a better understanding of the effect of processing on the end use of the products.

COUSCOUS

An outline of work underway and the experimental milling flours developed are given on the pages 46 through 48. Preliminary milling studies have been completed on a 97% extraction flour and semolina from durum wheat. The granulation and protein content of the 97% extraction flour are very nearly the same as those obtained in Morocco. The couscous preparations have been compared with the commercial Moroccan products and have met the approval of a taste panel of international students familiar with couscous. Improved cooking utensils have been obtained through the assistance of the Moroccan Embassy.

An Outline of a Work Schedule for a Couscous Study

Allen Kirleis

I. Milling procedure

- A. 97% extraction flour
- B. Semolina
- C. 97% extraction flour and "horsebean flour" of "chick pea flour"

II. Develop a standard method for preparation of couscous

III. Keeping quality

- A. Of 97% extraction flour and semolina and 97% extraction flour and horsebeans
    1. Development of fat acidity
- B. Of dried couscous made from 97% extraction flour and semolina and 97% extraction flour and horsebeans
    1. Development of fat acidity
    2. Possibly organoleptic test

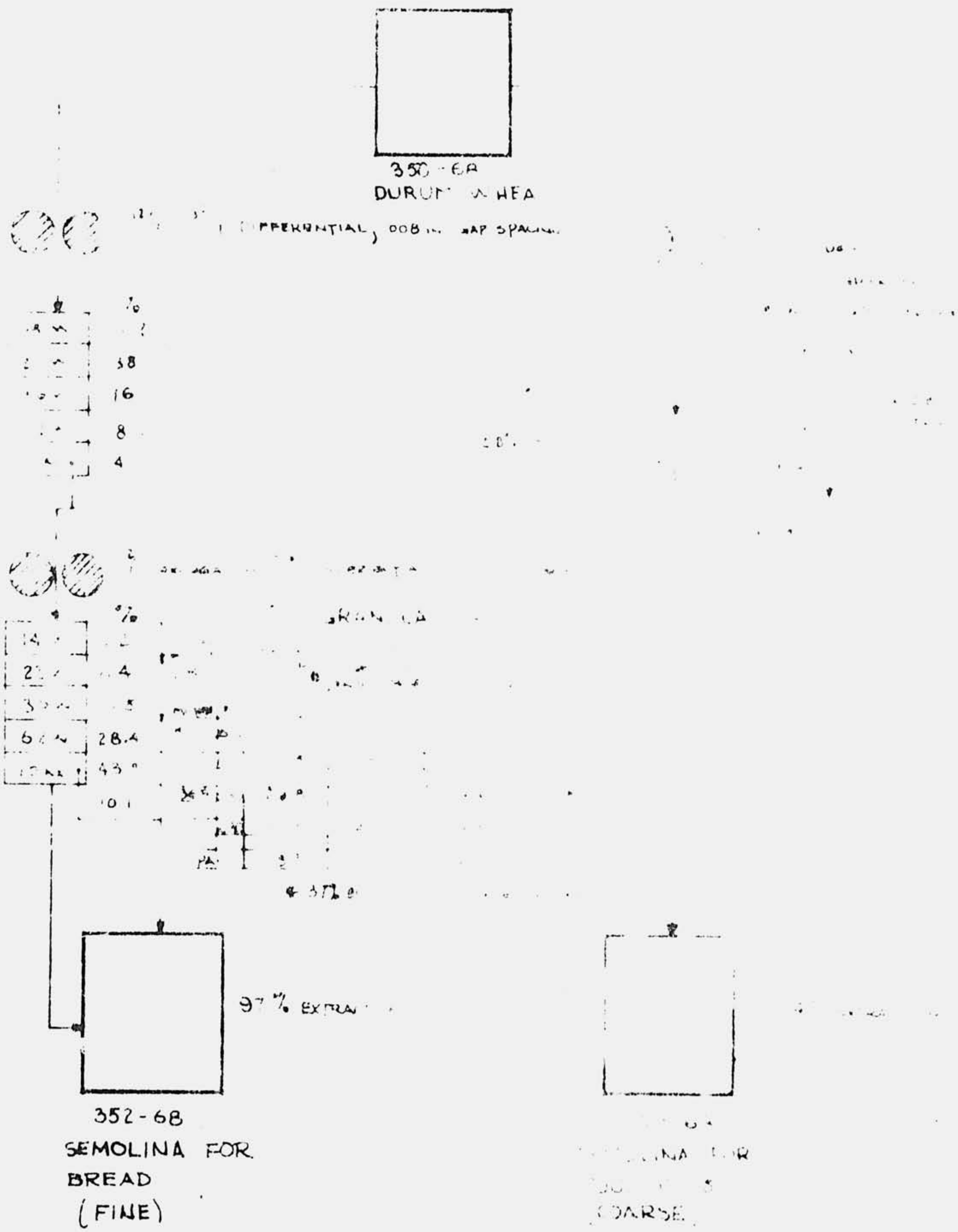
IV. Nutritive quality

- A. Determine vitamins and availability of protein on 97% extraction flour and semolina and 97% flour and horsebeans
- B. Determine vitamins and availability of protein on couscous made from 97% extraction flour and semolina and 97% flour and horsebeans
- C. Possibly rat studies of 97% extraction flour, semolina and couscous and blend

V. Acceptability of couscous from A, B, and C in I above

SAMPLES PRODUCED AT
KANSAS STATE UNIVERSITY

AIB - F - 3
JUNE 1968



AIP-F-9

48

DEPARTMENT OF GRAIN SCIENCE AND INDUSTRY
MILLING INDUSTRIES BUILDING
KSU KANSAS STATE UNIVERSITY *Manhattan, Kansas 66502*

DURUM MILLING

361-68

HARD DURUM AMBER — AMBER DURUM — DURUM — [illegible] FEED GRAIN

DURUM CHARACTERISTICS

- HARD VITREOUS ENDOSPERM – MILLERS DESIGNATE [illegible] DURUM GRAIN AS SEMOLINA TYPE OR FLOUR TYPE.

[illegible] CLEANING & CONDITIONING

- [illegible] — TO REMOVE VERY COARSE MATERIAL
- [illegible] SEPARATOR — REMOVE MATERIAL COARSER & FINER THAN WHEAT
- [illegible] INDENT [illegible] — REMOVE OATS & CRACKED WHEAT
- [illegible]
- [illegible]
- [illegible] — REMOVE STONE GRIT
- [illegible] — REMOVE GRIT, ERGOT, MUD BALLS
- [illegible]
- [illegible] -SHORT — 2½-3½ HRS - 1ST STAGE, ½ TO 1 HR - 2ND TEMPER, TO [illegible] % LEVEL

MILLING – TWO [illegible] PRODUCTS SEMOLINA [illegible]

SEMOLINA [illegible] TOTAL [illegible]

- 1-5-6 BREAKS [illegible]
- 1-5-8 SIZING [illegible] CORRUGATED [illegible] [illegible]
- 1-5 MIDDLINGS [illegible]
- 1-3 LOW [illegible]
- 1-3 TAILINGS

SIFTERS [illegible]

PURIFICATION [illegible]

[illegible] FINISHED [illegible]

DURUM [illegible]

- [illegible]
- [illegible]
- STEA [illegible]

[illegible] SEMOLINA [illegible] 100% [illegible]

362-68 — 363-68 — [illegible] — 365-[illegible]

SEMOLINA APPROX % [illegible] — 1ST CLEAR FLOUR 10.5% — 2ND CLEAR FLOUR 4.5% — MIDDS FOR ANIMAL FEED 25%

SEMOLINA SPECIFICATIONS

- THRU 30 OVER 60 WIRE LONG GOODS – BATCH EXTRUDED PROCESS
- THRU 40 OVER 80 WIRE LONG GOODS – AUTOMATED PROCESS
- GRANULARS – VARIOUS PERCENTAGES OF FLOUR FOR END PRODUCTS – [illegible] ON PART OF SPAGHETTI MANUFACTURERS
- GRIT – .0015 – IMPORTANT IN THIN WALLED EXTRUDED GOODS – SMEARS [illegible]
- COOKING QUALITY – ADEQUATE SWELL – NO GUMMYNESS – STAYS FIRM.
- ABSORPTION – UNIFORM HYDRATION – LOW ABSORPTION DRY DOUGH – AS PRODUCT IS DRIED HIGH PERCENTAGE OF WATER MEANS GREATER DRYING – MORE BRITTLENESS OR FRAGILE PRODUCT. FARINOGRAPH – 27-30 %
- COLOR – YELLOW COLOR DUE TO HIGH PERCENTAGE PIGMENTATION (DOUBLE BOND [illegible]) PARTICLE SIZE ALSO EFFECTS COLOR
  - [illegible] PIGMENT UNDESIRABLE, ESPECIALLY WHEN COOKED
  - [illegible]
  - [illegible]

MOROCCAN BREAD

Two studies are underway on Moroccan Breads. An Outline of Work on Characterizing and Supplementing Moroccan bread is given on page and a milling flow developed for Moroccan bread flour is given on page .

A program of study investigating new methods of milling wheat for Moroccan bread flour production and for processing chick pea and horsebean flours for supplementation is outlined on pages 52 and 53.

Chick peas and horsebean samples were obtained from Morocco. Their preliminary analyses indicated a high level of protein content. The amino acid contents for these legumes showed good levels of essential amino acids. It was proposed to use the flour of these legumes in fortifying the local bread to increase its nutritive value.

Samples similar to these legumes were obtained from a foreign food stored in Kansas City (Scimico Italian Supermarket). It was found that the chick pea was a product of Morocco, the horsebean was an Italian product.

Experimental milling was done with these legumes and experimental flows were developed (pages 54 and 55). Analyses were made for each fraction obtained. Horsebean flour was fractionated according to particle size and analyses for moisture content, protein, ash, crude fat and crude fiber were made.

An Outline of a Work Schedule for Study of Moroccan Breads

Luis Aira

This involves the following grains--rye, barley, millet and wheat (soft red winter)

1. Moroccan Bread

    Formulation

    Test Baking for Standard

    Characterization of Standard

    Evaluation

2. Grains -- Physical Properties

    Wheat

    Rye

    Barley

    Millet

3. Supplementation and Enrichment

    Legumes

    Lysine

    Standard Enrichment

        Physical Properties and Baking

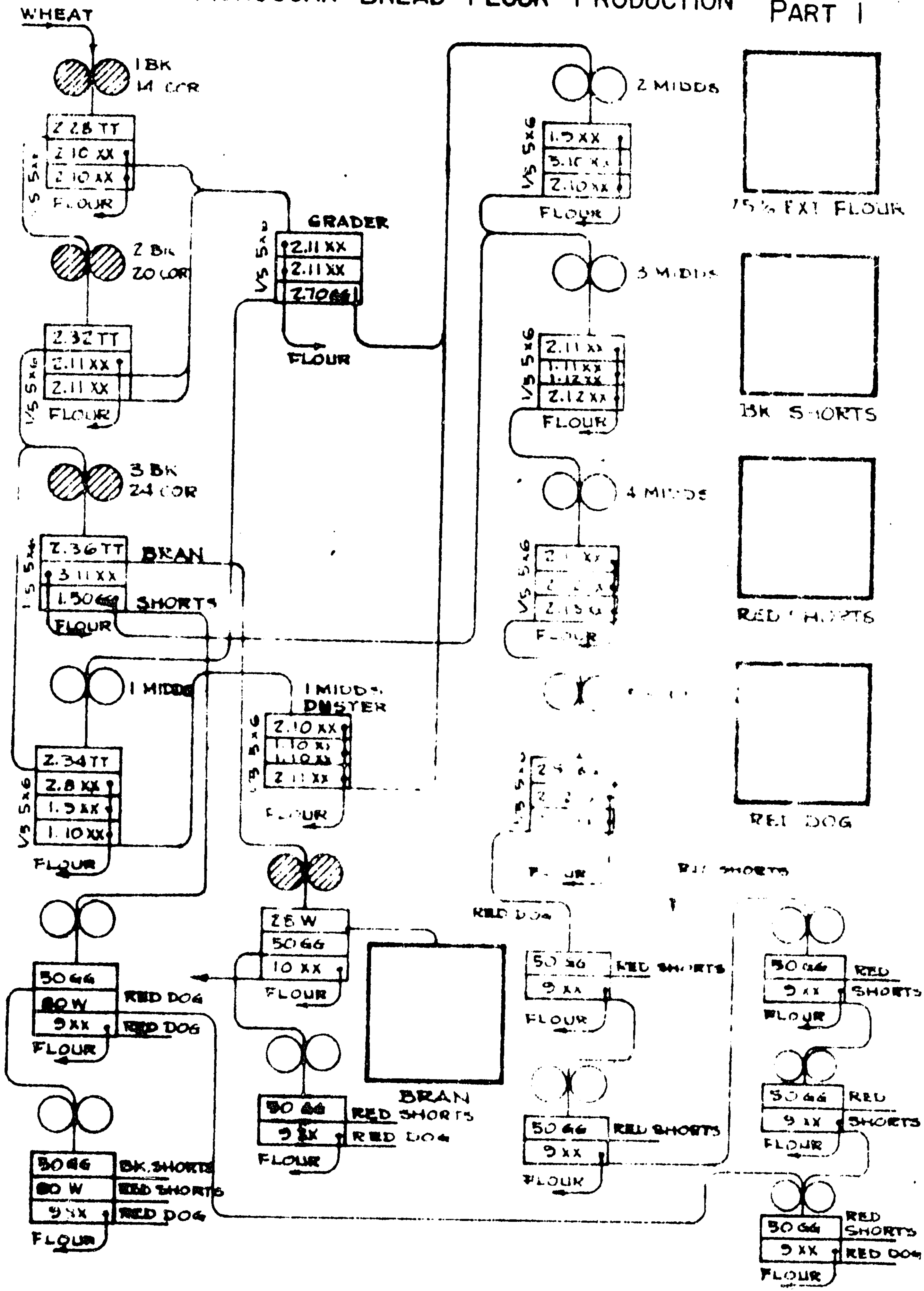
4. Characterization and Evaluation of Finished Products

    Organoleptic Evaluation Panel

    Biological

MOROCCAN BREAD FLOUR PRODUCTION

AID-F-8
PART I



The Proposed Outline and Schedule of Work on the Use of Chick Peas and Horsebeans In Moroccan Bread

M. Al Suaidy

I. Increasing yield and nutritive value of wheat products.

A. Grain and Treatment

Origin of Grain

From two Agricultural Stations in Kansas (Manhattan and Hays)

Variety:

Guide

Manhattan	Protein	12.0%
Hays	"	12.8%
Blended and tested here at KSU		13.9%

Grain:

(Ash	Test Wt.
(Protein	Pearling Test
(Moisture	1000 Kernel Wt
Fat)	Microscope Obser.
Fiber)	Potential yield

B. Treatments of Grain

Grain CONTROL ------- STANDARD Processing

Control ------- Sorghum Peeler

Cold Treatment

1. Temper at 4°C. water bath to 20% moisture.
2. Divide in half.
   a. Freeze one half at -10°C. for 72 hours.
   b. Second half storage at 40°F. for 72 hours.
3. Remove grain from freeze and cold room and dry in air oven at 110°F. over night.

C. Treatment on Sorghum "Peeler"

Control

Frozen Grain

Non-Frozen Grain

Non-frozen grain (cont.)

1. Short Tempering 25% moisture for 30 minutes.
2. Run through sorghum peeler at 1350 RPM with feeding gage at 4.5.
3. Sieve and Air separate--determine yield.
4. Dry in air oven at 110° F. over night.
5. Approximate analysis of fraction.
6. Store grain at 40°F.

D. OTHER TREATMENTS: (Proposed)

Using

1. Softner
2. Pearling or Engelburg Huller

II. Supplementation Studies

A. MILLING STUDIES

Temper to 16% moisture for 24 hours.

Mill using a flow for 85 and 97% extraction.

B. FLOUR STUDIES

Analyses: Moisture, ash, protein, fat and fiber.

Physical Dough Tests; Farinograph, Extensograph and Amylograph and Flour Colorimeter.

C. BAKING TEST

American Standard	85% extraction
Moroccan Bread	97% extraction

D. Supplementation on 85% and 97% Flour Extraction

Horsebean Flour (0, 1, 3, 6, 9, 12 - 50%)

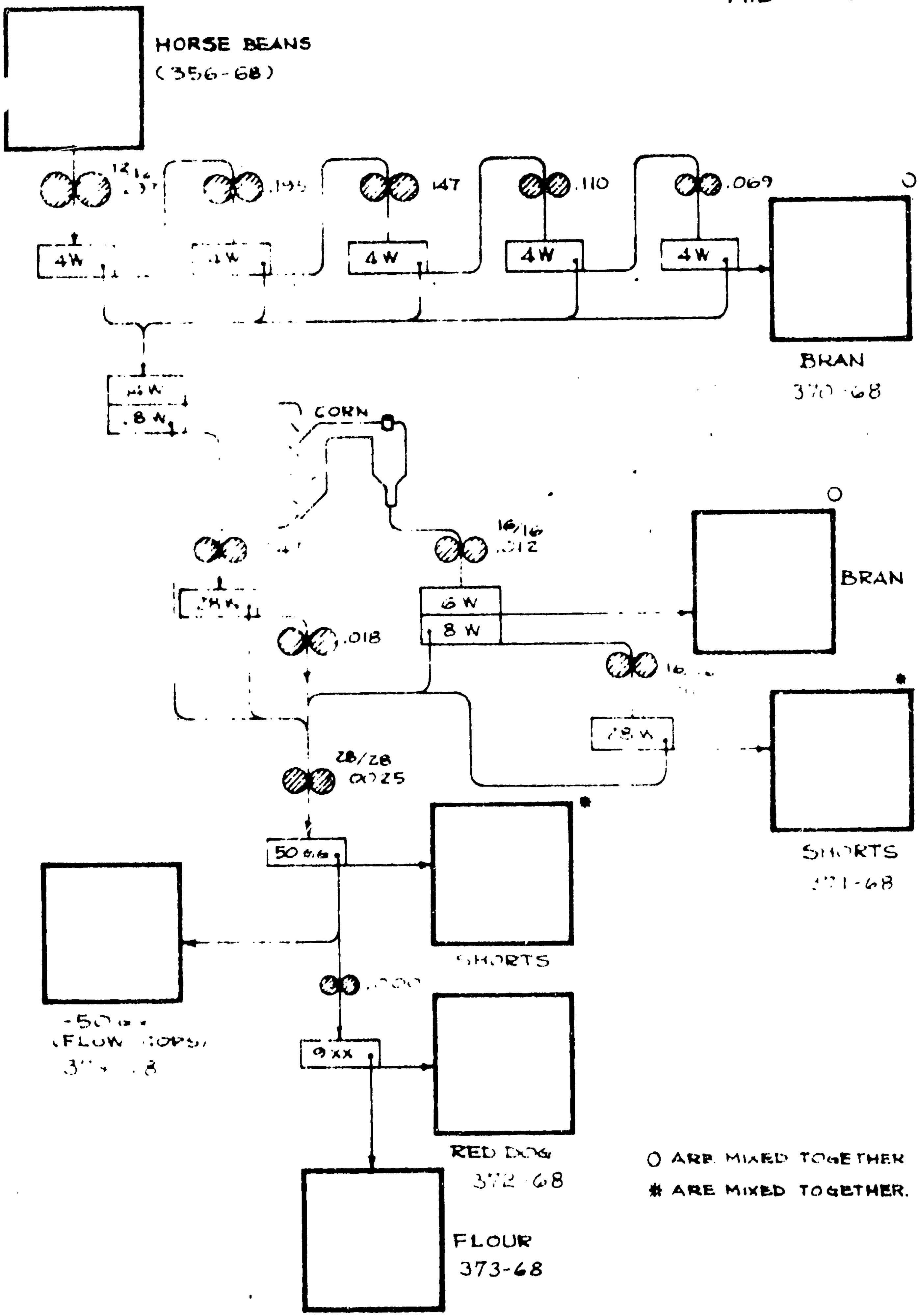
Chick Pea Flour (0, 1, 3, 6, 9, 12 - 50%)

1. Flour analyses - proximate, minerals and amino acids.
2. Granulation and yield.
3. Effect on physical dough properties.
4. Baking test - scoring.
5. Taste panel.
6. Bread analyses - proximate minerals and amino acids.

HORSE BEAN FLOW

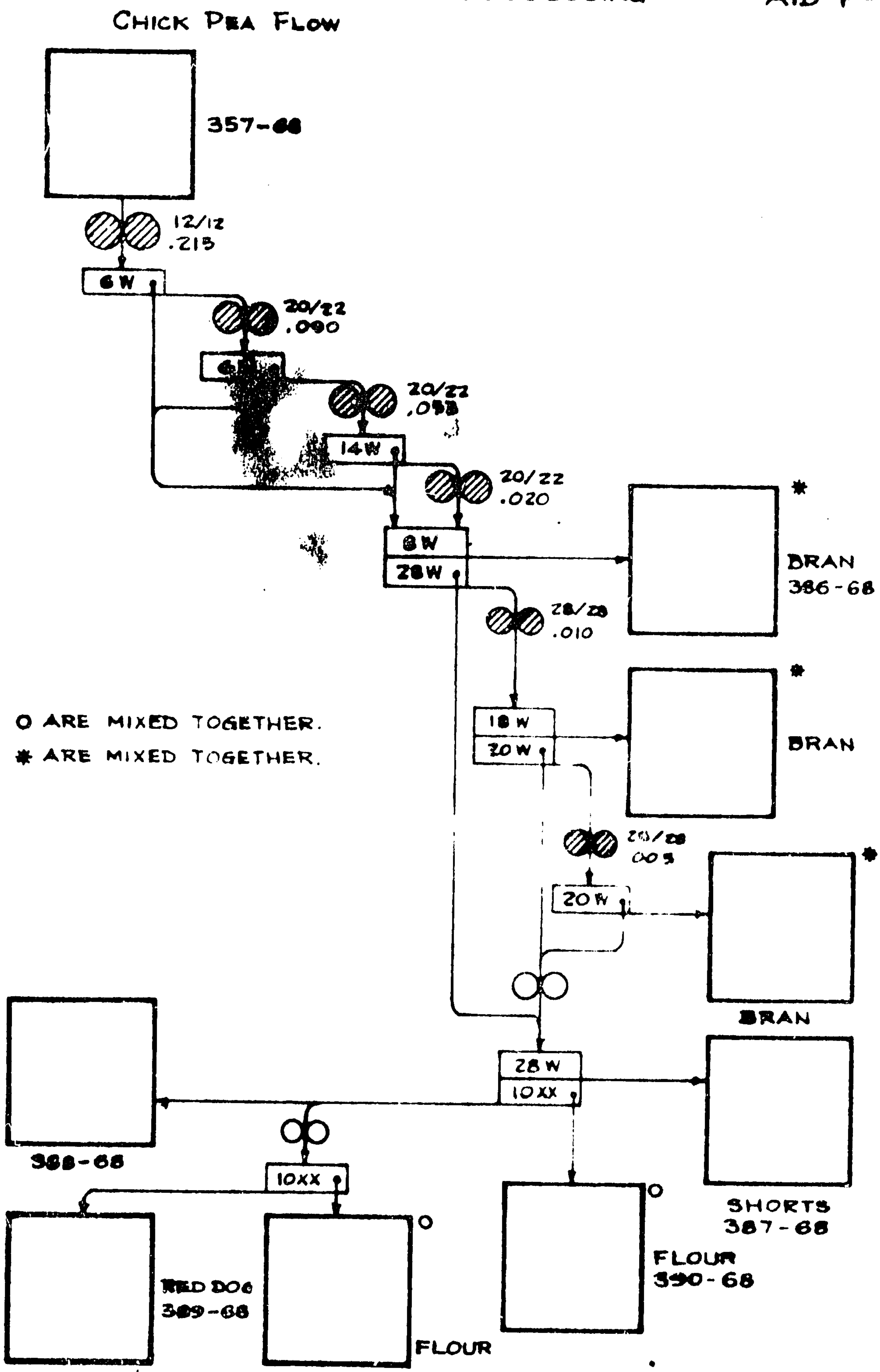
10-11-68

AID-F-5



Chick Pea Processing

AID-F-6



ROTI PRODUCTS

Considerable progress has been made on the milling and processing of roti products. The bulk of this progress is reported in the nutrition section as three papers submitted for publication (pages 101 through 151).

An outline of additional work is given on page 58.

Studies on the shelflife of Chapatis on Nan have been carried out as outlined on page 59. Each study was extended over a six-week period. In the packaging study, daily moisture losses were recorded during the initial week and then followed by weekly measurements.

The developing microbial population during storage was studied. Microbial evaluations were made on the initial ingredients, the mixes and the final products. It was found that the most undesirable micro-organisms were Aspergillus niger, Aspergillus flavus, Penicillium lilacium, and Aspergillus fumigatus. A study is now underway to add mold inhibitors that are acceptable under the laws of the countries concerned.

The shelflife and preserving studies are deemed necessary before marketing of chapatis and nan can be considered. Village or neighborhood bakeries are looked upon as advantageous developments to a nutrient supplementation program.

An Outline of the Work Schedule on Roti Products

Robert Tang

ATTA AND CHAPATI

1. Analysis for

    Amino Acid

    Vitamin - B, B_2, Nicotinic Acid, Pyrodovine

    Minerals

    Fats - Fats Acidity

2. Supplemented (5, 10, 20, 30%)

    Fish Protein (2)

    Sorghum Protein

    Wheat Protein Conc.

    Lysine

    Corn Protein Conc.

    Corn Soy Milk

    Legumes

        Analysis As Above

3. Atta and Chapati From Other Grains

    Corn

    Sorghum

    Millet

    Barley

4. Characterization and Evaluation of

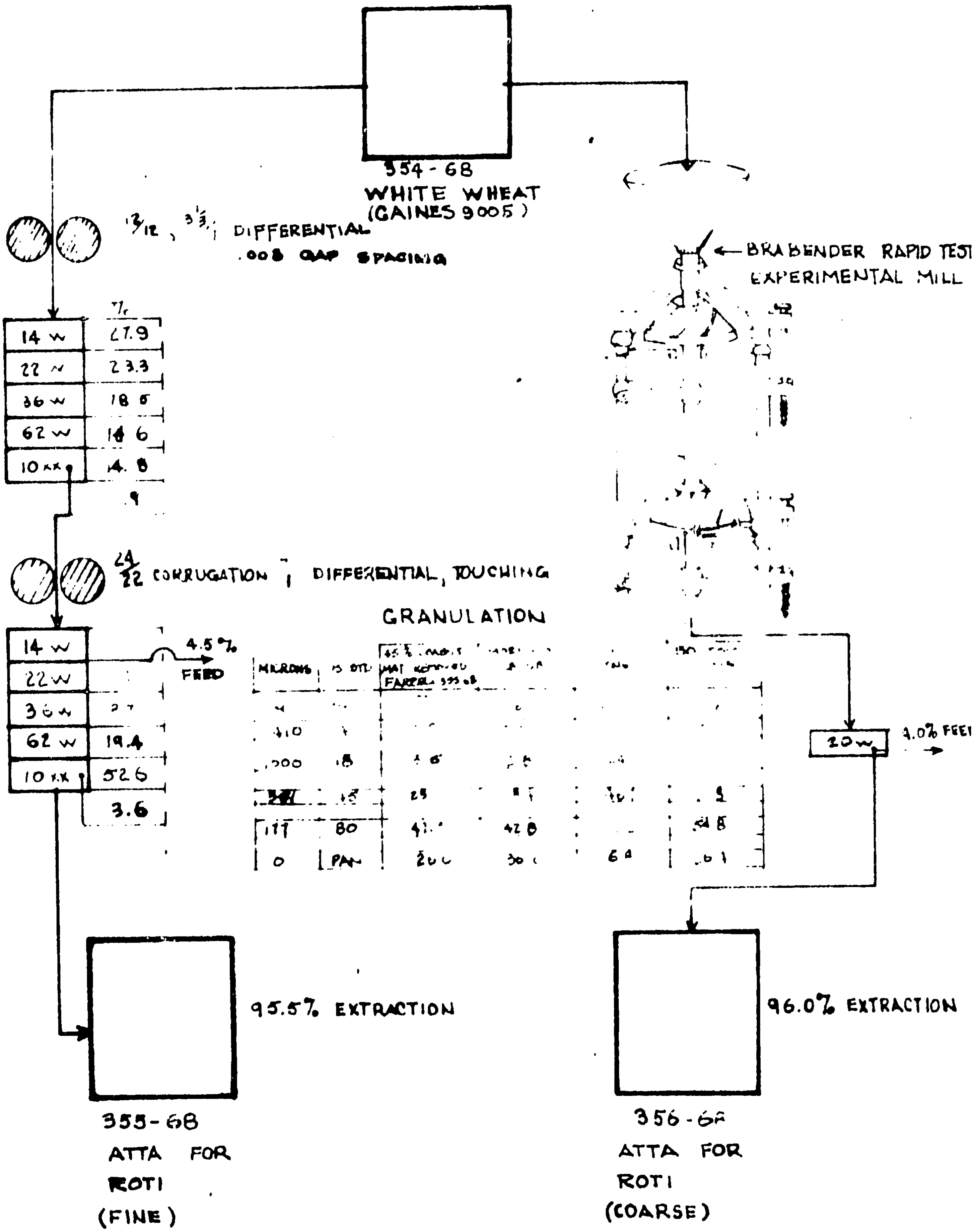
    Finished Product

    Organoleptic Evaluation

    Biological

SAMPLES PRODUCED AT KANSAS STATE UNIVERSITY

AID-F-4
JUNE 1968



Microbiological Studies of Chapatis and Nan for Quality Control and Keeping or Shelf Life

Abdul Rashid Mann

1. Microbiological survey of raw materials including atta.

   a. Bacterial
   b. Mold
   c. Yeast

2. Prepared chapatis and nans.

   1st steps in preparation - Samples for microbiological testing
   2nd step in preparation - Samples for microbiological testing
   3. The prepared chapatis and nan

3. Storage

   a. Keeping quality

      1. General microbial determination
      2. Specific - bacteria, yeast and mold

   b. Pathogens - Enterics

4 Packaging

   a. open - no coverage
   b. Poly - bags
   c. Saran - bag
   d. Foil - wrap
   e. Waxed paper
   f. Ordinary wrapping paper (Brown or white)

Protein Concentrate from Wheat Bran and Shorts

Preliminary studies on producing protein concentrate for human food from wheat millfeeds have been undertaken. Samples of bran and shorts were sacked off the stream while milling a Kansas hard red winter wheat. Germ and red dog were sacked off separately.

Samples of bran and shorts were ground separately by a MIKRO Grinder with the rotor at 7300 r.p.m.; the separator at 2000 r.p.m.; the process air at 400 cu. ft./min. Each ground sample was mixed by a tumbling blender and sifted by a G.W. lab sifter in 500 gram lots. Samples of the throughs were taken after each 30 seconds of sifting, weighed and analyzed separately.

Results of the analysis of fractions obtained are given on page 61.

High Lysine Corn

Many 5-lb. lots of yellow corn and high lysine corn (both white and yellow) were milled by many different flow diagrams to develop experimental milling procedures for the different kinds of corn, at low moistures (15-16%) and high moistures (22-23%) with and without impact type germination.

White high lysine corn grown in Kansas in 1967 was milled on experimental milling equipment in sufficient quantities to obtain 50 lbs. or more of flour, fine meal, and medium meal for testing by fine grinding and air classification for protein quantity and quality in the many fractions. This work is scheduled to start the week of December 11.

The analytical evaluation of the milling fractions obtained is given on page 62.

Sorghum Protein Concentrate

Considerable work has been done on developing high protein fractions from grain sorghum. Results of this work are found in the nutrition section on pages 158 to 172.

Ground Shorts Sifted on 9XX Sieve
500 g. sample

Code	Sieve	Time Sec.	Cum. Time Sec.	Through g.	Cum. Through g.	Moist. %	Pro. %	Pro. 14% m.b.	Ash %	Ash 14% m.b.
FS-1	9XX	30	30	135	135	9.0	19.6	18.5	3.9	3.7
FS-2	"	30	60	74	209	9.1	19.5	18.4	3.8	3.6
FS-3	"	30	90	61	270	9.3	19.0	18.0	3.7	3.5
FS-4	"	30	120	28	298	9.3	17.6	16.7	3.9	3.7
FS-5	"	30	150	16	314	9.2			4.1	3.9
FS-6	+9XX					9.2	13.5	12.8	4.9	4.6

Ground Shorts Sifted on 10XX Sieve
500 g. sample

Code	Sieve	Time Sec.	Cum. Time Sec.	Through g.	Cum. Through g.	Moist. %	Pro. %	Pro. 14% m.b.	Ash %	Ash 14% m.b.
-11	10XX	30	30	75	75	9.3	20.4	19.[illegible]	4.2	4.0
-12	"	30	60	55	130	9.3	20.2	19.2	3.9	3.7
-13	"	30	90	57	187	9.3	19.9	18.9	3.8	3.6
14	"	30	120	43	230	9.1	19.2	18.2	3.6	3.4
[illegible]	"	30	150	41	271	9.0	20.6	19.4	3.7	3.5
[illegible]	+10XX					8.9	13.9	[illegible]	4.7	4.4

Ground Bran Sifted on 9XX Sieve
500 g. sample

Code	Sieve	Time Sec.	Cum. Time Sec.	Through g.	Cum. Through g.	Moist. %	Pro. %	Pro. 14% m.b.	Ash %	Ash 14% m.b.
FB-1	9XX	30	30	71	71	9.8	[illegible]	17.4	5.5	5.2
FB-2	"	30	60	36	107	9.7	[illegible]	17.4	5.6	5.3
FB-3	"	30	90	27	134	9.7	[illegible]	17.4	5.7	5.4
FB-4	"	30	120	27	161	9.8	[illegible]	[illegible]	6.1	5.8
FB-5	"	30	150	19	180	9.8	[illegible]	[illegible]	6.5	6.2
FB-6	+9XX					9.8	[illegible]	[illegible]2	6.5	6.2

Ground Bran Sifted on 10XX Sieve
500 g. sample

Code	Sieve	Time Sec.	Cum. Time Sec.	Through g.	Cum. Through g.	Moist. %	Pro. %	Pro. 14% m.b.	Ash %	Ash 14% m.b.
FB-11	10XX	30	30	41	41	10.1	20.4	19.5	6.1	5.8
FB-12	"	30	60	37	78	9.9	20.7	19.8	5.6	5.3
FB-13	"	30	90	38	116	9.8	19.8	18.9	5.3	5.1
FB-14	"	30	120	31	147	9.8	18.7	17.8	5.6	5.3
FB-15	"	30	150	31	178	9.8	18.2	17.4	6.3	6.0
FB-16	+10XX					9.3	12.9	12.2	6.4	6.1

High Lysine Corn Milling

Lab No.		Identification	Date	Moisture	Protein %	Ash %	C. Fat %
G 1168	White	Hulls	29-Jan-68	5.5	12.8	2.2	6.0
G 1169	Corn	Germ	"	5.2	16.[illegible]	4.7	14.7
G 1170	High Lysine	+ 14W C. Grits	"	6.4	9.4	.85	1.7
G 1171	'67	+ 20W M. Grits	"	7.4	8.1	.62	1.0
G 1172		+ 50gg F. Grits	"	12.1	6.[illegible]	.34	0.3
G 1173		+ 50gg Flour	"	10.[illegible]	5.8	.26	0.5
G 1174	Yellow	Hulls	"	5.0	12.9	1.8	6.2
G 1175	Corn	Germ	"	4.4	14.4	4.3	18.4
G 1176	High Lysine	+ 14W C. Grits	"	8.4	9.2	.84	2.2
G 1177	'67	+ 20W M. Grits	"	7.8	8.6	.66	1.5
G 1178		+ 50gg F. Grits	"	8.6	7.5	.59	0.9
G 1179		+ 55gg Flour	"	8.9	6.5	.35	0.9

PHYSICAL PROPERTIES

Physical property evaluations are underway to determine the effect of supplements to the properties of wheat flour.

The list of supplements and their suggested addition level is as follows:

Supplement	Levels of additive
Peanut flour	0, 1, 2, 5, 8 and 50%
Fish protein concentrate (100, 200 and 300 mesh)	0, 1.5, 3, 5, 8 and 10%
L. Lysine - HCl	0, 0.1, 0.2, 0.3, and 0.4%
Soybean products	
Soy Isolate (fine, medium, coarse granulation)	0, 1, 3, 6, 9, 12 and 15%
Soy flour concentrate	0, 1, 3, 6, 8 and 50%
High lysine corn meal	0, 1, 3, 6, 9 and 50%
Corn-Soy-Milk (CSM)	0, 1, 6, 9 and 50%
Sorghum protein concentrate	0, 1, 6, 9 and 50%
Wheat protein concentrate	0, 1, 3, 6, 9 and 30%
Glandless Cottonseed flour	0, 1, 3, 6, 9 and 15%
Horsebean flour	0, 1, 3, 6, 9, 12 and 50%
Chickpea flour	0, 1, 3, 6, 9, 12 and 50%
Yeast concentrate	0, 1, 3, 4 and 6%

The general dough rheology is based upon the use of the farinograph, extensograph, amylograph and gassing power tests (See Table on page 64.

PHYSICAL PROPERTIES OF BLENDED FLOURS WITH PEANUT FLOURS

No.	% FLOUR PROTEIN*	% ASH	% MOISTURE	% FLOUR ABSORP-TION	mm GASSING POWER
Peanut flour	57.7	4.5	8.2	----	46.6
Low protein white flour	10.4	.4	12.9	60.3	20.2
+10 peanut flour	14.6	.8	12.4	64.3	36.5
+20 peanut flour	18.8	1.2	11.9	69.0	33.4
+30 peanut flour	21.8	1.6	11.5	73.5	38.6
+40 peanut flour	27.1	2.1	11.1	79.9	41.8
+50 peanut flour	31.2	2.5	10.8	83.6	41.9
Medium protein white flour	12.5	4.3	12.8	61.0	36.1
+10 peanut flour	16.2	.83	12.1	65.4	41.3
+20 peanut flour	20.9	1.2	11.9	71.8	38.9
+30 peanut flour	24.6	1.7	11.3	76.2	41.2
+40 peanut flour	28.7	2.1	10.9	80.5	43.5
+50 peanut flour	34.4	2.7	10.0	85.5	45.0
high protein white flour	13.0	.44	12.1	63.5	34.4
+10 peanut flour	17.6	.90	14.4	70.3	36.5
+20 peanut flour	20.6	2.0	11.5	72.3	42.4
+30 peanut flour	25.0	1.6	11.1	77.0	38.6
+40 peanut flour	29.0	2.0	10.7	81.5	52.2
+50 peanut flour	32.8	2.4	10.2	85.0	40.0

* Protein Factor 5.75

The peanut flour was blended with a low protein, a medium protein and a high protein wheat flour at the 5, 10, 15, 20, 30, 40, and 50 percent levels. The general increase in protein content resulting at each increment of blending is shown in the table on page 64. Results indicate that flour absorption increased as the increments of blending increased.

Farinograph data indicated a strengthening in the lower protein flour up to the 30% level, but above this level it became difficult to distinguish between the low, medium, or high protein flours with respect to the farinograph curve. The farinograph picture did indicate that there had been heat damage to the protein of the peanut flour. The extensograph data paralleled that of the farinograph.

The peanut flour blends were baked according to the standard pup loaf method. Results indicate that blends beyond the 30% level of peanut flour destroys all loaf volume. The loaf volume tends to decrease at the 30% level. The flavor beyond that point is not to be recommended.

The upper levels of the blends were tested by baking into nan, the Pakastani bread. The resultant product proved to be heavy but had good keeping quality. The flavor improved with age.

The physical dough testing with the soy isolate is divided into coarse, medium and fine granulation material. Thus for results indicate that the medium granulation is better with respect to flavor, loaf volume, grain and texture of finished bread but these studies are incomplete.

Preliminary physical property studies have been made upon the chick pea and horsebean flours produced. With the exception of the water absorption characteristics, the preliminary physical dough tests do not show the same trend as soy and peanut flour blends perhaps because these beans were not heat treated.

IMPROVING NUTRITIONAL VALUE OF CEREAL BASED FOODS
(NUTRITIONAL EVALUATION)

The enclosed attachments cover literature reviews which have been conducted on various aspects on legumes which may be important in nutritional evaluation of these products if they are to be additives in human diets.

Of specific interest has been information on toxic factors and/or inhibitors found in the chick peas and the bread beam.

Summaries covering some of the more pertinent references in these areas is given in the first attachments. Secondly, progress that has been made in analysis of samples collected in Morroco and Pakistan are summarized in the attached tables with data giving values for amino acid composition and protein values of the samples on which analysis has been completed. Also in progress is the evaluation of the mineral content of these samples using activation analysis.

Data available on some of the samples have been examined and it would appear that some of the data look reasonable, but that other samples need to be checked further to determine the significance of the values which have been obtained. Data on some samples for nitrogen level have not agreed well with the more common Kjeldahl analysis. These values are being re-checked and the work on the analysis is being evaluated to determine the accuracy of the information

Information covering three separate growth studies using rats are included. These studies cover work which was done to evaluate the effect of lysine and vitamin and mineral additions to atta used in making chapatis. In the second study the nutritional value of protein in fractions from sorghum grain is evaluated. These studies were designed to evaluate the protein quality of endosperm. The studies evaluated protein from fractions of floury endosperm and horny endosperm. In the third study evaluations were designed to determine the effect of minimum additions of vitamin and minerals which might result in the most improvement in growth rates. Complete vitamin and mineral additions to diets containing wheat flour or the cereal flours will result in good growth. In this study only those minerals calculated or most deficient were added in test diets.

If such additions are not made poor growth can be expected since high extration wheat flours and other cereal products contain certain amounts of vitamin and minerals but not adequate levels of all nutrients. Enrichment which supplied the lacking nutrients would aid in avoiding nutritional imbalance which might occur on the addition of single nutrients. Preliminary data obtained in the third rat study indicate the need for further evaluations related to the effects of only limited supplements of certain vitamins and minerals.

TOXIC FACTORS IN CHICK PEAS

The presence of toxic factors in legumes have been recognized by man since the dawn of history. Among the legume seeds of nutritional importance investigated, the trypsin inhibitor was found in the chick peas and other beans. The trypsin inhibitor was not found in non legumes.

Brochers and Ackerson (1950) have presented a table containing seeds of leguminosae and other seeds. Chick peas contain 32.3 units of inhibitor/ml. extract of sample. (Table attached).

They also studied the effect of autoclaving on the nutritive value of pulses. There was no correlation between the improvement in nutritive value after autoclaving and the presence or absence of the trypsin inhibitor.

Hirwe and Magar (1952) showed that trypsin inhibitor content of pulses was less than that of beans. They found that methionine supplementation to raw pulses increased nutritive values.

Chattopadhya and Banerjee (1953) studies the biological value of proteins of five varieties of pulses (including chick peas) by the rat growth method, both before and after 48 hours of germination. They reported that, trypsin - inhibitor activity did not change with germination indicating that the altered biological value of the protein is not due to either increases or decreases in their trypsin inhibitor activity.

Sohonie and Bhandarkar (1954) found that the trypsin inhibitor from chick peas are destroyed by heating at 100°C for one hour. Whereas the inhibitors from double beans are stable under these conditions. Autoclaving destroys most inhibitors with the exception of double bean inhibitor.

Stockman in (1931) worked on other legumes. Lathyrism is the only disease known to arise from their use. The poisonous principle is an acid, white and hygroscopic, extracted by macerating the ground peas in cold water or alcohol for several days, percipitating albumen, filtering and concentrating the liquid. Experiments were done with the active principle and the extract on monkeys, rabbits and frogs. It caused lesions in the brain and spinal cord and paralysis of motor nerves.

According to Altschul (1958), diseases caused by toxic factors are referred to as lathyrism, cicerism or odoratism. A species of cicer have been presumably pointed out as causative agent. He mentioned that the common reasons for lathyrism may be due to:

a) Abnormally high levels of selenium and manganese in certain legume seeds,

b) or a particular amino acid deficiency.

He has also presented a table on the "effect on amino acid composition of wheat and corn flours by addition of chick pea products and soybean meal." The table is attached with the report.

Altschul pointed out the common practice in preparing dishes by soaking first and throwing away the steeping water may help in diminishing the risks derived from the ingestion material containing the toxic factor. (He means the ingestion of toxic factor).

Abramova and Chernikov (1964) investigated the proteinase inhibitor in chick peas along with other legumes. The fat free flour was extracted, precipitated, filtered and dialyzed until salt free. The inhibitory effect of this material was investigated. The highest antitryptic and antichymotryptic activity was found in P. Vulgaris seeds followed in G. Max, C. Arictinum (chick peas), L. Esculenta and P. Sativum. None of these seeds exhibited antipaptic activity.

TABLE I

Trypsin Inhibitor in Seeds of the Leguminosae and Others

Description	Inhibitor Units/ml. Extract (equivalent to 0.1 g defatted meal) ×10⁻¹
Legumes[1]	
Arachis hypogaea—peanut	16.[illegible]
Canavalia ensiformis—jack bean	0
Caragana arborescens—Siberian pea tree	0
Cassia tora—sickle senna	0
Ceratonia siliqua—carob bean	41.4
Cercis canadensis—redbud tree	11.2
Chamaecrista fasciculata—partridge pea	6.5
Cicer arietinum—chick pea, garbanzo	22.[illegible]
Cyamopsis psoraloides—guar bean	0
Gleditsia triacanthos—honey locust	26.2
Gymnocladus dioica—Kentucky coffee bean	24.4
Lens esculenta—common lentil	0
Lespedeza stipulacea—Korean lespedeza	6.9
Lupinus angustifolius—blue lupine	0
Medicago sativa—alfalfa	8.6
Melilotus alba—white sweetclover	0
Melilotus officinalis—yellow sweetclover	0
Mucuna deeringianum—Florida velvet bean	11.5
Phaseolus aureus—golden mung bean	6.2
Phaseolus coccineus—scarlet runner bean	21.8
Phaseolus lunatus—lima bean	20.1
Phaseolus vulgaris—garden bean	44.1
Pisum sativum—garden pea	0
Pisum sativum var. *arvense*—field pea	0
Soja max—soybean	35.0
Sophora japonica—Japanese pagoda tree	19.7
Trifolium pratense—mammoth red clover	0
Vicia faba—horse bean	0
Vicia sativa—common vetch	0
Vigna sinensis—black eyed pea	43.7
Non-legumes	
Aleurites fordii—tung bean	[illegible]
Avena sativa—oats	0
Hordeum vulgare—barley	0
Linum usitatissimum—flax	0
Secale cereale—rye	0
Sorghum vulgare—Leoti	0
Triticum vulgare—wheat	0
Zea mays indentata—corn	0

[1] Nomenclature according to Graham, E. H., Legumes for Erosion Control and Wildlife, U.S. Dept. Agr. Misc. Publ. No. 412 (1941).

chick pea

TABLE IV

EFFECT ON AMINO ACID COMPOSITION OF WHEAT AND CORN FLOURS BY ADDITION OF CHICK PEA PRODUCTS AND SOYBEAN MEAL

Source of protein	Protein[a] (dry basis)	Amount containing 100 g. protein (dry basis)	Amounts of amino acids in 100 g. of protein: Leucine	Methionine	Phenylalanine	Lysine	Valine	Isoleucine	Threonine	Tryptophan
	%	g.	g.	g.	g.	g.	g.	g.	g.	g.
Flours										
Typical wheat flour[b]	12.5	800	7.0	2.0	5.5	1.9	4.1	4.2	2.7	0.8
Whole corn flour[b]	9.6	1042	15.0	3.1	5.0	2.2	5.8	6.4	3.7	0.6
Additives										
Soybean meal[b]	45.0	222	8.0	1.7	5.3	6.8	5.3	6.0	3.9	1.4
Whole chick pea flour[c]	23.5	426 }	8.0	1.5	6.5	6.5	6.2	5.9	6.0	1.0
Undefatted chick pea protein[c]	60.0	167 }								
Chick pea protein powder[c]	90.0	111 }								
Enriched wheat flour products										
20% Soybean meal	19.0	503	7.5	1.9	5.4	4.2	4.7	5.1	3.3	1.1
10% Chick pea flour	13.6	725	7.8	1.9	5.7	2.7	4.5	4.5	3.1	0.9
20% Chick pea flour	14.0	500	8.2	1.7	6.2	4.9	5.5	5.3	4.1	0.9
10% Undefatted chick pea protein	17.3	578	7.6	1.8	5.8	3.5	4.3	4.8	3.5	0.9
10% Chick pea protein powder	20.9	[illegible]	7.8	1.8	5.9	3.9	5.0	4.9	3.7	0.9
Enriched corn flour products										
20% Soybean meal	16.7	[illegible]	11.2	2.3	5.2	4.7	5.3	6.2	3.8	1.0
10% Chick pea flour	11.2	[illegible]	10.7	2.5	5.3	3.2	5.5	6.3	3.9	0.7
20% Chick pea flour	10.6	[illegible]	10.6	2.0	6.0	5.3	5.0	6.0	4.2	0.9
10% Undefatted chick pea protein	14.6	[illegible]	12.5	2.5	5.6	6.0	5.7	6.2	4.2	0.8
10% Chick pea protein powder	17.6	[illegible]	11.9	2.3	5.8	4.5	5.8	6.2	3.5	0.8
Essential amino acid requirements per day (adult)[d]			2.2	2.2	2.2	1.6	1.6	1.4	1.0	0.5

[a] Nitrogen × 6.25.

[b] R. Block and D. Bolling, "The Amino Acid Composition of Proteins and Foods," 2nd ed. Charles C. Thomas, Springfield, Illinois, 1951.

[c] E. Lemus C., of the Instituto Mexicano de Investigaciones Tecnológicas, unpublished work performed at the University of Wisconsin, 1952.

[d] Based on the recommended safe daily intake which is twice the minimal amount listed in Table III, Chapter 2, and in Table VIII, Chapter 18.

PROTEIN REQUIREMENTS

Mason <u>et</u> <u>al</u>. (1964) found that the American and European women had significantly higher basal metabolic rates than the Indian women. The differences could not be attributed to differences in age, height, weight, or muscle mass. They suggested that the differences may be due to several generations of Indians adapting to the tropical climate. Since the metabolic rates of the Indian women are lower, their protein needs may be lower.

The amino acid requirements for adult humans and for rats have been reported by Rose and others and is given in Processed Plant Protein Foodstuffs, p.24, (Altschul, 1958):

amino acid	adult human g/day	rat %/ diet
arginine	0.00	[illegible]
histidine	0.00	0.4
isoleucine	0.70	0.5
leucine	1.10	0.8
lysine	0.80	1.[illegible]
methionine	1.10	0.5
phenylalanine	1.10	[illegible]
threonine	0.50	[illegible]
tryptophan	0.25	[illegible]
valine	0.80	[illegible]

Hegsted (1957) estimated that children of the given ages require the amounts of protein listed below:

1 month -- 2.5 g/kg body weight
18 months -- 1.0 g/kg body weight
2.5 years -- 0.76-0.83 g/kg body weight
6.5 years -- 0.62-0.67 g/kg body weight

Howe et al. (1965) reported the following recommendations:

infants (at birth) -- 2.2 g/kg body weight
2 months -- 2.0 g/kg body weight
1 year -- 1.5 g/kg body weight
1-5 years -- 1.0-1.5 g/kg body weight

Plenert et al. (1965) found that increasing the protein intake of infants above 3 g/kg did not improve weight gain or utilization of food and energy.

Nitrogen balance studies (Nakagawa et al., 1962 have shown that 10-12 year old boys require approximately [illegible] g threonine (35 mg/kg), 0.9 g valine (33 mg/kg), and [illegible] g phenylalanine (27 mg/kg) daily.

Fomon and Filer (1966) reported that the isoleucine and valine requirements for infants were slightly lower than previous reports had indicated. Twenty infants were fed a formula which contained protein (6% of formula) in the form of methionine-supplemented soy isolate. They reported that 50-85 mg isoleucine/kg/day and 53-[illegible] mg valine/kg/day were sufficient for most children. These values they compared with 79-126 mg isoleucine/kg/day and 85-105 mg valine/kg/day reported by Snyderman et al. (1959, 1964).

PROTEIN AVAILABILITY

Autoclaving (121°C, 30 and 60 minutes) reduced the lysine content of chickpeas by 10% (González del Cueto et al., 1960). In contrast to reports that autoclaving reduced the arginine content of cottonseed meal, no measurable reduction in arginine concentration was observed in chickpeas (Gonzáles del Cueto et al., 1960). Kuiken and Lyman (1948) reported the true availability (amino acids fed minus amino acids in feces of rats) of wheat as follows:

arginine	96.4%
histidine	98.8%
isoleucine	95.0%
leucine	95.4%
lysine	92.8%
methionine	94.9%
phenylalanine	96.9%
threonine	92.2%
tryptophane	93.2%
valine	93.2%
total N	95.0%

Gupta et al. (1958) reported that on the basis of rat feeding experiments, lysine is 81-86% available in rice and 61-79% available in wheat.

The true digestibility of properly cooked legumes has been estimated to be between 85 and 95%, with beans being digested slightly poorer than peas (Aydroyd and Doughty, 1964). The protein content of some Indian pulses has been observed to increase during germination (Chattopadhyay and Banerjee, 1953). Genetic strains of chickpeas vary as much as 38% in protein content (Esh et al., 1960).

SUPPLEMENTATION OF DIETS

Howe et al. (1967) stated that fish protein concentrate and soybean meal are the only potentially available protein concentrates containing a sufficiently high lysine content to be useful as a supplement. In general they advocated the addition of pure amino acids to the staple foods. On the other hand, Hegsted (1968) stated that purified amino acids are too expensive at the present to be useful as supplements for developing areas.

Growth of children 2-5 years of age has been improved (highly significantly) by supplementing their usual rice and pulse diets with one ounce of a high protein food daily (Gumm et al., 1966). The food contained [illegible]% groundnut protein isolate, 15% roasted chickpea flour, vitamins and minerals and supplied 22.2 g protein per ounce.

Guttikar et al. (1965) evaluated a protein food based on groundnut, chickpea, and sesame flour (4:4:2) as being quite effective as a source of protein when fed at the rate of 1.5 g protein per kg body weight.

The effect of supplementing the rice diet of Indian girls (8-9 years) with lysine, methionine, and threonine has been studied (Parthasarathy et al., 1964). The rice diet contained 250 g rice, small amounts of legumes, vegetables, 45 g oil, and 5 g skim milk powder, vitamins, sugar, and a salt mixture. It furnished 1500 kcal/day and had a nitrogen retention of 9% of intake. A skim milk powder diet was formulated for comparative purposes: [illegible] g peanut oil, 125 g tapioca flour, [illegible] g [illegible] starch, [illegible] g skim milk powder, vitamins, sugar, and salt mixture. The nitrogen retentions for the supplemented diets were as follows: rice + 316 mg methionine, 1[illegible]%; rice + [illegible]28 mg lysine, 12.6%; rice + [illegible]16 mg methionine + [illegible] lysine, 13.5%; rice + 1128 mg lysine + [illegible] mg [illegible], 1[illegible]%; rice + 1128 mg lysine + [illegible] mg methionine + [illegible] mg threonine, 23.0%; skim milk powder diet, [illegible]%. Supplementation improved the net protein utilization: [illegible] diet, 2.9% and 54.9%; rice + methionine + lysine + threonine, [illegible]%; skim milk diet, 71%. The [illegible] (protein g/kg body weight) for the various diets were: rice, [illegible]; rice + lysine and/or methionine, [illegible]; rice + lysine + threonine, 0.85; rice + lysine + methionine + threonine, 0.91; skim milk, 0.98. Protein intake was 1.2[illegible]-1.3[illegible] g/kg body weight.

Barness <u>et</u> <u>al.</u> (1961) observed that wheat (cream of wheat cereal) fortified with lysine and potassium appeared to supply adequate protein for growing Latin American infants 3-17 months of age. The daily caloric intake was 75-125 kcal/kg; protein intake was 1.2-4.0 g/kg.

Chickpeas and broad beans have been used in foods in the Near East and other parts of the world to supplement the diet of small children (Autret and Van Veen, 1955; Asfour *et al.*, 1965). In India legume flour is sometimes added to wheat flour (up to 10%) to make chapatties (Aykroyd and Doughty, 1964).

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% SAMPLE

	78-68 Lentils	81-68 Moroccan Lentils	346-68 Lentils	324-68 Lentils No. 53	321-68 111 Feies	79-68 Horse Beans
Protein	24.1	23.0	17.0	25.8	24.1	26.4
Moisture	10.6	10.7	11.7	10.7	[illegible]	11.0
Lysine	2.019	1.776	1.246	1.812	1.732	1.676
Histidine	0.661	0.613	0.651	0.648	0.650	0.613
Ammonia	0.428	0.417	0.317	0.468	0.488	0.433
Arginine	2.045	1.846	1.537	2.192	2.640	2.440
Aspartic acid	2.904	2.551	2.291	3.242	2.887	2.901
Threonine	0.920	0.851	0.740	0.974	0.929	0.949
Serine	1.206	1.148	0.970	1.302	1.201	1.243
Glutamic acid	4.063	3.924	3.487	4.550	4.492	4.607
Proline	1.416	0.827	1.337	1.089	1.016	1.014
Glycine	0.964	0.902	0.775	1.053	1.067	1.046
Alanine	1.018	0.924	0.796	1.105	1.052	0.062
Half Cystine	0.026	0.000	0.0	0.0	0.365	0.0
Valine	1.266	1.114	1.016	1.182	0.690	1.232
Methionine	0.098	[illegible]	0.274	0.099	0.122	0.113
Isoleucine	1.047	0.922	0.780	0.904	1.074	1.060
Leucine	1.612	1.405	1.364	1.844	1.662	1.687
Tyrosine	0.797	0.644	0.574	0.786	0.832	0.798
Phenylalanine	1.171	1.075	1.040	0.285	1.090	1.039
Nitrogen Recovery	94.78	89.42	106.60	91.83	98.80	88.41
Oxidations:						
Cystine				0.150	0.272	
Methionine				0.093	0.148	

% SAMPLE

	83-68 Good Horse Beans	331-68 Northern Beans	335-68 Lg. Kidney Beans	344-68 Feveroles	347-68 Horse Beans	182-68 Red Kidney Beans	73-68 Haricot Beans
Protein	26.3	23.3	22.9	25.8	27.3	21.4	20.8
Moisture	10.1	13.4	11.5	10.3	9.8	10.3	10.6
Lysine	1.308	1.705	1.559	1.555	1.613	1.575	1.419
Histidine	0.501	0.723	0.677	0.613	0.612	0.653	0.567
Ammonia	0.360	0.454	0.432	0.452	0.474	0.414	0.322
Arginine	2.206	1.673	1.491	2.674	2.354	1.592	1.119
Aspartic acid	2.319	2.823	2.898	2.789	2.760	2.852	2.555
Threonine	0.779	1.032	0.991	0.848	0.952	0.932	0.924
Serine	0.983	1.452	1.377	1.207	1.175	1.374	1.236
Glutamic acid	3.649	3.694	4.075	3.965	4.452	4.059	3.465
Proline	0.789	1.215	0.850	1.007	0.874	0.914	0.894
Gylcine	0.882	0.950	0.896	1.022	1.005	0.917	0.819
Alanine	0.887	1.016	0.933	0.977	1.018	0.980	0.876
Half Cystine	0.000	0.255	0.0	0.349	0.0	0.210	0.211
Valine	0.993	1.192	1.316	1.119	1.197	0.971	1.001
Methionine	0.062	0.210	0.213	0.115	0.063	0.210	0.174
Isoleucine	2.008	1.077	1.084	0.964	1.040	1.075	0.943
Leucine	1.332	1.869	1.659	1.745	1.585	1.884	1.634
Tyrosine	0.633	0.757	0.742	0.784	0.799	0.797	0.700
Phenylalanine	0.791	1.295	1.309	1.035	1.047	1.335	1.305
Nitrogen Recovery	76.08	94.99	92.03	89.52	83.26	98.84	87.50
Oxidations:							
Cystine		0.243	0.213			0.194	
Methionine		0.265	0.255			0.170	

% SAMPLE

	75-68 Moroccan Beans	85-68 Poor Horse Beans	322-68 319 Feveroles	348-68 Ground Shorts	124A-68 White Wheat	128A-68 Stone Ground White Wheat	127-68 White Wheat
Protein	22.7	22.0	24.9	21.1	10.7	11.6	12.2
Moisture	10.6	10.7	10.9	13.1	13.2	11.7	11.9
Lysine	1.628	1.441	1.580	0.586	0.324	0.333	0.322
Histidine	0.721	0.527	0.631	0.529	0.244	0.260	0.270
Ammonia	0.517	0.448	0.459	0.864	0.340	0.318	0.385
Arginine	1.619	1.979	2.402	1.126	0.509	0.573	0.575
Aspartic acid	2.783	2.355	2.883	1.225	0.598	0.661	0.601
Threonine	0.915	0.815	0.886	0.657	0.342	0.377	0.366
Serine	1.183	1.031	1.172	1.107	0.535	0.557	0.564
Glutamic acid	4.375	3.758	4.314	8.613	3.517	3.885	3.814
Proline	1.016	0.891	1.013	2.533	1.024	1.276	1.169
Glycine	0.984	0.922	1.044	0.928	0.456	0.474	0.471
Alanine	1.003	0.901	1.008	0.777	0.427	0.438	0.438
Half Cystine	0.0	0.268	0.257	0.702	0.353	0.310	0.471
Valine	1.096	0.965	1.143	1.006	0.505	0.606	0.478
Methionine	0.331	0.093	0.075	0.159	0.123	0.181	0.128
Isoleucine	0.941	0.882	1.018	0.800	0.394	0.445	0.423
Leucine	1.704	1.432	1.628	1.390	0.764	0.720	0.808
Tyrosine	0.730	0.697	0.792	0.708	0.362	0.344	0.368
Phenylalanine	1.306	0.928	1.044	1.101	0.522	0.512	0.555
Nitrogen Recovery	96.48	90.99	91.97	108.51	96.11	94.41	91.37
Oxidations:							
Cystine			0.294		0.255	0.276	0.331
Methionine			0.16[illegible]		0.160	0.177	0.190

% SAMPLE

	307-68 HA-3 277	313-68 BT 3597	311-68 BT 3597	58-68 Coarse Bran	91-68 #1 Durum	312-68 BT 908	308-68 3225
Protein	11.8	11.5	11.1	14.1	11.6	10.5	10.3
Moisture	9.2	11.6	10.7	11.4	11.8	11.3	10.9
Lysine	0.315	0.332	0.317	0.598	0.316	0.304	0.294
Histidine	0.260	0.254	0.239	0.392	0.238	0.232	0.231
Ammonia	0.307	0.353	0.366	0.322	0.394	0.339	0.308
Arginine	0.546	0.549	0.530	0.994	0.540	0.499	0.523
Aspartic acid	0.671	0.626	0.652	1.130	0.685	0.624	0.589
Threonine	0.335	0.344	0.337	0.494	0.329	0.328	0.301
Serine	0.584	0.527	0.538	0.672	0.580	0.523	0.492
Glutamic acid	3.929	3.698	3.530	2.941	3.891	3.457	3.143
Proline	1.252	1.218	1.210	0.980	1.266	1.186	1.114
Glycine	0.431	0.436	0.455	0.817	0.421	0.431	0.404
Alanine	0.402	0.405	0.414	0.731	0.402	0.393	0.374
Half Cystine	0.232	0.372	0.383	0.392	0.308	0.353	0.265
Valine	0.515	0.501	0.496	0.697	0.474	0.476	0.463
Methionine	0.055	0.151	0.069	0.151	0.055	0.052	0.086
Isoleucine	0.426	0.306	0.330	0.399	0.374	0.352	0.332
Leucine	0.701	0.729	0.736	0.868	0.732	0.686	0.660
Tyrosine	0.339	0.316	0.326	0.399	0.321	0.323	0.297
Phenylalanine	0.557	0.517	0.479	0.570	0.530	0.472	0.469
Nitrogen Recovery	89.34	92.61	94.47	91.78	93.90	95.71	92.24
Oxidations:							
Cystine	0.265	0.267	0.276	0.315		0.230	0.247
Methionine	0.120	0.158	0.164	0.194		0.129	0.034

% SAMPLE

	310-68 BT 2306	93-68 Durum	57-68 Fine Bran	[illegible]-68 [illegible] Rec Winter	[illegible] 3424	9[illegible]-68 #2 Durum	[illegible]-68 Strai[illegible] [illegible] Grade Flour [illegible]
Protein	10.9	13.0	14.9	[illegible]	[illegible]	1[illegible].6	9.[illegible]
Moisture	11.7	11.7	11.1	[illegible]	[illegible]	[illegible]	12.4
Lysine	0.280	0.324	0.614	[illegible]	[illegible]	0.342	0.20[illegible]
Histidine	0.227	0.266	0.371	0.258	0.251	0.305	0.200
Ammonia	0.300	0.371	0.333	0.374	0.326	0.372	0.371
Arginine	0.486	0.553	0.957	0.580	0.534	0.652	0.392
Aspartic acid	0.525	0.631	0.103	0.586	0.566	0.757	0.392
Threonine	0.324	0.385	0.521	0.343	0.338	0.398	0.272
Serine	0.503	0.608	0.665	0.525	0.538	0.699	0.461
Glutamic acid	3.364	4.070	3.068	3.584	3.449	4.780	3.668
Proline	1.005	1.255	1.092	1.032	1.023	1.557	1.092
Glycine	0.425	0.527	0.773	0.461	0.445	0.499	0.337
Alanine	0.375	0.444	0.728	0.413	0.416	0.470	0.291
Half Cystine	0.430	0.436	0.405	0.335	0.354	0.391	0.366
Valine	0.455	0.549	0.800	0.581	0.487	0.621	0.440
Methionine	0.041	0.145	0.200	0.131	0.083	0.129	0.104
Isoleucine	0.368	0.444	0.457	0.412	0.399	0.419	0.341
Leucine	0.703	0.846	0.883	0.699	0.761	0.865	0.611
Tyrosine	0.337	0.406	0.428	0.352	0.351	0.412	0.316
Phenylalanine	0.488	0.582	0.591	0.531	0.520	0.696	0.477
Nitrogen Recovery	87.45	88.50	88.65	91.30	91.26	93.37	97.67
Oxidations:							
Cystine	0.250			0.296	0.246		0.215
Methionine	0.151			0.163	0.192		0.112

% SAMPLE

	84-68 Halba-Ext.	71-68 Bird Seed	151-68 Lobin	325-68 204 Soja	70-68 Broken Split Peas	332-68 Gorden Peas	333-68 Small Br. Crowder
Protein	25.5	16.3	23.7	38.4	22.4	27.3	20.4
Moisture	9.70	10.0	10.0	8.1	10.8	12.4	12.7
Lysine	1.637	0.357	1.746	2.800	1.753	2.350	1.495
Histidine	0.617	0.329	0.780	1.094	0.564	0.695	0.653
Ammonia	0.401	0.395	0.415	0.799	0.357	0.577	0.428
Arginine	2.344	0.947	1.725	3.275	2.433	2.855	1.482
Aspartic acid	2.864	0.904	3.065	4.996	2.897	3.124	2.248
Threonine	0.950	0.403	0.959	1.654	0.877	1.128	0.858
Serine	1.248	0.680	1.286	2.150	1.118	1.393	1.121
Glutamic acid	4.266	4.842	4.725	8.301	4.203	5.126	3.821
Proline	1.030	1.198	1.388	1.999	1.177	1.146	0.983
Glycine	1.183	0.479	1.015	1.723	0.966	1.305	0.947
Alanine	0.997	0.634	1.046	0.757	1.006	1.314	0.994
Half Cystine	0.143	0.491	0.0	1.101	0.153	0.271	0.107
Valine	1.167	0.791	1.300	1.925	1.121	0.883	1.058
Methionine	0.159	0.208	0.277	0.467	0.311	0.0	0.267
Isoleucine	1.245	0.669	1.061	1.942	0.974	1.159	0.903
Leucine	1.498	0.159	1.727	2.822	1.817	1.981	1.621
Tyrosine	0.783	0.421	0.799	1.519	0.763	0.898	0.728
Phenylalanine	1.042	0.902	1.418	2.124	1.069	1.272	1.175
Nitrogen Recovery	89.62	86.62	97.08	102.93	101.2	100.51	97.36
Oxidations:							
Cystine			0.218			0.349	0.207
Methionine			0.189			0.285	0.281

% SAMPLE

	336-68 Crowder Cow Pea	328-68 191 Pois	36-68 Wheat & Barley	144-68 Barley	94-68 Barley	338-68 Hg.-treated Sorghum	126A-68 Sorghum
Protein	23.3	23.7	12.1	10.8	9.4	10.2	9.5
Moisture	14.1	9.9	11.6	11.0	11.3	12.6	12.3
Lysine	1.799	1.849	0.302	0.354	0.322	0.220	0.182
Histidine	0.836	0.555	0.231	0.210	0.185	0.225	0.193
Ammonia	0.536	0.365	0.232	0.304	0.226	0.283	0.261
Arginine	2.004	1.940	0.484	0.516	0.441	0.363	0.333
Aspartic acid	3.061	2.697	0.578	0.696	0.540	0.818	0.664
Threonine	1.033	0.984	0.348	0.383	0.324	0.365	0.314
Serine	1.377	1.111	0.515	0.493	0.398	0.481	0.438
Glutamic acid	4.937	4.013	3.501	3.063	2,293	2.441	2.072
Proline	1.283	0.876	1.227	1.215	0.988	0.736	0.743
Glycine	1.092	1.067	0.411	0.455	0.363	0.283	0.314
Alanine	1.117	1.084	0.411	0.457	0.368	0.925	0.894
Half Cystine	0.0	0.402	0.307	0.326	0.242	0.045	0.190
Valine	1.394	1.120	0.492	0.537	0.457	0.606	0.481
Methionine	0.383	0.183	0.136	0.036	0.068	0.199	0.043
Isoleucine	1.080	1.029	0.394	0.402	0.321	0.532	0.384
Leucine	1.978	1.519	0.750	0.762	0.638	1.410	1.254
Tyrosine	0.838	0.824	0.355	0.369	0.292	0.341	0.384
Phenylalanine	1.488	1.162	0.595	0.570	0.482	0.388	0.511
Nitrogen Recovery	107.51	90.78	83.95	93.10	85.75	93.50	90.87
Oxidations:							
Cystine	0.235		0.146	0.219			0.141
Methionine	0.332		0.182	0.139			0.120

% SAMPLE

	318-68 SH20-Hybrid Mawcain	319-68 Sorghum Vulgare	77-68 White Corn from Fez	334-68 American Corn	129-68 Domestic Corn	315-68 D117 Hybrid Double	74-68 American Corn
Protein	16.3	10.5	10.4	11.4	9.3	10.1	16.1
Moisture	11.6	12.1	11.3	13.6	11.5	11.4	11.0
Lysine	0.280	0.238	0.231	0.259	0.283	0.267	0.298
Histidine	0.330	0.210	0.227	0.343	0.269	0.280	0.294
Ammonia	0.475	0.327	0.255	0.307	0.186	0.233	0.234
Arginine	0.568	0.361	0.433	0.428	0.434	0.443	0.442
Aspartic acid	1.115	0.862	0.761	0.775	0.632	0.764	0.832
Threonine	0.507	0.341	0.365	0.424	0.351	0.367	0.444
Serine	0.709	0.530	0.472	0.592	0.454	0.528	0.594
Glutamic acid	3.921	2.495	2.393	2.712	1.901	2.213	2.569
Proline	1.263	1.169	1.193	1.277	0.839	1.081	1.156
Glycine	0.441	0.329	0.341	0.384	0.344	0.362	0.401
Alanine	1.575	1.028	0.994	0.957	0.685	0.816	0.942
Half Cystine	0.301	0.0	0.110	0.351	0.171	0.213	0.126
Valine	0.818	0.517	0.588	0.577	0.468	0.461	0.603
Methionine	0.200	0.021	0.239	0.204	0.019	0.040	0.153
Isoleucine	0.664	0.414	0.456	0.443	0.334	0.324	0.439
Leucine	2.089	1.446	1.387	1.630	1.017	1.399	1.427
Tyrosine	0.696	0.399	0.468	0.521	0.371	0.412	0.485
Phenylalanine	0.880	0.558	0.568	0.641	0.427	0.537	0.563
Nitrogen Recovery	92.07	97.17	96.98	98.84	88.66	94.39	65.08
Oxidations:							
Cystine	0.269	0.158		0.251	0.208	0.210	
Methionine	0.267	0.099		0.227	0.171	0.176	

% SAMPLE

	148-68 Mung	345-68 Mung Bean	131A-68 Mung	337-68 White Mallet	72A-68 Millet	341-68 Canary Seed	340-68 Mustard
Protein	23.4	21.9	22.9	10.6	10.1	16.6	26.0
Moisture	11.7	11.9	11.1	12.2	10.9	12.7	7.10
Lysine	1.696	1.653	1.757	0.189	0.186	0.535	1.210
Histidine	0.651	0.612	0.660	0.217	0.204	0.318	0.576
Ammonia	0.419	0.376	0.366	0.319	0.242	0.479	0.532
Arginine	1.629	1.550	1.656	0.357	0.402	1.134	1.444
Aspartic acid	3.026	2.731	3.080	0.692	0.677	1.357	1.477
Threonine	0.851	0.804	0.833	0.340	0.328	0.486	0.891
Serine	1.333	1.238	1.281	0.733	0.615	0.700	0.936
Glutamic acid	4.665	4.196	4.598	2.359	2.279	3.840	4.109
Proline	1.136	1.037	1.297	0.679	0.724	0.841	1.260
Glycine	0.966	0.901	0.913	0.252	0.282	0.625	1.073
Alanine	1.130	0.993	1.001	1.173	1.003	0.740	0.910
Half Cystine	0.107	0.200	0.0	0.182	0.085	0.457	0.666
Valine	1.321	0.405	1.339	0.242	0.532	0.778	0.919
Methionine	0.266	0.278	0.250	0.160	0.256	0.220	0.091
Isoleucine	1.128	1.010	1.058	0.422	0.602	0.636	0.850
Leucine	2.002	1.825	1.736	1.311	1.047	1.089	1.442
Tyrosine	0.798	0.764	0.663	0.423	0.345	0.504	0.584
Phenylalanine	1.515	1.421	1.414	0.613	0.515	0.849	0.872
Nitrogen Recovery	96.76	92.87	96.00	91.10	89.48	89.06	74.10
Oxidations:							
Cystine	0.186		0.163	0.157		0.355	0.546
Methionine	0.277		0.290	0.510		0.272	0.354

% PROTEIN

	78-68 Lentils	81-68 Moroccan Lentils	346-68 Lentils	324-68 Lentils No. [illegible]	[illegible]-68 [illegible] Feles	79-68 Horse Beans	83-68 Good Horse Beans
Protein	24.1	23.0	17.0	[illegible]8	[illegible]	26.4	26.3
Moisture	10.6	10.7	11.7	10.[illegible]	1[illegible]	11.0	10.1
Lysine	8.377	7.721	7.329	7.02[illegible]	[illegible].185	6.347	4.974
Histidine	2.741	2.665	3.828	2.513	2.698	2.322	1.906
Ammonia	1.778	1.812	1.864	1.815	2.024	1.641	1.367
Arginine	8.484	8.026	9.040	8.49[illegible]	10.953	9.241	8.387
Aspartic acid	12.049	11.090	13.479	12.566	11.980	10.987	8.818
Threonine	3.819	3.701	4.351	3.774	3.854	3.593	2.963
Serine	5.003	4.991	5.705	5.048	4.984	4.707	3.736
Glutamic acid	16.859	17.062	20.509	17.634	18.638	17.451	13.875
Proline	5.877	3.596	7.862	4.222	4.215	3.839	2.998
Glycine	3.999	3.922	4.560	4.082	4.427	3.961	3.352
Alanine	4.224	4.020	4.683	4.285	4.367	4.022	3.374
Half Cystine	0.106	0.000	0.000	0.000	1.516	0.000	0.000
Valine	5.252	4.844	5.979	4.582	2.863	4.665	3.777
Methionine	0.405	0.777	1.613	0.382	0.508	0.428	0.236
Isoleucine	4.344	4.010	4.587	3.506	4.458	4.016	7.633
Leucine	6.690	6.110	8.025	7.149	6.897	6.390	5.065
Tyrosine	3.305	2.801	3.377	3.048	3.450	3.024	2.407
Phenylalanine	4.859	4.676	6.117	4.982	4.524	3.937	3.[illegible]
Oxidation:							
Cystine				0.581	1.130		
Methionine				0.360	0.615		

% PROTEIN

	331-68 Northern Beans	335-68 Lg. Kidney Beans	344-68 Fever[illegible]	[illegible]-68 Horse Beans	18[illegible]-68 Red Kidney Beans	[illegible]-68 Haricot Beans	75-68 Moroccan Beans
Protein	23.3	22.9	25.8	2[illegible].[illegible]	[illegible]	20.8	22.7
Moisture	13.6	11.5	10.3	[illegible]	10.[illegible]	10.6	10.6
Lysine	7.317	6.983	6.02[illegible]	[illegible]	7.362	6.822	7.[illegible]72
Histidine	3.102	2.958	2.378	[illegible]	3.050	2.724	3.177
Ammonia	1.950	1.884	1.751	[illegible]	1.933	1.548	2.279
Arginine	7.180	6.509	10.364	8.623	[illegible]	5.378	7.134
Aspartic acid	12.115	12.656	10.811	10.111	13.329	12.283	12.258
Threonine	4.430	4.327	3.285	3.487	4.357	4.441	4.033
Serine	6.232	6.012	4.677	4.303	6.420	5.941	5.211
Glutamic acid	15.853	17.795	15.370	16.309	18.969	16.660	19.273
Proline	5.213	3.710	3.904	3.203	4.271	4.296	4.476
Glycine	4.076	3.911	3.963	3.682	4.287	3.936	4.337
Alanine	4.361	4.076	3.785	3.729	4.579	4.211	4.421
Half Cystine	1.094	0.000	1.353	0.000	0.982	1.012	0.000
Valine	5.115	5.746	4.337	4.385	4.538	4.955	4.830
Methionine	0.900	0.929	0.445	0.231	0.982	0.838	1.460
Isoleucine	4.624	4.733	3.736	3.808	5.023	4.534	4.147
Leucine	8.020	7.246	6.762	5.807	8.803	7.855	7.503
Tyrosine	3.248	3.238	3.037	2.926	3.723	3.364	3.217
Phenylalanine	5.558	5.716	4.010	3.836	6.240	6.274	5.755
Oxidation:							
Cystine	1.044	0.929			0.905		
Methionine	1.136	1.114			0.793		

% PROTEIN

	85-68 Poor Horse Beans	322-68 319 Feveroles	348-68 Ground Shorts	124-68 White Wheat	128-68 Stone Ground White Wheat	127-68 White Wheat	307-68 MA-3 277
Protein	22.0	24.9	21.1	10	11.6	12.2	11.8
Moisture	10.7	10.9	13.1	13.2	.1	11.9	9.2
Lysine	6.551	6.345	2.776	3.026	2.872	2.639	2.667
Histidine	2.396	2.532	2.505	2.278	2.243	2.214	2.205
Ammonia	2.035	1.843	4.097	3.174	2 741	3.157	2.602
Arginine	8.994	9.647	5.337	4.761	4.941	4.716	4.631
Aspartic acid	10.706	11.578	5.806	5.589	5.703	4.927	5.682
Threonine	3.704	3.558	3.114	3.192	3.250	2.996	2.839
Serine	4.688	4.705	5.248	4.996	4.806	4.623	4.946
Glutamic acid	17.081	17.324	40.821	32.865	33.488	31.262	33.296
Proline	4.048	4.069	12.004	9.568	10.999	9.581	10.614
Glycine	4.189	4.194	4.396	4.260	4.090	3.862	3.653
Alanine	4.095	4.047	3.681	3.991	3.772	3.592	3.403
Half Cystine	1.217	1.030	3.325	3.297	2.675	3.859	1.966
Valine	4.385	4.589	4.770	4.721	5.221	3.915	4.361
Methionine	0.421	0.302	0.755	1.153	1.563	1.050	0.470
Isoleucine	4.010	4.088	3.792	3.678	3.836	3.465	3.610
Leucine	6.511	6.539	6.586	7.144	6.206	6.624	5.943
Tyrosine	3.167	3.182	3.355	3.388	2.969	3.020	2.874
Phenylalanine	4.220	4.193	5.219	4.881	4.410	.547	4.724
Oxidation:							
Cystine		1.182		2.382	2.380	2.711	2.075
Methionine		0.661		1.493	1.523	1.638	1.016

% PROTEIN

	313-68 BT3597	311-68 BT2511	56-68 Coarse Bran	61-68 #1 Durum	312-68 BT-908	308-68 3225	310-68 BT2306
Protein	11.5	11.1	14.1	1[illegible].6	10.5	10.3	10.9
Moisture	11.6	10.7	11.4	11.8	[illegible]	10.9	11.7
Lysine	2.891	2.852	4.176	[illegible]	2.899	2.854	2.567
Histidine	2.207	2.151	2.777	2.053	2.210	2.247	2.082
Ammonia	3.072	3.301	2.281	3.398	3.229	2.993	2.757
Arginine	4.777	4.775	7.052	4.659	4.752	5.075	4.462
Aspartic acid	5.441	5.875	8.015	5.903	5.938	5.716	4.812
Threonine	2.988	3.039	3.501	2.837	3.125	2.927	2.974
Serine	4.585	4.843	4.764	4.997	4.984	4.778	4.611
Glutamic acid	32.152	31.798	20.857	33.547	32.922	30.516	30.864
Proline	10.589	10.901	6.948	10.913	11.297	10.820	9.222
Glycine	3.787	4.103	5.794	3.626	4.107	3.927	3.899
Alanine	3.520	3.730	5.187	3.466	3.742	3.634	3.438
Half Cystine	3.233	3.446	2.781	2.658	3.362	2.574	3.946
Valine	4.355	4.469	4.945	4.090	4.530	4.492	4.170
Methionine	1.313	0.624	1.072	0.303	0.499	0.838	0.378
Isoleucine	3.360	2.972	2.832	3.224	3.352	3.225	3.374
Leucine	6.340	6.634	6.158	6.309	6.534	6.441	6.495
Tyrosine	2.745	2.933	2.831	2.767	3.072	2.884	3.093
Phenylalanine	4.498	4.315	4.042	4.571	4.500	4.550	4.478
Oxidation:							
Cystine	2.317	2.488	2.236		2.191	2.397	2.294
Methionine	1.371	1.473	1.379		1.226	0.328	1.383

% PROTEIN

	93-68 Durum	57-68 Fine Bran	55-68 Soft Red Winter	309-68 3424	92-68 #2 Durum	56-68 Straight Grade Flour "Force"	84-68 Halba Ext.
Protein	13.0	14.9	11.7	[illegible]	[illegible]	9.6	25.5
Moisture	11.7	11.1	12.6	[illegible]	11.4	12.4	9.70
Lysine	2.495	4.124	2.837	2.867	2.514	2.161	6.421
Histidine	2.043	2.492	2.209	2.257	2.240	2.084	2.421
Ammonia	2.852	2.235	3.194	2.933	2.737	3.861	1.572
Arginine	4.255	6.426	4.960	4.808	4.796	4.083	9.193
Aspartic acid	4.857	7.401	5.013	5.097	5.564	4.084	11.231
Threonine	2.964	3.495	2.934	3.044	2.929	2.834	3.724
Serine	4.676	4.465	4.485	4.850	5.142	4.801	4.896
Glutamic acid	31.306	20.593	30.629	31.074	35.150	38.209	16.728
Proline	9.654	7.327	8.817	9.220	11.450	11.374	4.038
Glycine	4.051	5.188	3.939	4.011	3.668	3.505	4.460
Alanine	3.414	4.886	3.526	3.747	3.455	3.034	3.910
Half Cystine	3.355	2.716	2.863	3.185	2.875	3.809	0.563
Valine	4.221	5.371	4.964	4.388	4.567	4.579	4.576
Methionine	1.117	1.342	1.118	0.752	0.949	1.088	0.624
Isoleucine	3.412	3.067	3.521	3.595	3.082	3.554	4.883
Leucine	6.509	5.927	5.975	6.856	6.359	6.367	5.876
Tyrosine	3.125	2.876	3.012	3.160	3.029	3.291	3.069
Phenylalanine	4.478	3.964	4.536	4.684	5.116	4.965	4.088
Oxidation:							
Cystine			2.526	2.219		2.235	
Methionine			1.392	1.731		1.165	

% PROTEIN

	71-68 Bird Seed	151-68 Lobia	325-68 204 Soja	70-68 Broken Split Peas	332-68 Garden Peas	333-68 Small Br. Crowder	336-68 Crower Cow Pea
Protein	16.3	23.7	38.4	[illegible]	27.3	20.4	23.3
Moisture	10.0	10.0	8.1	10.8	12.[illegible]	12.7	14.1
Lysine	2.192	7.366	7.293	7.825	8.609	7.329	7.723
Histidine	2.019	3.292	2.850	2.518	2.544	3.201	3.587
Ammonia	2.421	1.751	2.081	1.595	2.114	2.100	2.299
Arginine	5.810	7.279	8.527	10.862	10.456	7.266	8.600
Aspartic acid	5.543	12.932	13.011	12.934	11.442	11.021	13.139
Threonine	2.472	4.046	4.306	3.914	4.131	4.205	4.435
Serine	4.173	5.427	5.600	4.989	5.101	5.497	5.911
Glutamic acid	29.705	19.937	21.618	18.785	18.851	18.728	21.189
Proline	7.349	5.856	5.207	5.255	4.197	4.816	5.508
Glycine	2.936	4.283	4.487	4.402	4.781	4.640	4.688
Alanine	4.198	4.413	4.576	4.501	4.812	4.873	4.793
Half Cystine	3.011	0.000	2.867	0.685	0.992	0.524	0.000
Valine	4.855	5.483	5.013	5.005	3.236	5.184	5.984
Methionine	1.274	1.167	1.217	1.388	0.000	1.309	1.643
Isoleucine	4.103	4.478	5.056	4.348	4.247	4.426	4.637
Leucine	6.498	7.286	7.348	8.113	7.255	7.948	8.6[illegible]
Tyrosine	2.583	3.370	3.955	3.407	3.291	3.569	3.596
Phenylalanine	5.531	5.985	5.532	4.773	4.658	5.760	6.388
Oxidation:							
Cystine		0.921			1.278	1.012	1.009
Methionine		0.796			1.045	1.375	1.425

% PROTEIN

	328-68 191 Pois	36-68 Wheat & Barley	144-68 Barley	94-68 Barley	338-68 Hg-treated Sorghum	126-68 Sorghum	318-68 SM20 Hybrid Mawcain
Protein	23.7	12.1	10.8	9.4	10.2	9.5	16.3
Moisture	9.9	11.4	11.0	11.3	12.6	12.3	11.6
Lysine	7.801	2.492	3.277	3.424	2.153	1.915	1.716
Histidine	2.342	1.908	2.028	1.969	2.201	2.035	2.023
Ammonia	1.542	2.668	2.815	2.402	2.776	2.745	2.917
Arginine	8.186	4.004	4.779	4.697	3.557	3.510	3.486
Aspartic acid	11.382	4.773	6.442	5.746	8.017	6.991	6.841
Threonine	4.151	2.874	3.542	3.450	3.579	3.302	3.110
Serine	4.687	4.264	4.560	4.234	4.716	4.608	4.347
Glutamic acid	16.932	28.934	28.175	24.393	23.929	21.810	24.054
Proline	3.694	10.138	11.251	10.299	7.216	7.817	7.750
Glycine	4.502	3.397	4.213	3.857	2.778	3.308	2.708
Alanine	4.573	3.398	4.233	3.915	9.073	9.411	9.660
Half Cystine	1.694	2.538	3.015	2.574	0.439	2.003	1.846
Valine	4.725	4.067	4.972	4.860	5.942	5.067	5.020
Methionine	0.771	1.120	0.332	0.718	1.950	0.450	1.228
Isoleucine	4.344	3.258	3.723	3.419	5.220	4.039	4.076
Leucine	6.410	6.200	7.052	6.787	13.819	13.203	12.819
Tyrosine	3.479	2.931	3.421	3.107	3.339	4.041	4.270
Phenylalanine	4.904	4.920	5.279	5.123	3.807	5.381	5.399
Oxidation:							
Cystine		1.208	2.027			1.486	1.648
Methionine		1.500	1.286			1.267	1.637

Z PROTEIN

	319-68 Sorghum Vulgare	77-68 White Corn from Fez	334-68 American Corn	129-68 Domestic Corn	315-68 DII Hybrid Double	74-68 American Corn	149-68 Mung
Protein	10.5	10.4	11.4	9.3	10.1	16.1	23.4
Moisture	12.1	11.3	13.6	11.5	11.4	11.0	11.7
Lysine	2.271	2.221	2.275	3.04[illegible]	2.643	1.849	7.247
Histidine	2.000	2.180	3.013	2.894	2.772	1.827	2.782
Ammonia	3.117	2.456	2.693	1.997	2.307	1.455	1.792
Arginine	3.440	4.162	3.753	4.665	4.390	2.746	6.963
Aspartic acid	8.214	7.316	6.797	6.791	7.566	5.169	12.931
Threonine	3.244	3.512	3.723	3.771	3.635	2.760	3.636
Serine	5.052	4.535	5.189	4.885	5.227	3.692	5.698
Glutamic acid	23.764	23.012	23.789	20.441	21.913	15.959	19.936
Proline	11.131	11.470	11.204	9.019	10.599	7.180	4.855
Glycine	3.135	3.283	3.369	3.702	3.[illegible]87	2.488	4.213
Alanine	9.788	9.555	8.394	7.366	8.081	5.852	4.830
Half cystine	0.000	1.055	3.079	1.837	2.105	0.784	0.457
Valine	4.928	5.656	5.061	5.034	4.563	3.745	5.645
Methionine	0.199	2.294	1.789	0.201	0.391	0.952	1.137
Isoleucine	3.947	4.389	3.886	3.593	3.207	2.728	4.822
Leucine	13.775	13.340	14.296	10.939	13.855	8.861	8.557
Tyrosine	3.798	4.503	4.566	3.985	4.075	3.014	3.409
Phenylalanine	5.314	5.463	5.623	4.595	5.314	3.496	6.475
Oxidation:							
Cystine	1.509		2.205	2.232	2.077		0.797
Methionine	0.945		1.989	1.842	1.739		1.183

	345-68 Mung Beans	131-68 Mung	[illegible] White Millet	[illegible]	[illegible]	340-68 Mustard	339-68 Pumpkin Seeds
Protein	21.9	22.9	[illegible]		[illegible]	[illegible]	30.0
Moisture	11.9	11.1	[illegible]	[illegible]		[illegible]	6.9
Lysine	7.547	7.673	1.785	[illegible]	[illegible]	4.656	4.020
Histidine	2.796	2.883	[illegible]	[illegible]	[illegible]	2.215	2.363
Ammonia	1.715	1.600	3.005	[illegible]	[illegible]	2.004	1.316
Arginine	7.079	7.230	3.369	3.984	6.833	[illegible]	15.235
Aspartic acid	12.469	13.451	6.530	6.701	[illegible]	5.679	9.845
Threonine	3.671	3.639	3.210	3.245	2.925	3.425	2.826
Serine	5.655	5.594	6.914	6.089	4.219	3.600	5.202
Glutamic acid	19.160	20.078	22.259	22.565	23.131	15.805	19.725
Proline	4.734	5.665	6.405	7.666	[illegible]	4.847	3.674
Glycine	4.113	3.985	2.376	2.591	[illegible]	4.126	5.935
Alanine	4.534	4.371	11.068	9.926	4.460	3.502	4.159
Half Cystine	0.912	0.000	1.718	0.840	2.756	2.556	2.321
Valine	1.851	5.848	2.286	5.265	4.688	3.533	4.298
Methionine	1.270	1.091	1.509	2.534	1.323	0.351	1.579
Isoleucine	4.610	4.621	3.982	3.979	3.829	3.268	3.556
Leucine	8.334	7.581	12.367	10.366	6.559	5.547	6.589
Tyrosine	3.489	2.897	3.988	3.418	3.033	2.246	3.717
Phenylalanine	6.490	6.177	5.780	5.100	5.113	3.355	4.829
Oxidation:							
Cystine		0.710	1.484		2.140	2.099	1.357
Methionine		1.264	[illegible]		1.640	1.362	2.221

% PROTEIN

	152-68 Rice	80-68 Chick Peas	8[illegible]-68 Chick Peas	[illegible]-68 [illegible] Peas	[illegible]	[illegible]-68 Chick Peas	392-68 Chick Peas
Protein	[illegible]	**21.[illegible]**	19.[illegible]	[illegible]	[illegible]	8.[illegible]	19.8
Moisture	12.8	9.90	[illegible]		[illegible]	[illegible]	9.0
Lysine	3.989	6.832	[illegible]	[illegible]	[illegible]	[illegible]9	7.312
Histidine	3.156	2.534	[illegible].628	[illegible]	[illegible]	2.8[illegible]	2.642
Ammonia	2.236	1.802	1.61[illegible]	[illegible]	[illegible]	1.[illegible]71	1.714
Arginine	8.046	10.339	8.825	[illegible]	[illegible]	[illegible]928	10.216
Aspartic acid	10.649	12.745	12.353	1[illegible].884	[illegible]	12.542	[illegible]2.147
Threonine	3.870	3.770	3.879	4.[illegible]3	[illegible]	3.[illegible]98	3.685
Serine	5.223	5.877	5.520	5.479	4.393	5.606	5.247
Glutamic acid	19.659	18.404	17.740	19.444	14.[illegible]9[illegible]	17.689	17.108
Proline	4.815	3.593	4.111	3.743	3.[illegible]16	4.418	4.131
Glycine	4.551	4.163	4.183	4.263	[illegible].25[illegible]	4.378	4.177
Alanine	5.790	4.374	4.537	4.473	[illegible].584	4.519	4.329
Half Cystine	2.554	1.557	1.859	0.861	[illegible].188	2.627	2.191
Valine	6.297	4.995	4.895	4.929	3.741	4.591	4.365
Methionine	1.519	0.883	0.964	1.238	0.734	0.906	1.026
Isoleucine	4.352	4.017	4.442	4.530	3.050	4.459	4.259
Leucine	7.202	6.878	7.833	7.000	5.948	8.101	7.646
Tyrosine	4.706	1.940	3.126	3.226	2.332	3.099	2.868
Phenylalanine	5.191	4.169	6.171	6.216	5.037	5.837	5.623
Oxidation:							
Cystine	2.434						
Methionine	2.575						

Studies on Attas and Chapatis I [1]

Experimental Production of Atta

M. Shafiq Chaudhry, [2] M. M. MacMasters,

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Summary

An experimental method was developed for making atta, the coarse flour from which unleavened bread (chapatis) is made in Pakistan and India. Attas of 80% and 95% extraction were prepared from Hard Red Winter, Hard Red Spring, Durum, White Club, Soft Red Winter and Pakistani wheats. Particle size distribution of experimental attas were in the range of that of typical Pakistani attas. Proximate composition and dough characteristics of the experimental attas were determined. A standard method was developed and used to produce chapatis from the experimental attas. The chapatis were evaluated organoleptically by a panel using a scoring system devised for the purpose. All attas except those from Durum wheat yielded satisfactory chapatis. Color apparently is a major factor in determining acceptability, the White

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[1] Contribution No. 649, Department of Grain Science and Industry, Kansas Agricultural Experiment Station, Kansas State University, Manhattan, Kansas 66502.

[2] This paper is based in part on the dissertation presented by M. Shafiq Chaudhry in partial fulfillment of the requirements for the Ph.D. degree. Dr. Chaudhry's present address is Department of Food Science, West Pakistan Agricultural University, Lyallpur, Pakistan.

Club and Pakistani wheat products were found to be significantly more acceptable than those from any red wheat.

Introduction

Unleavened bread is a staple article of food in Pakistan and India. It is similar in appearance to a tortilla but made of coarse wheat flour and known as a "chapati". The flour from which chapatis are made is called "atta". The typical chapati is prepared from atta and water mixed into a dough that is cooked on a flat, ungreased, hot surface. The chapati is turned several times during cooking and finally, if of good quality, it puffs, i.e., the two surfaces separate because of considerable expansion of gases, probably mostly steam, between them. The puffing subsides as the chapati cools, so the cooked chapati resembles a light tan tortilla flecked with dark brown spots. When cold, a cooked chapati is soft and pliable.

There currently is much interest in possible improvement of average diets in both Pakistan and India. As chapatis are the staple food and sometimes practically the only food in large parts of both countries, improved nutrition must depend primarily on improvement of the nutritive value of chapatis. Particle size of conventional wheat flour of Europe and the Americas is, however, usually considered too small for good chapatis. There is very little in the literature on the production and characteristics of atta. Yet it is obviously very difficult to study nutritional improvement of a product unless the raw material is either readily available or can easily be produced.

Materials and Methods

Seven samples of wheat were used for the study. Each was fumigated when received.

Hard Red Winter: One sample, Triumph variety, from a farm near Scott City, Kansas.

Hard Red Spring: One sample, Selkirk variety from Minnesota.

Durum: One commercial blend from Peavey Mills, Minneapolis.

White Club: Two samples, Burt and Gaines varieties, respectively, grown in the state of Washington.

Soft Red Winter: One composite sample already on hand.

Pakistani: One blend of improved varieties C-273 and C-228 from the Department of Plant Breeding and Genetics, West Pakistan Agricultural University, Lyallpur.

Five hundred grams of each sample was milled and the resulting atta tested for making chapatis. (Wichita variety, (Hard Red Winter) a commercial blend of Hard Red Spring and Omar variety, (White Club) also were used in preliminary tests and found to be not appreciably different from other samples in their respective classes.)

A milling method was developed that yielded attas closely approximating in properties samples obtained from Pakistan. A Hart-Carter Dockage Tester was used for cleaning, with all settings as recommended by the manufacturer. Each sample was conditioned to 15% moisture content by adding the calculated amount of water as a spray to the grain as it was tumbled in a small rotating drum. The conditioned wheat was held in polyethylene bags 24-48 hours before milling. The milling flow sheet is shown in Fig. 1. Ross experimental roller mills were used.

All except the smooth pair of rolls were of "Getchell" type, set dull to dull. The sifting was carried out on a Smico laboratory sifter for 2 min., except in the fourth step where the time was 15-30 sec., depending on the wheat being milled, to obtain approximately 5% overs of 44 W.

Two types of atta, 95% and 80% extraction, were obtained. For 95% extraction, 5% bran (overs of 44 W from the fourth grind) was removed. For 80% extraction, 15% fines (thrus of 10XX) was also removed. After appropriate removal the remaining millstreams were pooled and blended 25 min. in a laboratory blender.

Eleven samples of atta that represented products made (a) on steel roller mill (A-E), (b) on the manually operated stone grinder locally known as a "chakki" in Pakistan (F-H), and (c) on animal-powered stone burr mills (I-K) were employed to determine the particle size distribution of acceptable attas. (Letters refer to designations in Fig. 3.) Two hundred grams of atta were sifted for 2 min. on a Rotap sifter through sieves indicated in Fig. 1. The overs of each sieve and thrus of 150 W were used to calculate a cumulative particle size curve.

Analyses for moisture, crude protein, ash, crude fat and crude fiber were made according to methods 44-15, 46-10, 08-10, 30-20, and 32-15, respectively, in Cereal Laboratory Methods (1962).

Preliminary studies were made of doughs prepared by housewives from Pakistan and India. The amounts of water used by three housewives with 300 grams of atta of 95% extraction (from Gaines variety wheat) were 49%, 59%, and 71.5%, respectively. A small amount of vegetable oil was added when 49% water was used. Each dough was immediately placed in a large size farinograph bowl and the consistency determined. The values were 1,000 B.U., 780 B.U. and 410 B.U., respectively. All gave acceptable chapatis.

A mechanical procedure to evaluate doughs, for chapatis was devised on the basis of knowledge obtained of machinery used for making tortillas. Two sets of sheeting rolls were adapted to determine machinability. The first set, a product of National Machinery Co., had a roll speed of 85 r.p.m., peripheral speed 84 ft. per min.; this set was adjusted to a clearance of one-eighth inch between the rolls. The second set, a product of Anetsburger Bros., Inc., had a roll speed of 60 r.p.m., peripheral speed 52 ft. per min., adjustment was made to a clearance of 0.050 in. between the rolls. Attas were evaluated for machinability by starting at 71% absorption and decreasing absorption by 1% at each trial until a dough was obtained that made a clean pass through each set of rolls. Wrinkling after the second rolls could be reduced by (a) substituting 2% water with an equal amount of vegetable oil (Wesson oil), (b) reducing absorption by 5% from the level that gave no sticking to the rolls, (c) generous use of dusting flour (atta). Combining the three factors completely eliminated wrinkling and improved the handling properties of the chapatis. In Pakistan and India, the housewife commonly uses over 70% absorption and employs dusting flour (atta) to improve handling properties. Fat is sometimes used in making chapatis in India; the product is then not a chapati but a "paratha". Economic considerations often prohibit the use of butter fat or processed vegetable oils in India and Pakistan.

Procedures 54-21 and 54-10 in Cereal Laboratory Methods (1962) were used to evaluate dough characteristics in the farinograph and extensiograph, respectively.

Cooked chapatis were evaluated organoleptically by a panel of judges composed of seven students from Pakistan and India to whom chapatis were a common and well-known food. A scoring system was devised by which each characteristic was evaluated on a scale from 0 to 10, a score of 0 representing the poorest quality and 10 the best (Fig. 2). Each chapati was prepared from 50 gm. of atta, sheeted, cooked on a hot plate, cooled for about 5 minutes and wrapped in wax paper until it was presented to the judges. Organoleptic data were analyzed by students "t" distribution test and analysis of variance (Alder and Roessler 1958).

Results and Discussion

The particle size distribution of attas obtained from Pakistan varied considerably (Fig. 3); that of sample A, from a modern mill, was considered to represent what would probably be available for large-scale production of chapatis, similar to production of bread in a commercial bakery.

The method developed for milling wheat to atta gave products with particle size distribution well within the limits of distribution found for Pakistani attas (Figs. 4, 5, 6), although there were large variations among both the commercial and the experimentally milled samples. Attas of 95% extraction from Pakistani and Hard Red Spring wheats were similar in particle size distribution. However, Aziz and Bhatti (1962) found a wide range in the granularity of attas from various sources, yet all made good chapatis. Probably color is more important than granularity, within a wide range, in determining quality of atta.

Proximate composition of the attas is shown in Table I. Protein content was from 11.6[illegible]% to 15.42%, ether extract was from 1.40% to 2.02%, and ash content was from 1.38% to 1.81%. Hard Red Winter wheat most nearly approached Pakistani wheat in the protein content of the atta, whereas the hard wheats gave attas of appreciably higher ash content than that of atta from Pakistani wheat.

No conditions were found that permitted preparation of a machinable dough [illegible] wheat atta. Attas of the other wheats were machinable when water was added at 5% below maximum absorption, 2% of the water was replaced with vegetable oil, and generous use was made of dusting fl[illegible]

Farinograph curves (titration to 500 B.U.) are shown in Figs. 7 and 8, extensigraph curves are shown in Figs. 9 and 10. Neither showed differences that could be related to differences in quality of chapatis made from attas.

Rate of extraction of the atta had no significant effect on acceptability of chapatis except in the case of Gaines wheat, where the atta of 95% extraction was judged to yield a slightly better chapati than the atta of 80% extraction (Table II).

When chapatis from attas of 95% extraction were compared, those from Burt, Gaines and Pakistani wheats were significantly better than the others, chiefly on the basis of color, but with a slight influence from flavor differences (Table III).

A similar trend was noted when chapatis from attas of 80% extraction were compared. In this series, flavor played a more pronounced role in the differences. The judges may have been more influenced by color than they realized, as the tests were carried out under ordinary fluorescent lighting. The tests may not have shown actual differences in flavor, but simulated the usual conditions of consumption closely enough to give good indication of consumer preference.

The results explain why U.S. wheats are often judged inferior for making atta. If only White Club wheats were supplied to atta producers, the quality of U.S. wheats might well be judged excellent.

Alder, H. L., and Roessler, E. B., 1958. Statistical Procedures. 2nd ed. Mimeographed, University of California, Davis.

American Association of Cereal Chemists Cereal Laboratory Methods, 7th ed. The Association, St. Paul, Minnesota. 1962.

Aziz, M. A., and Bhatti, H. M., 1962. Quality considerations for chapatis (unleavened pancakes). Agricultura, Pakistan 13 (1), 157-164.

The authors are grateful to the Western Wheat Quality Laboratory for supplying the White Club wheats and to those who furnished the other samples; to the Ganesh Flour Mills, Lyallpur, Pakistan, for a sample of atta; to the members of the judging panel. The senior author appreciates the support of himself by A.I.D. during the study and the facilities, equipment and supplies furnished by Kansas State University.

TABLE I

Chemical analysis of atta samples milled from indicated wheats*

Atta	Extraction rate	Moisture (%)	Crude protein (%)	Crude fat (%)	Ash (%)
Hard Red Winter	80%	12.95	14.56	1.66	1.72
Hard Red Winter	95%	13.03	15.04	1.47	1.60
Hard Red Spring	80%	13.43	13.69	2.02	1.76
Hard Red Spring	95%	13.21	14.11	1.85	1.61
Soft Red Winter	80%	13.35	12.92	1.85	1.81
Soft Red Winter	95%	13.35	12.46	1.70	1.62
Burt	80%	13.30	11.65	1.59	1.44
Burt	95%	13.02	12.02	1.40	1.38
Gaines	80%	13.28	12.45	1.76	1.64
Gaines	95%	12.79	12.04	1.42	1.55
Pakistani	95%	12.45	15.42	1.59	1.44

* Crude protein, crude fat, and ash are expressed on moisture free basis

TABLE II

Effect of the rate of extraction on the organoleptic properties of chapatis prepared from attas of 80% and 95% extraction of indicated wheats.

Type of wheat	Rate of extraction, %	Average score of seven panel members			
		Color	Flavor	Texture	Acceptability
Hard Red Winter	80	7.00	7.57	7.71	8.00
		n.s	n.s	n.s	n.s
	95	7.29	7.43	7.29	8.00
Hard Red Spring	80	7.86	7.29	7.43	7.43
		n.s	n.s	n.s	n.s
	95	7.14	7.43	7.29	7.21
Soft Red Winter	80	6.86	7.00	7.14	7.14
		n.s	n.s	n.s	n.s
	95	7.71	7.43	7.57	7.57
Burt Wheat	80	9.93	8.79	8.57	9.36
		n.s	n.s	n.s	n.s
	95	9.79	8.43	8.57	9.07
Gaines Wheat	80	9.14	8.86	8.64	8.93
		n.s	n.s	n.s	*
	95	9.57	9.00	8.71	9.36

* significant at 0.05 level

n.s nonsignificant

TABLE III

Analyses of variance for color, flavor, texture and acceptability of chapatis prepared from attas of 95% extraction of different wheats.

Source of variance	Degrees of freedom	Mean square and significance			
		Color	Flavor	Texture	Acceptability
Wheat	5	22.768**	3.820*	2.114 n.s	7.394**
Error	36	0.710	1.483	1.609	0.831
Total	41				

n.s. nonsignificant

* significant at 0.05 level

** significant at 0.01 level

TABLE IV

Analyses of variance for color, flavor, texture and acceptability of chapatis prepared from attas of 80% extraction of different wheats.

Source of variation	Degrees of freedom	Mean square and significance			
		Color	Flavor	Texture	Acceptability
Wheat type	5	23.84**	8.148**	2.024 n.s.	13.924**
Error	36	0.78	1.286	2.175	0.944
Total	41				

n.s. nonsignificant

** significant at 0.01 level

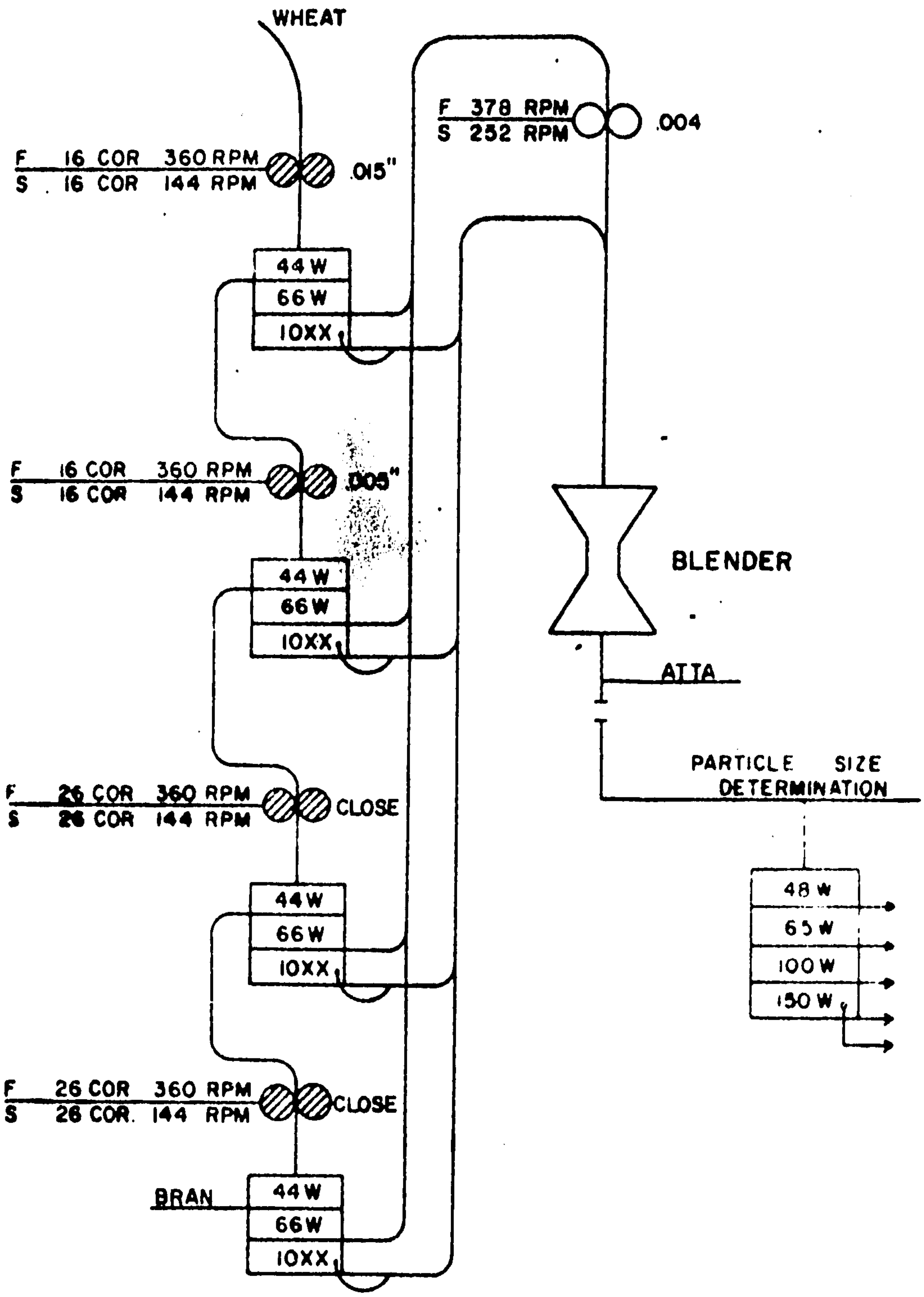


Figure 1. A schematic flow sheet for milling of atta from wheat and set of Tyler sieves used in particle size determination.

FIGURE 2

Department of Grain Science and Industry

Score Sheet for Chapatis

Name________________________ Date________________________

Please examine the Chapatis samples and score these with respect to the qualities in question, using the following scale:

Best________________10 points

Poorest______________ 0 points

Quality in question	Score
1. Color	
2. Flavor	
3. Texture	
4. Acceptability	

Suggestions or Comments:

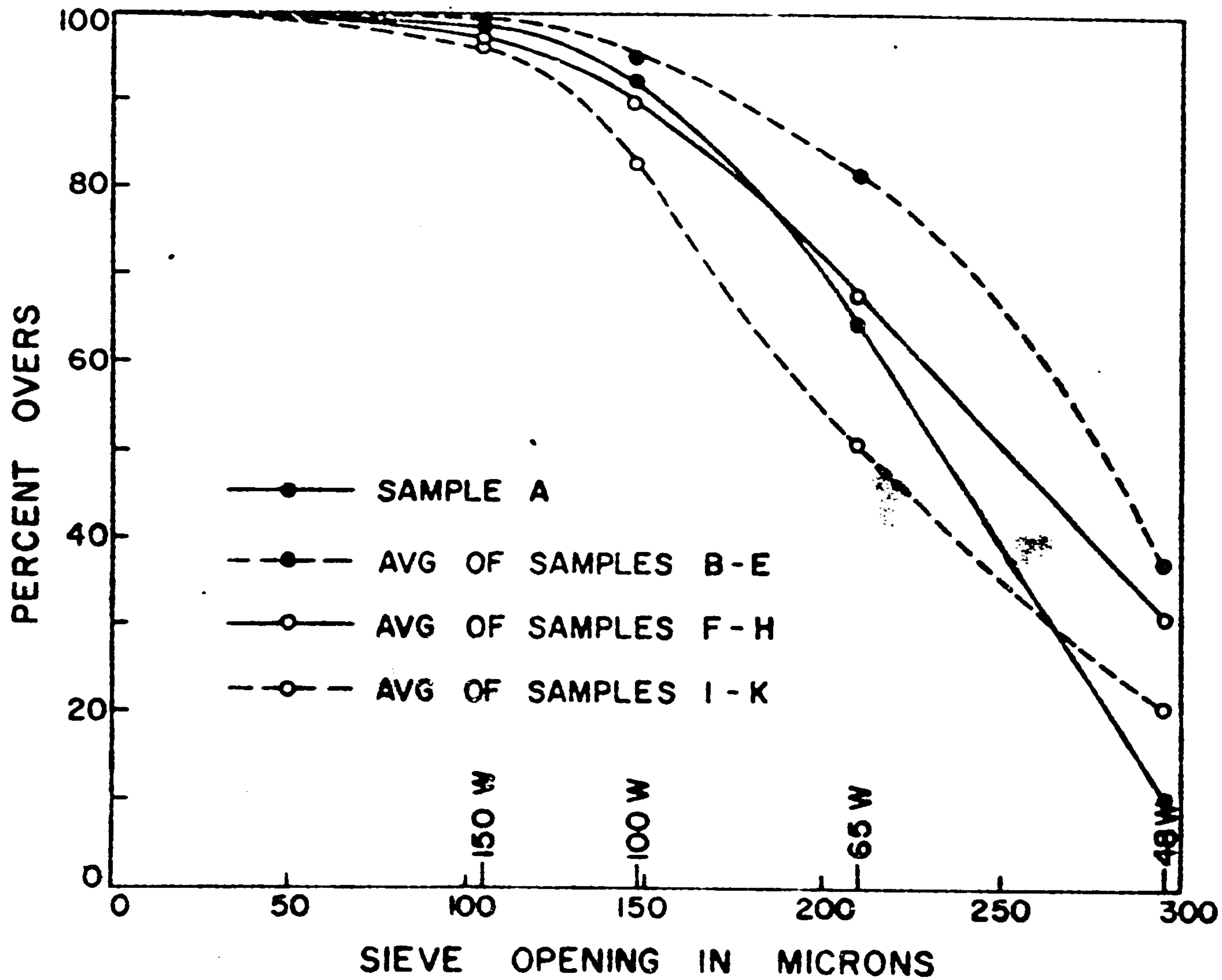


Figure 3. Cumulative particle size distribution curves of atta samples imported from Pakistan.

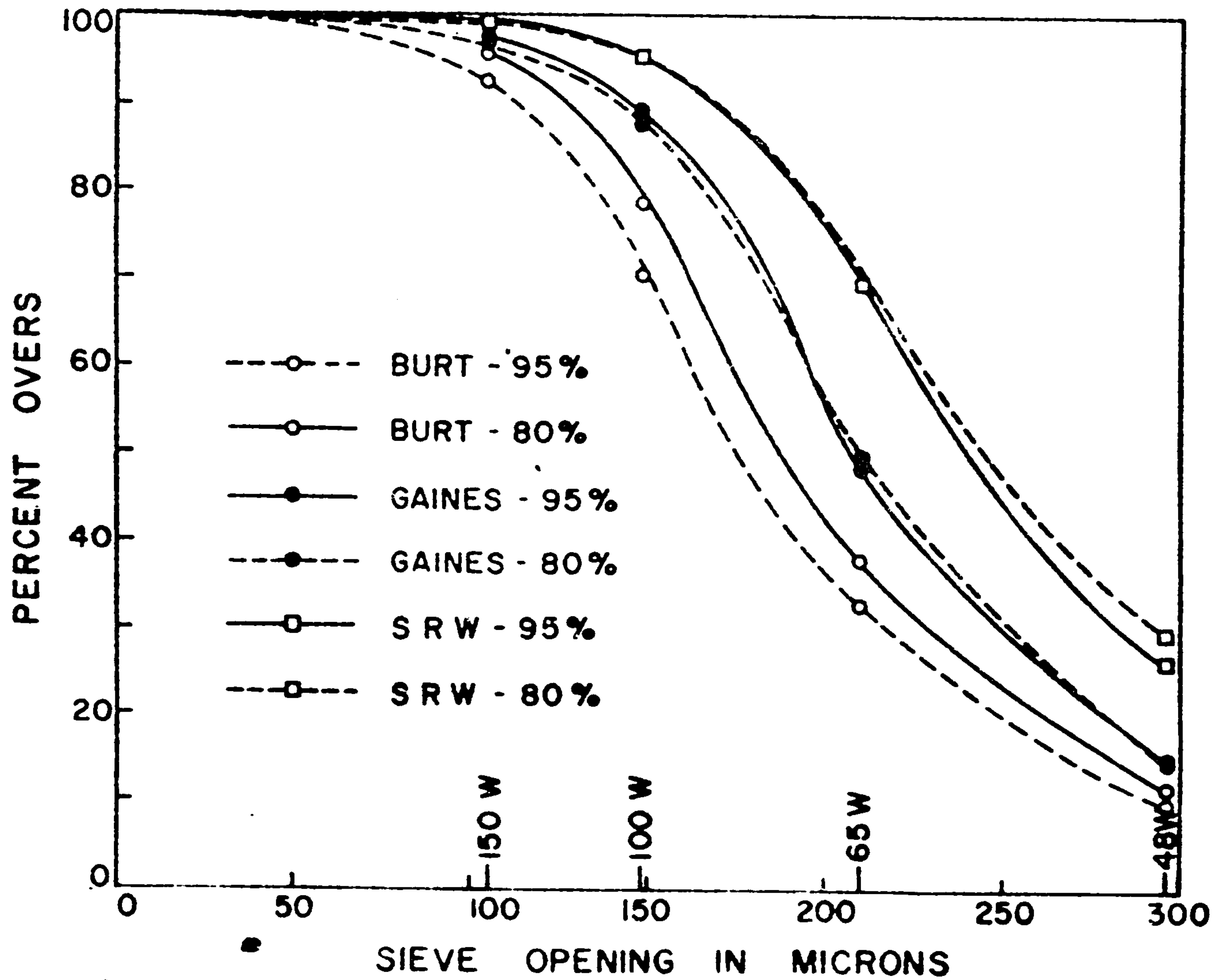


Figure 4. Cumulative particle size distribution curves of attas milled from Burt, Gaines and Soft Red Winter wheats.

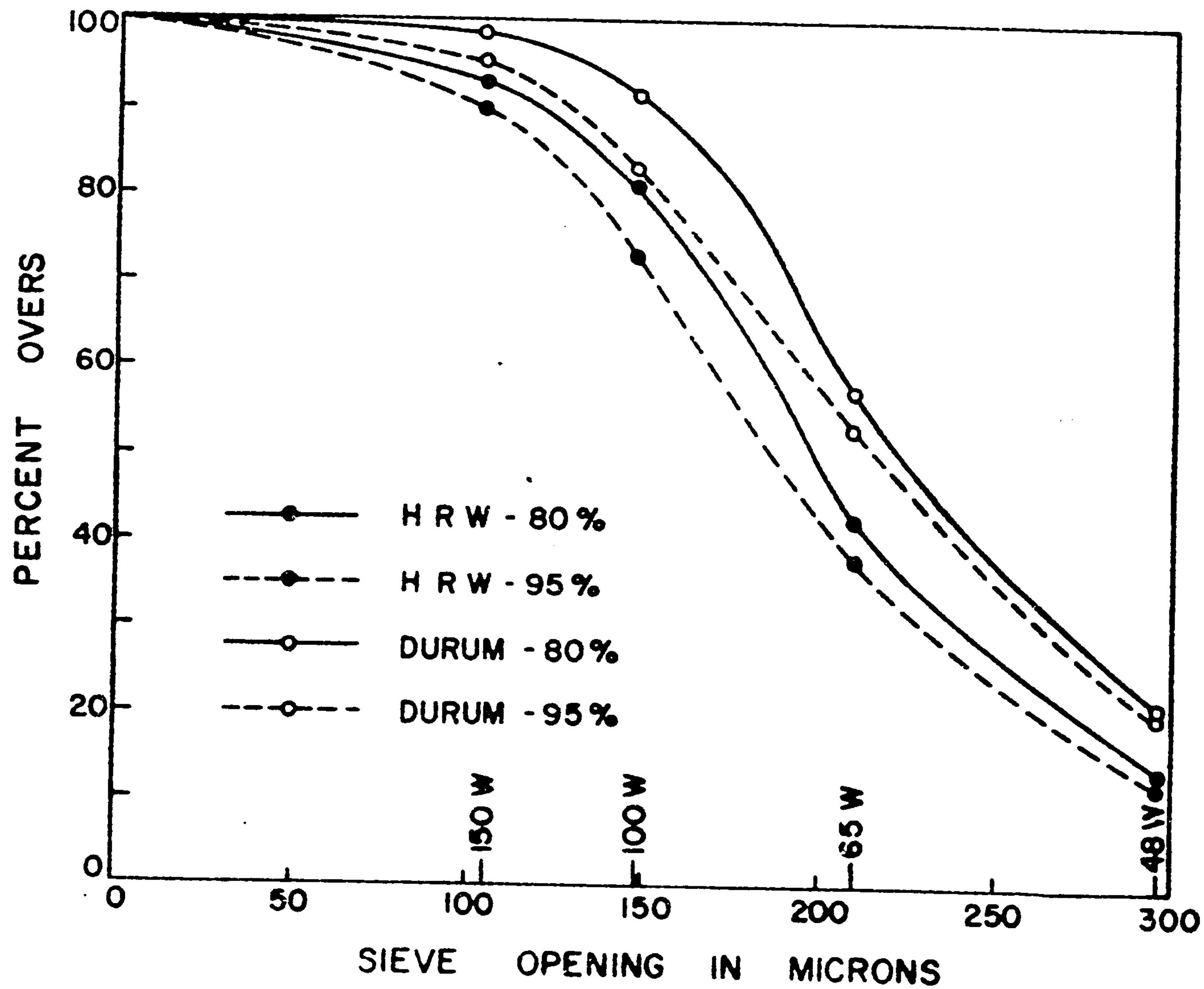


Figure 5. Cumulative particle size distribution curves of attas milled from Hard Red Winter and Durum wheats.

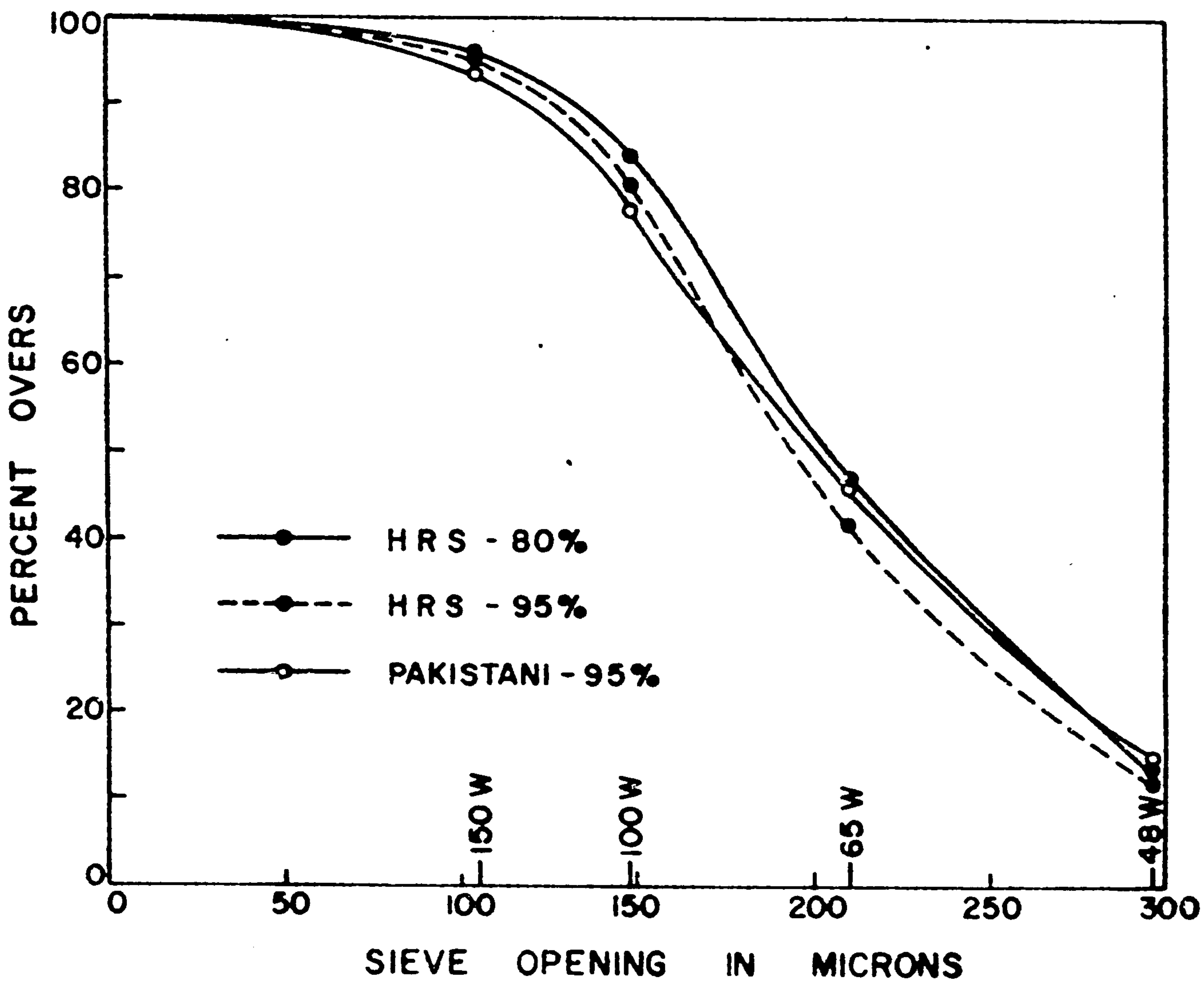
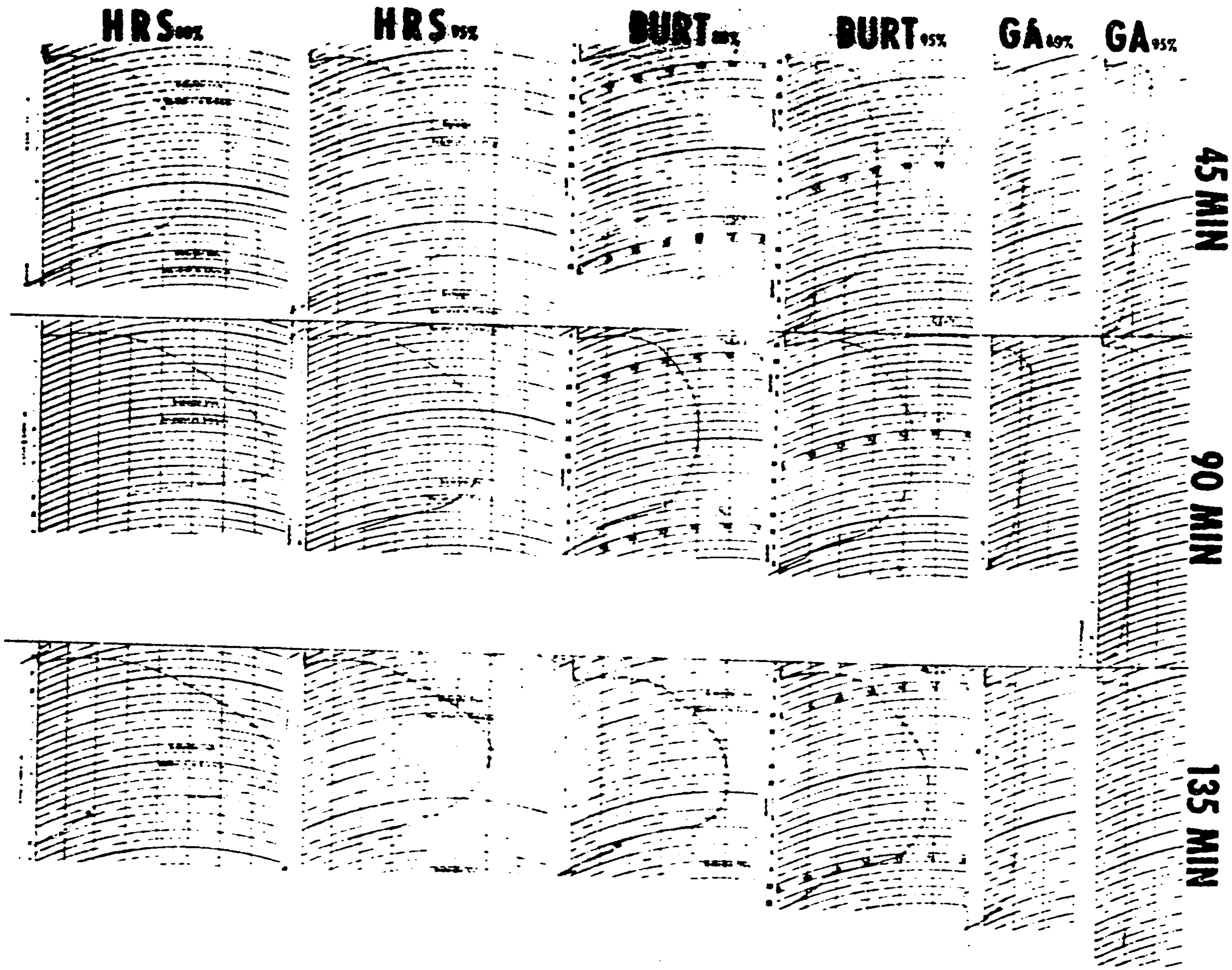


Figure 6. Cumulative particle size distribution curves of attas milled from Hard Red Spring and Pakistani wheats.

Figure 7. Farinograph curves of attas from Gaines, Burt, and HRS Wheats



HRS 80%
HRS 95%
BURT 80%
BURT 95%
GA 80%
GA 95%
45 MIN
90 MIN
135 MIN

Figure 8. Farinograph curves of attas from SRW, HRW and C 273 Wheats

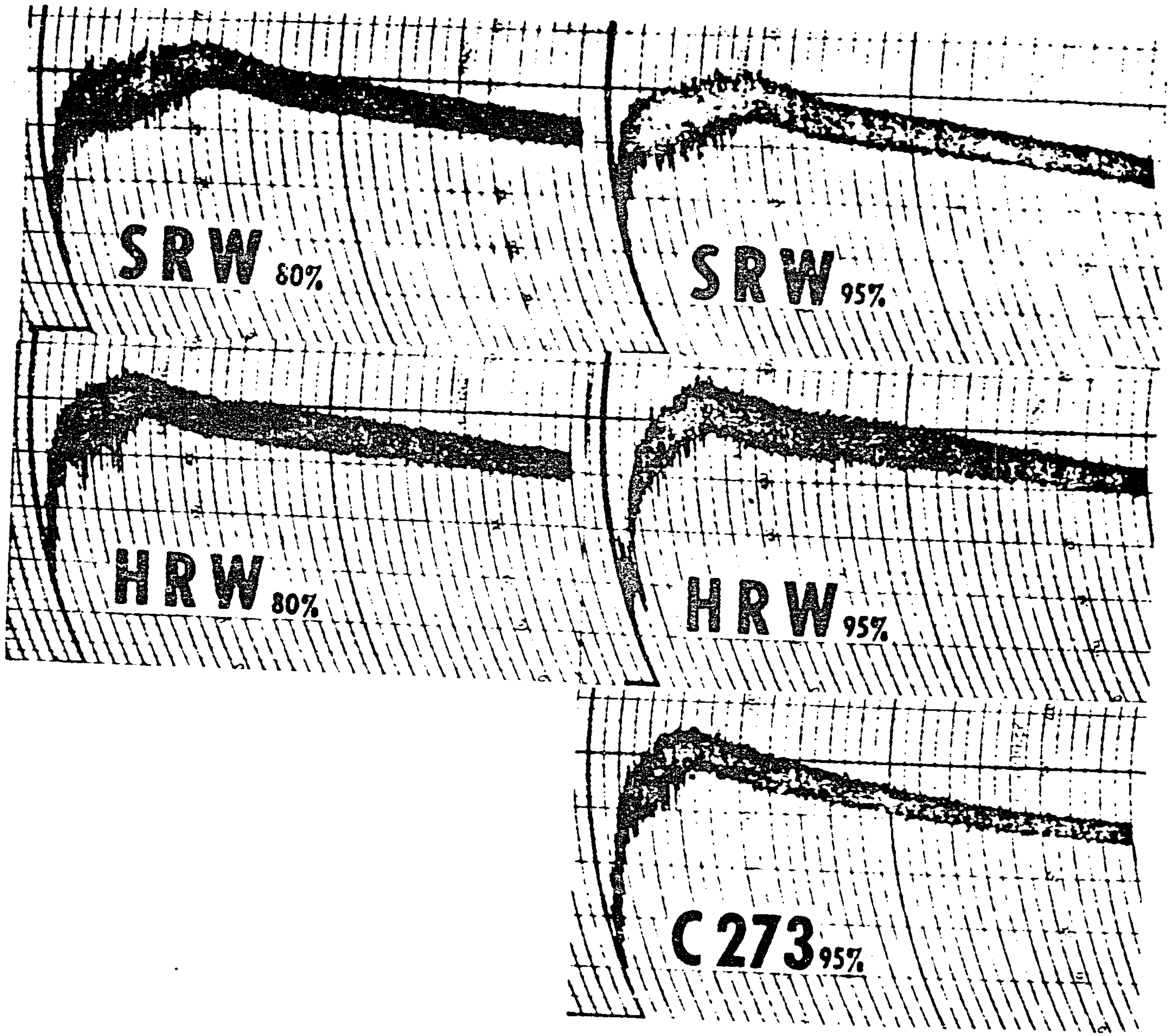

SRW 80%
SRW 95%
HRW 80%
HRW 95%
C 273 95%

Figure 9. Extensiograph curves of attas from Gaines, Burt, and HRS Wheats

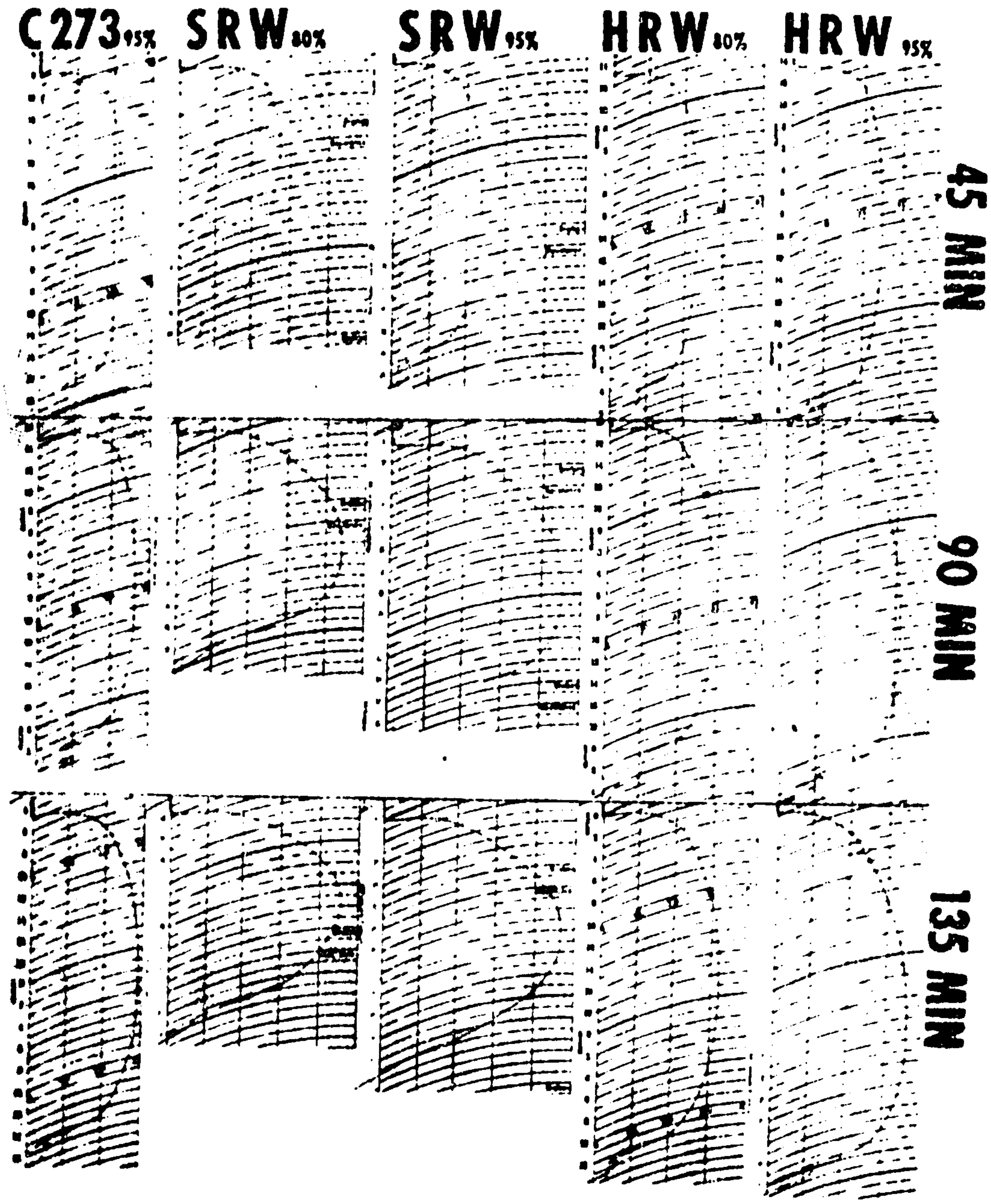
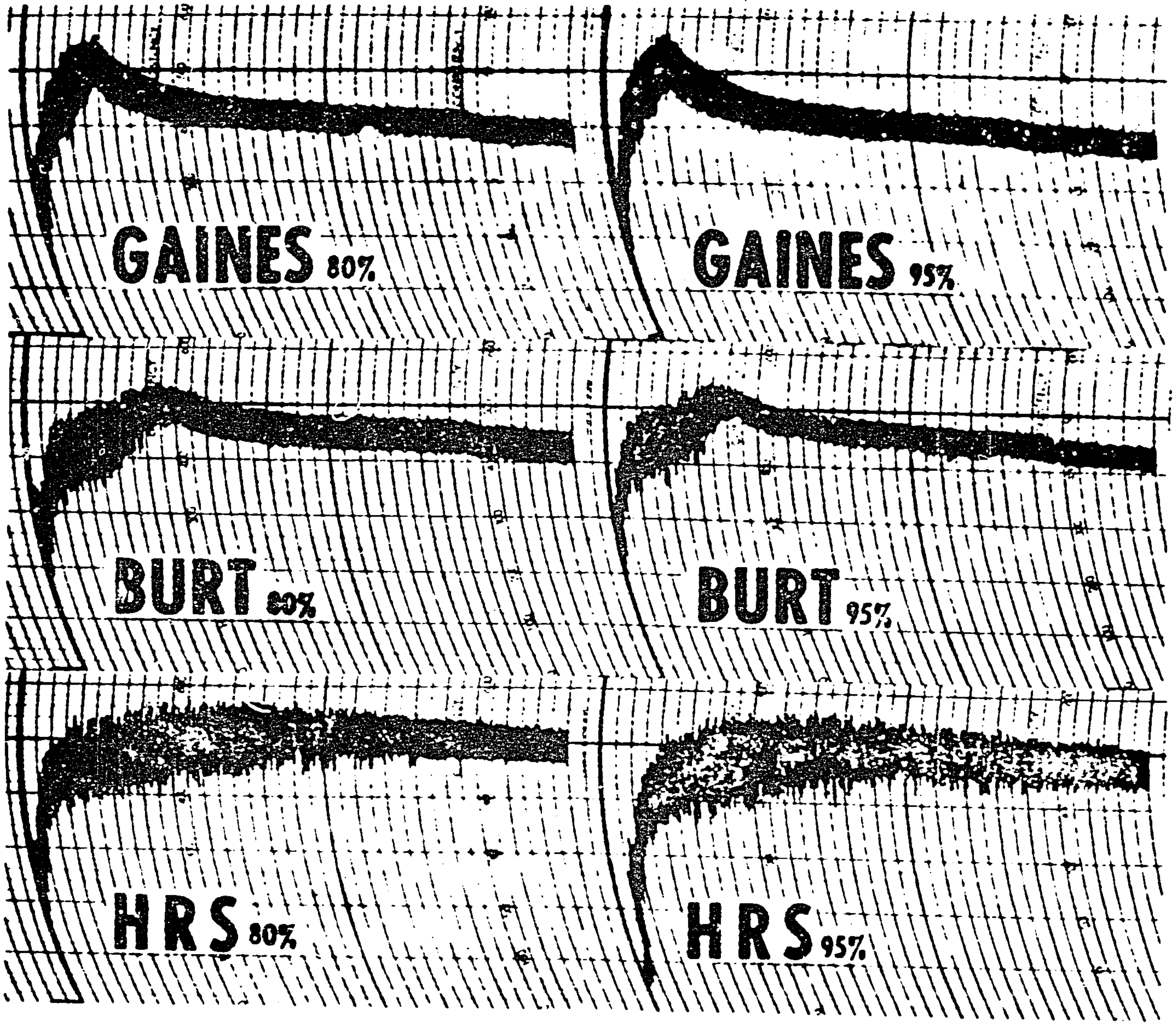

C273 95%
SRW 80%
SRW 95%
HRW 80%
HRW 95%
45 MIN
90 MIN
135 MIN

Figure 10. Extensiograph curves of attas from HRW, SRW, and C 273 Wheats


GAINES 80%
GAINES 95%
BURT 80%
BURT 95%
HRS 80%
HRS 95%

Studies on Attas and Chapatis II

Nutritional Value of Chapatis With and Without Added Lysine

M. Shafiq Chaudhry[1], M. M. MacMasters,
and W. J. Hoover

Summary

Rats were fed ground whole wheat, attas of 80% and 95% extraction and chapatis made from them with and without supplementation with vitamins and minerals and with lysine at two levels of supplementation but without supplementary vitamins and minerals. Growth rates and protein efficiency ratios (PER) were evaluated weekly over an eight week period. The PER values were higher for chapatis than for attas from which they were prepared. Supplementation with vitamins and minerals resulted in an increase in PER during the 8 week feeding trial. A similar improved PER resulted during the first four weeks on diets with added lysine but without added vitamins and minerals, but an adverse effect on PER during the second four week period was found using this diet. Livers of rats fed lysine-supplemented diets had lower moisture content and higher protein content than those of the rats on other diets. Fortification of cereal products with lysine in the absence of adequate concurrent fortification with vitamins and minerals may not be of value when the products form essentially the only article of diet as is often true in developing countries.

1/ Contribution No. _____. Department of Grain Science and Industry, Kansas Agricultural Experiment Station, Kansas State University, Manhattan, Kansas 66502.

This paper is taken from a portion of the dissertation presented by M. Shafiq Chaudhry in partial fulfillment of the requirements for the Ph.D. degree at Kansas State University. Dr. Chaudhry's present address is Department of Food Science, West Pakistan Agricultural University, Lyallpur.

Introduction

Improving the nutritional status of developing nations, most of which produce insufficient protein for the national need, is currently of much interest. Often a cereal food constitutes the major portion of the diet of most of the people and may even be essentially their sole source of nutrition. In West Pakistan and a large portion of India, unleavened bread, known as "chapatis", holds that position. Improvement of the nutritional status of the people in those areas will be most easily and acceptably accomplished by improvement of the nutritional value of chapatis.

Flour enrichment programs in the United States, Newfoundland, the Philippines and elsewhere have established the beneficial nutritional effects of vitamin and mineral supplementation of basic cereal foods. There have been very few studies made of the nutritional value of chapatis. The Protein Efficiency Ratio (PER) of chapatis was reported by Shayamala and Kennedy (1962) to be about 20% higher than that of unheated flour, and replacement of 10% flour with soy flour or dry milk solids was found to further increase the PER. Imtiaz (1962) reported that chapatis prepared from whole-wheat pastry flour with the addition of 15% medium fat soy flour and 10% dry skimmed milk supported excellent growth of rats.

In areas where chapatis form the staple food, it has been felt that the limiting amino acid in the diet is lysine, since the lysine content of wheat protein is known to be the limiting factor in that protein for humans. It is likely that vitamins and minerals are not at optimal levels in diets based largely on chapatis. The losses of thiamin that occur during milling of wheat to the coarse flour, called "atta", from which chapatis are made, was studied by Singh <u>et al</u>. according to Aziz and Bhatti (1962). Losses of 20% to over 50% of thiamine were reported, the loss being dependent upon the type of milling.

The present study was undertaken to explore the possibility of improving the nutritional value of chapatis by the fortification of atta with lysine and some vitamins and minerals.

Materials and Methods

Gaines variety White Club wheat was milled experimentally to produce two attas of 80% and 95% extraction respectively; the wheat and the milling procedure were described by Chaudhry *et al*. (1968).

Chapatis were prepared in batches, each from 1000 grams of atta (d.b.), to which 70-75% distilled water was added to produce a dough of the proper consistency. The dough was kneaded by hand, divided into balls weighing 50 grams each, and each ball shaped with a rolling pin into a chapati of 6- to 7-inch diameter. Each chapati was cooked on an ungreased hot plate (290^o - 300^oC.) for approximately two minutes.

Cooked chapatis were air-dried in the laboratory (65^o - 75^oF.) for 48-72 hours, then ground in a Wiley Hammer Mill No. 1 to pass through a 1-mm. sieve.

Diets containing the two attas and whole ground wheat, as well as the cooked, dried and ground chapatis, were prepared and fed to weanling male rats, as shown in Table I. Each prepared diet was analyzed for moisture content, and 2% sodium chloride and 5% refined cottonseed oil (d.b.) were added to each. The moisture content of each diet was then adjusted to 15% by the addition of distilled water. Vitamin and mineral supplementation levels were based upon multiple increments of the amounts available in the original grain, rather than upon known dietary requirements of the test animals.

Male weanling rats (Sprague-Dawley strain) were used in the studies. They were fed a stock diet for one day before being housed individually.

Five randomly selected rats were maintained on each diet. Initial weight was taken after the animals had been on the diets for 5 days and weekly thereafter, for a total of 8 weeks. Food and water were provided ad libitum. At the end of 8 weeks, the rats were sacrificed and the liver of each was removed for analysis for moisture, crude fat and crude protein.

Whole wheat, attas and chapatis were analyzed for moisture, crude fat, nitrogen, ash, crude fiber, thiamine, niacin, riboflavin, calcium, and iron contents by methods 44-15, 30-20, 46-10, 08-10, 32-15, 86-80, 86-51, 86-70, 40-20, and 40-41 respectively, in Cereal Laboratory Methods (1962). The factor 5.7 was used to convert nitrogen to crude protein value. *Lactobacillus plantarum* NRRL B-531 was the organism used in determining niacin.

Each liver was wrapped in aluminum foil and frozen. The frozen liver was sliced rapidly, and appropriate amounts weighed for analysis. Moisture was determined by the vacuum oven method (100°C., 5 hrs.); dried samples were extracted for 8 hours with ethyl ether (high heat, Goldfish extractor) for crude fat determination. The Kjeldahl method was used to determine nitrogen.

Data on weight gain and on protein efficiency were analyzed by two way classification analysis of variance, Fryer (1966). Duncan's New Multiple Range Test, as outlined by Fryer (1966) was used to determine the significance of differences among means of percentage gain in weight and protein efficiency ratio.

Results and Discussion

Chemical analyses of the wheat, attas and chapatis are shown in Table II, where each value is an average of 4 to 6 replications. No significant difference in vitamin contents was found between the attas of 80% and 95% extraction. The three vitamins that were determined decreased in amount during cooking of the chapatis, but the difference was not significant when atta of one extraction rate was compared with chapatis made from it. With the exception of minerals, atta of 80% extraction and chapatis prepared from it showed higher contents of nutrients than atta of 95% extraction and chapatis prepared from it.

Average cumulative weight gain curves are shown in Figs. 1, 2, and 3. Atta of 95% extraction (Diet III) promoted significantly better growth than that of 80% extraction (Diet II) and than whole wheat (Diet I) during the first week, otherwise the three diets yielded no significant differences, (Figs. 1 and 2).

Feeding studies to determine the nutritive value of vitamins and minerals added in making chapatis from atta of 80% extraction showed that supplementation at levels of 50% (Diet VIII) or 100% (Diet IX) above the level in the original wheat (Diet I) gave a significant improvement (Fig. 2). Similar results were obtained with chapatis made from atta of 95% extraction in which the vitamins and minerals were added to make them equal in the atta to the amounts present in the original whole wheat (Diet VII). Comparison of the data suggested that rats fed diets based on atta of 80% extraction (Diet IV) and chapatis made from it performed better than those fed diets based on atta of 95% extraction (Diet III) and chapatis made from it. The differences were, however, not statistically significant. Hepburn et al. (1960) found less than half as high a concentration of lysine in the best patent flour than in germ. Removal of 15% fines during production of atta of 80% extraction would therefore, mean removal of 15% lysine-poor material, with the result that the amino acid balance of the atta would be improved. The chapatis made from atta of 80% extraction also contained more vitamins than those made from atta of 95% extraction.

Supplementation with lysine led to unexpected results (Fig. 3). Addition of lysine at 0.2% (Diet X) and 0.4% (Diet XI) the weight of the atta significantly improved the performance of the test animals during the first four weeks, but caused a decline in the growth rate during the subsequent four weeks. Such an effect has not been reported in any of the numerous studies on lysine supplementations of foods. Rosenberg and Rohdenberg (1952) found significantly improved nutritional value to result from addition of lysine at 0.2% to 0.8% levels to a diet of which 90% was air dried bread; those workers considered 0.2% to 0.4% to be about the optimal level for lysine supplementation, and other workers have come to similar conclusions.

Lack of fortification with vitamins and minerals of the diets to which lysine was added might have caused the observed results. Fortification of wheat products with lysine to provide better nutrition for developing nations has generally been recommended. Apparently this is a promising procedure when the diet of the people contains other sources of vitamins, minerals and even small amounts of methionine. In economically poor areas of Pakistan and India, chapatis often form the sole article of food consumed over long periods of time. Little fruit, vegetables, fats or oils, meats or fish are eaten with the chapatis in such areas. In view of the results of the present study, it appears that atta supplementation with lysine is of questionable value unless adequate enrichment with vitamins, minerals and other amino acids in marginal supply is also practiced.

Data showing consumption of feed and of protein, gain in weight and PER are given in Table III, and data on analysis of variance are shown in Table IV. Differences in PER among the diets in both four week periods were tested for significance by Duncan's NMRT. During the first four weeks, Diet XI (0.4% lysine supplemented) gave the highest PER, but that diet and Diet X (supplemented with lysine at 0.2% level) gave the lowest PER values during the second four week period. PER values were higher for chapatis than for the attas from which they were prepared. This may be due to nutrient availability rather than protein quality. Shayamala and Kennedy (1962) attributed a similar difference found in their studies to the destruction of Trypsin inhibitor during baking. Two other possible factors may be involved. First, Parihar and Chatterji (1956) determined by X-ray diffraction studies that starch is gelatinized during the baking of chapatis. The starch would therefore be more susceptible to the action of digestive enzymes. Second, although no information is available on the fate of phytin during the baking of chapatis, Kent (1966) states that phytin is hydrolyzed during the baking of bread. If hydrolysis occurs as chapatis are baked, phosphorus would be freed, and there would be less probable formation of complexes of calcium and iron with phytin.

During the first four weeks, supplementation with vitamins, minerals and lysine resulted in an increase of the PER and the increased value continued during the second four weeks, except in the cases of supplementation with lysine.

Data obtained on the livers at the end of the feeding experiment indicated that the supplementation of the diet with lysine increased protein content and decreased moisture content of the liver. No consistent effects were obtained as the result of rate of extraction of atta, baking or supplementation with vitamins and minerals.

(Acknowledgments)

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TABLE 1

Composition of diets

(2% sodium chloride and 5% fat not shown in this table, were added to diets before feeding to rats)

Diet No.	Code	Description	The amount of various nutrients added (expressed as mg./100 g.) Thiamine HCl	Niacin	Riboflavin	Calcium Carbonate	Fe $SO_4 \cdot 7H_2O$	Lysine HCl
I	WW	Whole ground wheat	-	-	-	-	-	-
II	AT-80	Atta, 80% extraction	-	-	-	-	-	-
III	AT-95	Atta, 95% extraction	-	-	-	-	-	-
IV	CH-80	Chapati from atta of 80% extraction	-	-	-	-	-	-
V	CH-95	Chapati from atta of 95% extraction	-	-	-	-	-	-
VI	CH-80 IX	Chapati from atta of 80% extraction	0.008	1.25	0.031	6.71	-	-
VII	CH-95 IX	Chapati from atta of 95% extraction	0.188	1.41	0.046	-	-	-
VIII	CH-80 1.5X	Chapati from atta of 80% extraction	0.368	2.35	0.056	93.64	11.67	-
IX	CH-80 2X	Chapati from atta of 80% extraction	0.735	4.70	0.112	187.28	23.34	-
X	CH-80 2L	Chapati from atta of 80% extraction	-	-	-	-	-	200
XI	CH-80 4L	Chapati from atta of 80% extraction	-	-	-	-	-	400

TABLE II

Analysis of wheat, attas and chapatis (moisture free basis)

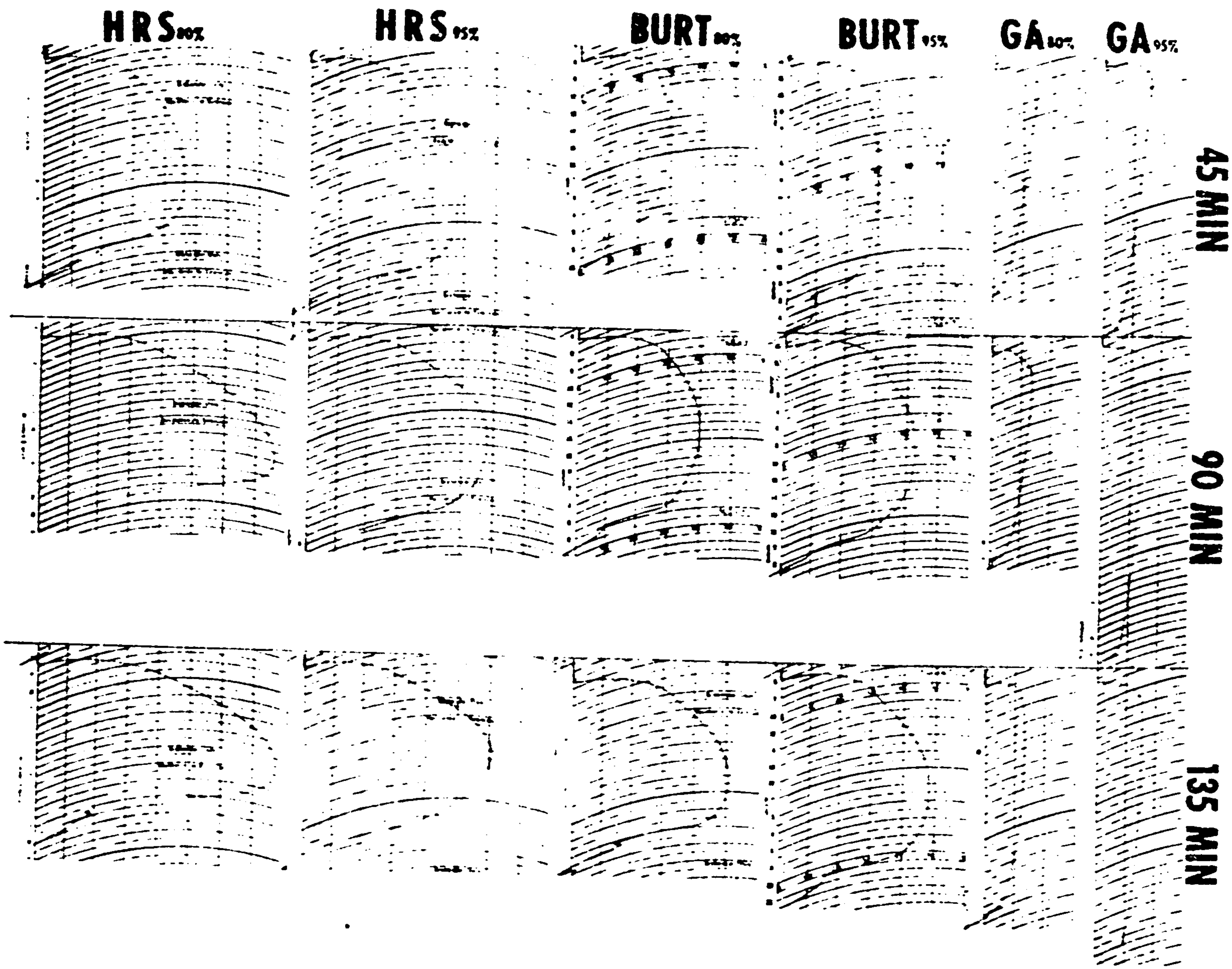
Sample	Moisture %	Crude protein %	Crude fat %	Crude fiber %	Ash %	Iron mg%	Calcium mg%	Niacin mg%	Thiamin mg%	Ribo-flavin
Whole wheat	9.97	12.22	1.70	2.62	1.713	4.89	58.4	4.70	0.733	0.112
Atta of 80% extraction	12.39	12.16	2.04	1.95	1.611	4.96	56.3	4.28	0.728	0.0[illegible]6
Atta of 95% extraction	12.57	12.07	1.81	1.72	1.482	5.07	53.9	3.78	0.680	0.074
Chapatis from atta of 80% extraction	7.28	12.15	1.21	2.02	1.643	5.77	56.5	3.58	0.728	0.081
Chapatis from atta of 95% extraction	6.54	12.09	1.00	1.79	1.491	7.52	65.1	3.42	0.548	0.066
LSD 0.01 level		n.s	[illegible]	[illegible]	0.036	0.177	3.89	1.087	0.203	0.0199

TABLE III

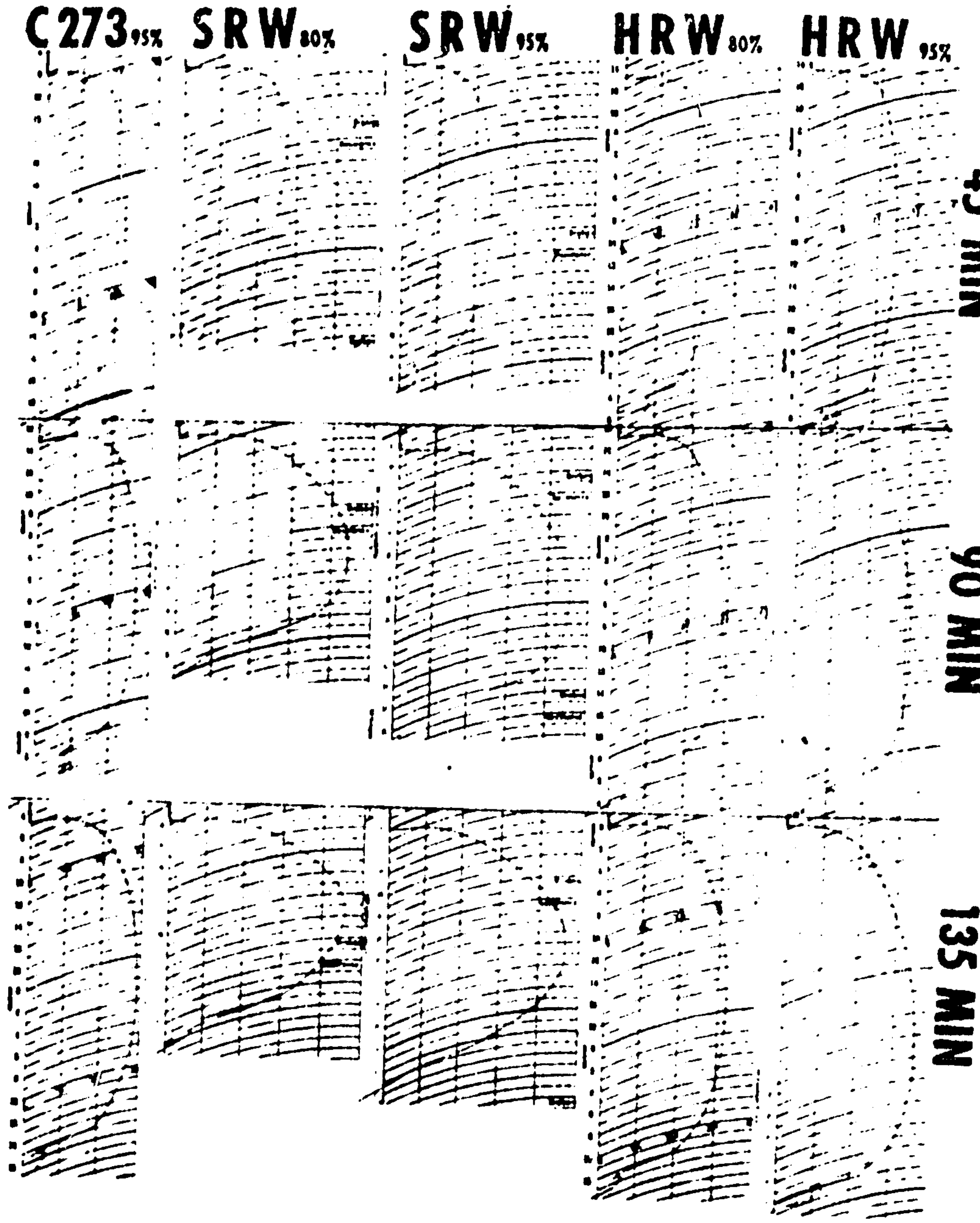
Average amount of feed consumed, protein consumed, gain in weight and protein efficiency ratio (P.E.R. of different diets for two periods of four weeks each.

Diet No.	First four week period				Second four week period			
	Feed consumed (g.)	Protein consumed (g.)	Gain in weight (g.)	P.E.R.	Feed consumed (g.)	Protein consumed (g.)	Gain in weight (g.)	P.E.R.
I	225.4	21.66	22.20	1.031	201.2	19.34	13.20	0.680
II	205.0	20.40	22.60	1.107	200.2	19.92	18.80	0.797
III	235.2	22.44	22.20	1.011	198.6	18.95	16.40	0.873
IV	201.8	19.84	26.80	1.348	191.4	18.81	22.00	1.172
V	185.6	17.76	23.00	1.290	176.2	16.86	12.80	0.786
VI	217.2	21.52	27.20	1.265	197.8	19.60	22.60	1.156
VII	185.0	17.95	23.80	1.311	193.8	18.18	17.80	0.968
VIII	216.2	21.31	32.00	1.4[illegible]	201.2	19.84	22.20	1.105
IX	261.2	25.62	39.20	1.53[illegible]	272.8	26.76	35.00	1.317
X	200.2	20.00	36.40	1.724	190.0	18.98	11.00	0.544
XI	191.6	19.35	35.20	1.821	225.2	22.74	8.8	0.410

Figure 10. Extensiograph curves of attas from HRW, SRW, and C 273 Wheats



HRS 80%
HRS 95%
BURT 80%
BURT 95%
GA 80%
GA 95%
45 MIN
90 MIN
135 MIN


C273 95%
SRW 80%
SRW 95%
HRW 80%
HRW 95%
45 MIN
90 MIN
135 MIN

Studies on Attas and Chapatis II

Nutritional Value of Chapatis With and Without Added Lysine

M. Shafiq Chaudhry[1], M. M. MacMasters, and W. J. Hoover

Summary

Rats were fed ground whole wheat, attas of 80% and 95% extraction and chapatis made from them with and without supplementation with vitamins and minerals and with lysine at two levels of supplementation but without supplementary vitamins and minerals. Growth rates and protein efficiency ratios (PER) were evaluated weekly over an eight week period. The PER values were higher for chapatis than for attas from which they were prepared. Supplementation with vitamins and minerals resulted in an increase in PER during the 8 week feeding trial. A similar improved PER resulted during the first four weeks on diets with added lysine but without added vitamins and minerals, but an adverse effect on PER during the second four week period was found using this diet. Livers of rats fed lysine-supplemented diets had lower moisture content and higher protein content than those of the rats on other diets. Fortification of cereal products with lysine in the absence of adequate concurrent fortification with vitamins and minerals may not be of value when the products form essentially the only article of diet as is often true in developing countries.

1/ Contribution No. _____. Department of Grain Science and Industry, Kansas Agricultural Experiment Station, Kansas State University, Manhattan, Kansas 66502.

This paper is taken from a portion of the dissertation presented by M. Shafiq Chaudhry in partial fulfillment of the requirements for the Ph.D. degree at Kansas State University. Dr. Chaudhry's present address is Department of Food Science, West Pakistan Agricultural University, Lyallpur.

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Supplementation with lysine led to unexpected results (Fig. 3). Addition of lysine at 0.2% (Diet X) and 0.4% (Diet XI) the weight of the atta significantly improved the performance of the test animals during the first four weeks, but caused a decline in the growth rate during the subsequent four weeks. Such an effect has not been reported in any of the numerous studies on lysine supplementations of foods. Rosenberg and Rohdenberg (1952) found significantly improved nutritional value to result from addition of lysine at 0.2% to 0.8% levels to a diet of which 90% was air dried bread; those workers considered 0.2% to 0.4% to be about the optimal level for lysine supplementation, and other workers have come to similar conclusions.

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IX	CH-80 2X	Chapati from atta of 80% extraction	0.735	4.70	0.112	187.28	23.34	-
X	CH-80 2L	Chapati from atta of 80% extraction	-	-	-	-	-	200
XI	CH-80 4L	Chapati from atta of 80% extraction	-	-	-	-	-	400

TABLE II

Analysis of whole wheat, atta and chapatis
(moisture free basis)

Sample	Moisture %	Crude protein %	Crude fat %	Crude fiber %	Ash %	Iron mg%	Calcium mg%	Niacin mg%	Thiamin mg%	Riboflavin
Whole wheat	9.97	12.22	1.70	2.62	1.713	4.89	58.4	4.70	0.733	0.112
Atta of 80% extraction	12.39	12.16	2.04	1.95	1.611	[illegible]	56.3	4.28	0.728	0.096
Atta of 95% extraction	12.57	12.07	1.81	1.72	1.482	5.07	53.9	3.78	0.680	0.074
Chapatis from atta of 80% extraction	7.28	12.15	1.21	2.02	1.643	5.77	56.5	3.58	0.728	0.081
Chapatis from atta of 95% extraction	6.54	12.09	[illegible]	[illegible]	[illegible]	7.52	65.1	3.42	0.548	0.066
LSD 0.01 level		[illegible]	[illegible]	[illegible]	[illegible]	0.177	3.89	[illegible]	0.203	0.0199

TABLE [illegible]

Average amount of feed consumed, protein consumed, gain in weight and protein efficiency ratio (P.E.R. of different diets in two periods of four weeks each.

Diet No.	First four week period				Second four week period			
	Feed consumed (g.)	Protein consumed (g.)	Gain in weight (g.)	P.E.R.	Feed consumed (g.)	Protein consumed (g.)	Gain in weight (g.)	P.E.R.
I	225.4	21.66	22.20	1.031	201.2	19.34	13.20	0.680
II	205.0	20.40	22.60	1.107	200.2	19.92	16.80	0.797
III	235.2	22.44	22.20	1.011	198.6	18.95	16.40	0.873
IV	201.8	19.84	26.80	1.348	191.4	18.81	22.00	1.172
V	185.6	17.76	23.00	1.290	176.2	16.86	12.80	0.786
VI	217.2	21.52	27.20	1.266	197.8	19.60	22.60	1.156
VII	185.0	17.95	23.80	1.3[illegible]	193.8	18.18	17.80	0.968
VIII	216.2	21.31	32.00	1.4[illegible]	201.2	19.84	22.20	1.105
IX	261.2	25.62	39.20	1.5[illegible]	272.8	26.76	35.00	1.317
X	200.2	20.[illegible]	36.[illegible]	1.724	190.0	18.98	11.00	0.544
XI	191.6	19.35	35.2[illegible]	1.821	225.2	22.74	8.8	0.410

TABLE IV

Analysis of variance for protein efficiency ratio of various diets during two growth periods of four weeks each.

Source of variation	Degree of freedom	Sum of squares	Mean square	F value
Periods	1	5.54268	5.5427	109.76**
Diets	10	2.6688	0.2669	5.285**
Periods X Diets	10	4.78756	0.4788	9.481**
Error	88	4.44127	0.0505	
Total	109	17.44031		

** significant at 0.01 level.

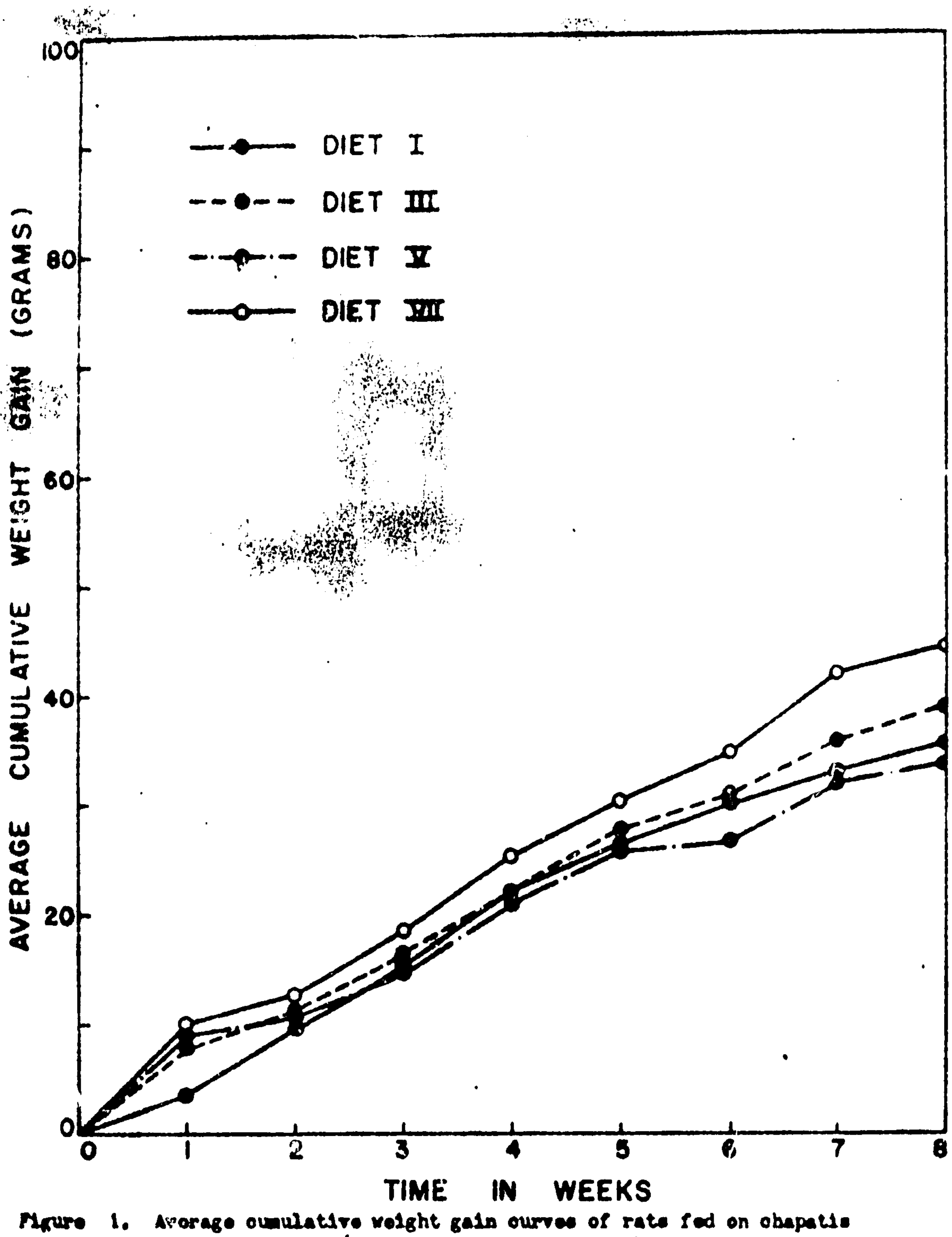


Figure 1. Average cumulative weight gain curves of rats fed on chapatis prepared from 95% extraction atta and supplemented with vitamins and minerals.

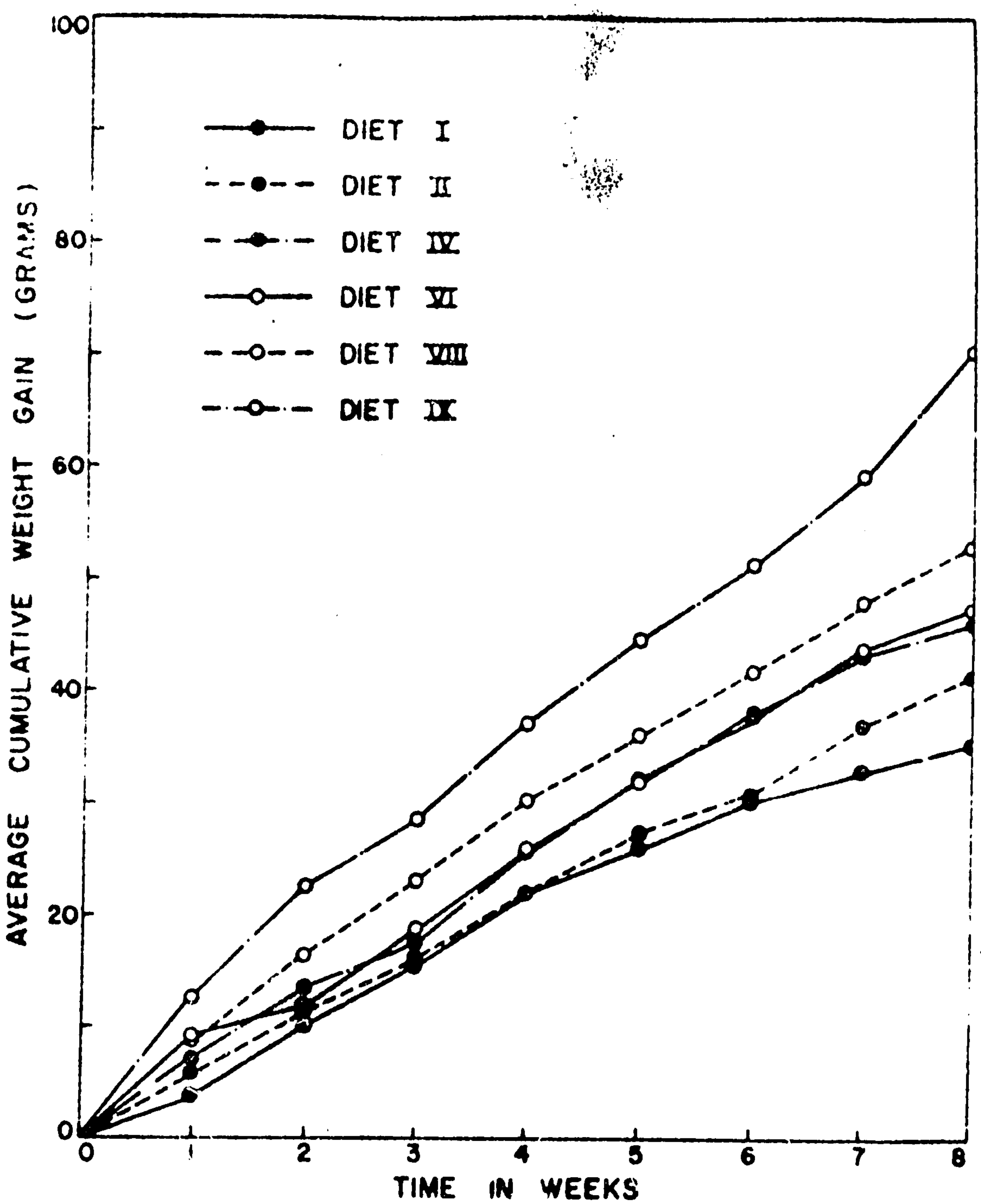


Figure 2. Average cumulative weight gain curves of rats fed on chapatis prepared from 80% extraction atta and supplemented with vitamins and minerals.

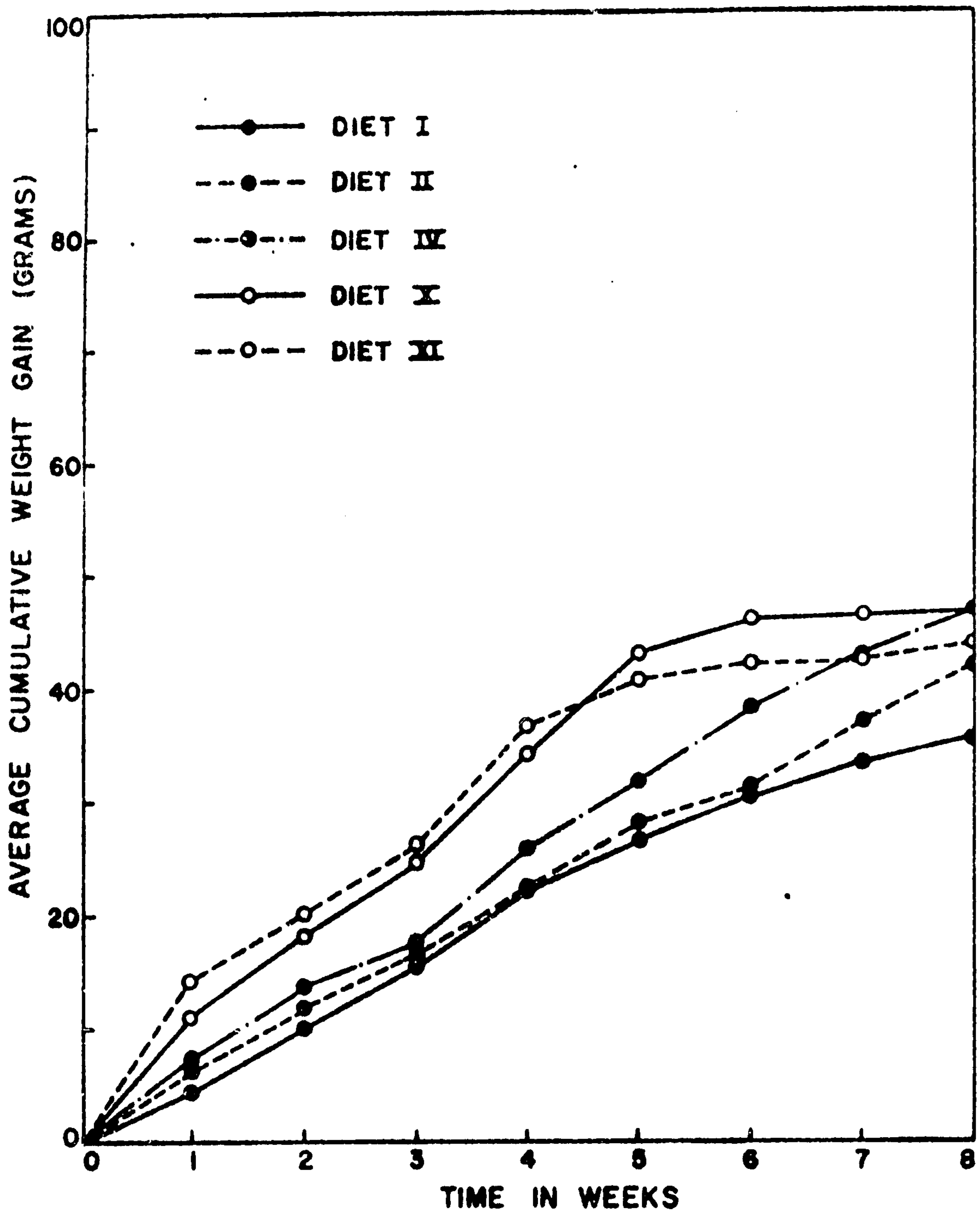


Figure 3. Average cumulative weight gain curves of rats fed on chapatis prepared from 80% extraction atta and supplemented with lysine.

Studies on Attas and Chapatis III

A Note on the Relative Importance of Vitamins and Minerals as Dietary Supplements[1/]

Hsin Y. Chung, M. M. MacMasters and W. J. Hoover

Summary

Feeding experiments with weanling male rats indicate that adequate supplementation of chapatis with vitamins and minerals is as necessary for optimal growth as is supplementation with lysine. Supplementation of flour or atta with lysine for nutritional improvement in protein-poor countries may be of questionable value unless adequate vitamins and minerals are also supplied.

Introduction

Chaudhry et al. (196-b), feeding chapatis supplemented with 0.4% lysine to weanling male rats, found loss in weight of the rats by the eighth week. It was postulated that the natural vitamin and mineral supply perhaps became inadequate because of increased metabolic activity brought about by the stimulation of growth caused by the lysine added in the feeding trials.

Exploratory studies were undertaken with the limited amount of atta prepared by Chaudhry et al. (196-a) that remained after the feeding experiments (Chaudhry et al. 196-b) were concluded.

1/ Contribution No. ______. Department of Grain Science and Industry, Kansas Agricultural Experiment Station, Kansas State University, Manhattan, Kansas 66502.

This note is based on part of the dissertation presented by Hsin Y. Chung in partial fulfillment of the requirements for the Ph.D. degree.

Materials and Methods

The amount of atta (80% extraction) available was estimated to be sufficient to make enough chapatis to feed nine rats for six weeks. Three weanling male rats (Sprague-Dawley strain), chosen at random, were therefore placed on each of three diets after two days on a commercial feed (Purina Dog Chow) and water *ad libitum*:

A. Ground chapatis + 0.4% lysine

B. Ground chapatis + 0.4% lysine + vitamins and minerals

C. Ground chapatis + 0.4% lysine + 0.04% methionine + vitamins and minerals.

The composition of the vitamin-mineral supplement is shown in Table I. In the study made by Chaudhry *et al*. (196-b) vitamins and minerals were added to diets, not supplemented with lysine on the basis of multiple increments of the amounts present in the original whole wheat. In the present study, supplementation of the diets was based upon the levels recommended by the National Research Council.

Proximate compositions of the three diets are shown in Table II.

Results and Discussion

Results of the experiment are shown in Figure 1. Supplementation with 0.4% lysine alone gave a cumulative weight gain that was only slightly above that obtained by Chaudhry *et al*. (196-b). The rats used in the present studies were delayed in transit, so were several days older when entering the trials than the rats used in the former studies. Weights of the older rats were understandably somewhat higher than weights of those previously used.

The addition of the complete vitamin and mineral supplement used in the present study greatly increased the gain in weight of the rats over that obtained when 0.4% lysine alone was added. Moreover, the gain was much greater than was obtained by Chaudhry et al. (1968 b) using a limited vitamin supplement.

Addition of 0.64% methionine to the lysine-supplemented diet containing vitamins and minerals caused no appreciable difference in weight gained.

Further work is needed to determine the minimal effective amounts of vitamins and minerals needed to supplement chapatis for human nutrition. The present exploratory experiments, however, give strong evidence that vitamins and minerals must be supplied in adequate amounts if good results are to be obtained through supplementation of atta or chapatis with lysine.

Table I

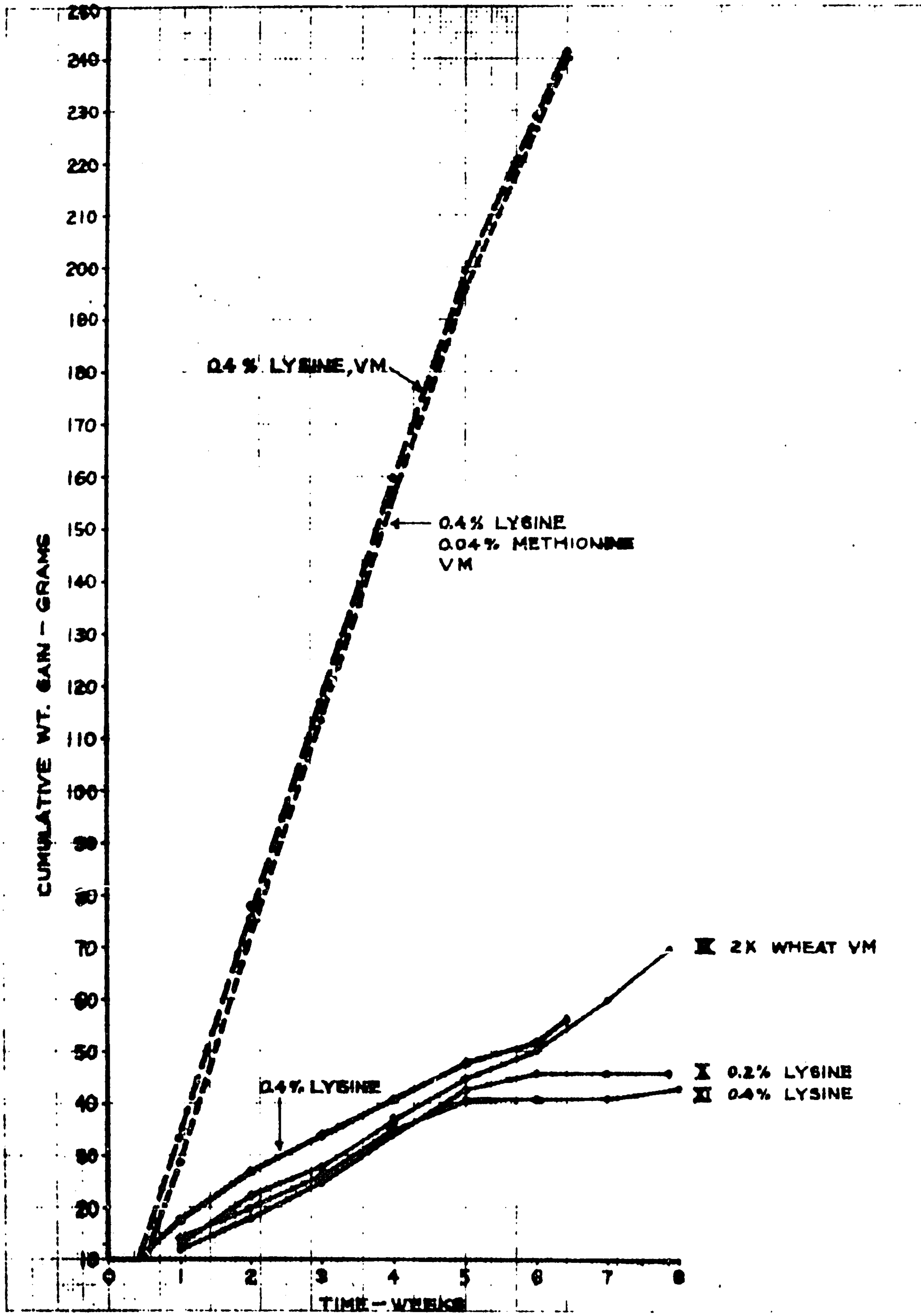
Vitamin and Mineral Contents of Diets

Vitamin or Mineral	Supplementation per 100 gm. of Diet: Present study	Chaudhry et al. (19[illegible])	By wheat flour, 80% extra.	Recommended by NRC
Vitamin A, I.U.	1000	0	0	200
Vitamin D, I.U.	100	0	-	-
Vitamin E, mg	10	0	-	6
Vitamin K, mg	0.5	0	-	0.01
Thiamine HCl, mg	0.5	0.73	0.26	0.25
Vitamin B_6, mg	0.4	0	-	0.12
Niacin, mg	4.0	3.50	2.0	1.5
Ca pantothenate, mg	25	0	-	0.8
Choline chloride, mg	200	0	-	75
Vitamin B_{12}, [illegible]	2	0	-	0.5
Riboflavin, mg	1	0.081	0.0[illegible]	-
PABA, mg	10	0	-	-
Biotin, mg	0.0[illegible]	0	-	-
Folic acid, mg	0.2	0	-	-
Calcium, mg	700	56.5	24	600
Phosphorus, mg	500	0	191	500
Sodium, mg	50	79	1	50
Potassium, mg	180	0	95	180
Chlorine, mg	241	122	-	50
Magnesium, mg	40	0	-	40
Manganese, mg	5	0	-	5
Iron, mg	5	5.77	1.3	2.5
Copper, mg	0.5	0	-	0.5
Zinc, mg	2.5	0	-	1.2
Iodine, mg	0.15	0	-	0.015

Table II

Proximate Composition of Diets (dry basis)

	A	B	C
Crude Protein	12.0	12.3	12.6
Crude Fat	5.3	5.6	4.8
Crude Fiber	1.8	2.3	2.2



CUMULATIVE WT. GAIN – GRAMS
TIME – WEEKS
0.4 % LYSINE, VM
0.4 % LYSINE
0.04 % METHIONINE
VM
0.4 % LYSINE
IX 2X WHEAT VM
X 0.2 % LYSINE
XI 0.4 % LYSINE

REFERENCES

Chaudhry, M. S., Farrell, E. P., MacMasters, M. M., and Hoover, W. J. 196-a. Studies on attas and chapatis I. Experimental production of atta. Food Technol.

Chaudhry, M. S., MacMasters, M. M., and Hoover, W. J. 196-b. Studies on attas and chapatis II. Nutritional value of chapatis with and without added lysine. Food Technol.

U.S.D.A. 1963. Composition of foods (raw, processed, prepared). Agricultural Research Service, U. S. Department of Agriculture, Agricultural Handbook No. 8.

Nutritional Evaluation of Wheat Based Foods:

Rat Study I. Studies on minimum supplementation of high extraction flour.

Objective: To study the effect of supplementing 97% extraction wheat flour with limiting amino acids, minerals, and vitamins, each of the rations shown in Table 1 were fed to eight weanling (21-day old) female albino rats of the Sprague-Dawley strain. The duration of the study was 28 days following an adjustment period of three days.

Procedure: Diet I, the control diet, was designed to meet all NRC minimal requirements for the rat. Diet I was supplemented with four amino acids (lysine, threonine, valine, and methionine), six minerals (manganese, iodine, calcium, phosphorus, sodium, and chlorine), and four vitamins (vitamins A, D, and B_{12}, and riboflavin). Supplementation of these nutrients was based on analytical values on the wheat products and a comparison with requirement values. Diets II through VII had one or more of these supplements omitted as follows: Diet II--threonine, valine, and methionine; Diet III--calcium; Diet IV--one-half the level of calcium supplied in the control; Diet V--phosphorus; Diet VI--iodine; Diet VII--vitamin B_{12}. Diet VIII was supplemented with lysine and with vitamins and minerals greater than the minimal requirements. Diet VIII was included to compare results of the present experiment with those of previous experiments of Chung ( ) and Chaudhry ( ).

	I	II	III	IV	V	VI	VII	VIII
	Control I	[illegible] II	No Ca Suppl.	½ Ca Suppl.	No P Suppl.	No I Suppl.	No [illegible] Suppl.	Prov. Expt.
L Lys HCl	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
dl [illegible]	0.19	—	0.19	0.19	0.19	0.19	0.19	—
L Val	0.24	—	0.24	0.24	0.24	0.24	0.24	—
dl [illegible]	0.17	—	0.17	0.19	0.19	0.17	0.17	—
$MnSO_4 \cdot H_2O$	0.0089	0.0089	0.0089	0.0089	0.0089	0.0089	0.0089	—
KI	0.000002	0.000002	0.000002	0.000002	0.000002	—	0.000002	—
$CaCO_3$	0.411	0.411	—	—	1.521	0.411	0.164	—
H_3PO_4 [illegible]	—	—	0.91	0.4574	—	—	—	—
Dical P	1.334	1.334	—	1.070	—	1.334	1.334	2.70
NaCl	0.1143	0.1143	0.1143	0.1143	0.1143	0.1143	0.1148	0.127
Mg [illegible]	—	—	—	—	—	—	—	0.066
C [illegible]	—	—	—	—	—	—	—	0.05
KCl	—	—	—	—	—	—	—	0.344
Ribo	0.000181	0.000181	0.000131	0.000131	0.000181	0.000181	0.000181	0.001
Vit A	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0017	0.004
Vit [illegible]	0.0114	0.0114	0.0114	0.0114	0.0114	0.0114	—	0.095
Vit D	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Vit E	—	—	—	—	—	—	—	0.091
Vit K	—	—	—	—	—	—	—	0.014
Thia-HCl	—	—	—	—	—	—	—	0.0005
Pyridox HCl	—	—	—	—	—	—	—	0.0004
Niacin	—	—	—	—	—	—	—	0.004
Ca [illegible]	—	—	—	—	—	—	—	0.025
[illegible]	—	—	—	—	—	—	—	0.010
Bio[illegible]	—	—	—	—	—	—	—	0.00002
Folic [illegible]	—	—	—	—	—	—	—	0.0002
Choline Cl	—	—	—	—	—	—	—	0.80
Wess[illegible]	3.983	3.983	3.983	3.983	3.983	3.983	3.983	5.00
Corn St[illegible]	2.9362	3.3362	2.8710	3.1802	3.1610	2.9362	2.7476	0.717
[illegible]	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
W[illegible] Flour	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0
Grand Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 1. Composition of [illegible]

The nitrogen content of the diets was determined by the Kjeldahl method (A.O.A.C. 2.036). The diets contained the following amounts of protein (N x 6.25):

Diet I	10.85%
Diet II	10.29%
Diet III	10.75%
Diet IV	10.75%
Diet V	10.75%
Diet VI	10.86%
Diet VII	10.86%
Diet VIII	10.42%

Animals were weighed weekly. Protein efficiency ratios (PER) were calculated at the end of the 28-day study. The cumulative weight gains and PER's are shown in Table 2.

Table 2. Cumulative weight gains and protein efficiency ratios of rats fed experimental diets.

Diet	Cumulative Weight Gains, g.				PER
	7 days	14 days	21 days	28 days	
I	14.4	39.6	64.4	84.2	1.99
II	18.8	44.5	69.8	91.9	2.18
III	17.0	38.0	61.6	73.9	1.80
IV	17.4	42.5	69.8	89.0	2.13
V	13.1	34.9	55.6	75.5	1.95
VI	15.4	40.1	64.9	86.2	2.03
VII	12.9	32.6	56.0	77.0	1.97
VIII	16.2	44.5	71.4	92.6	2.11

The analysis of variance (Table 3) showed that differences among PER's were significant at the 1% level.

Table 3. Analysis of variance of PER data.

Source	d.f.	S.S.	M.S.	F
Diets	7	0.824	0.118	4.701**
Error	56	1.405	0.025	

$F_{.05} = 2.18$ $LSD_{.05} = 0.1584$

$F_{.01} = 2.98$

Differences among diets at the 5% level are summarized below

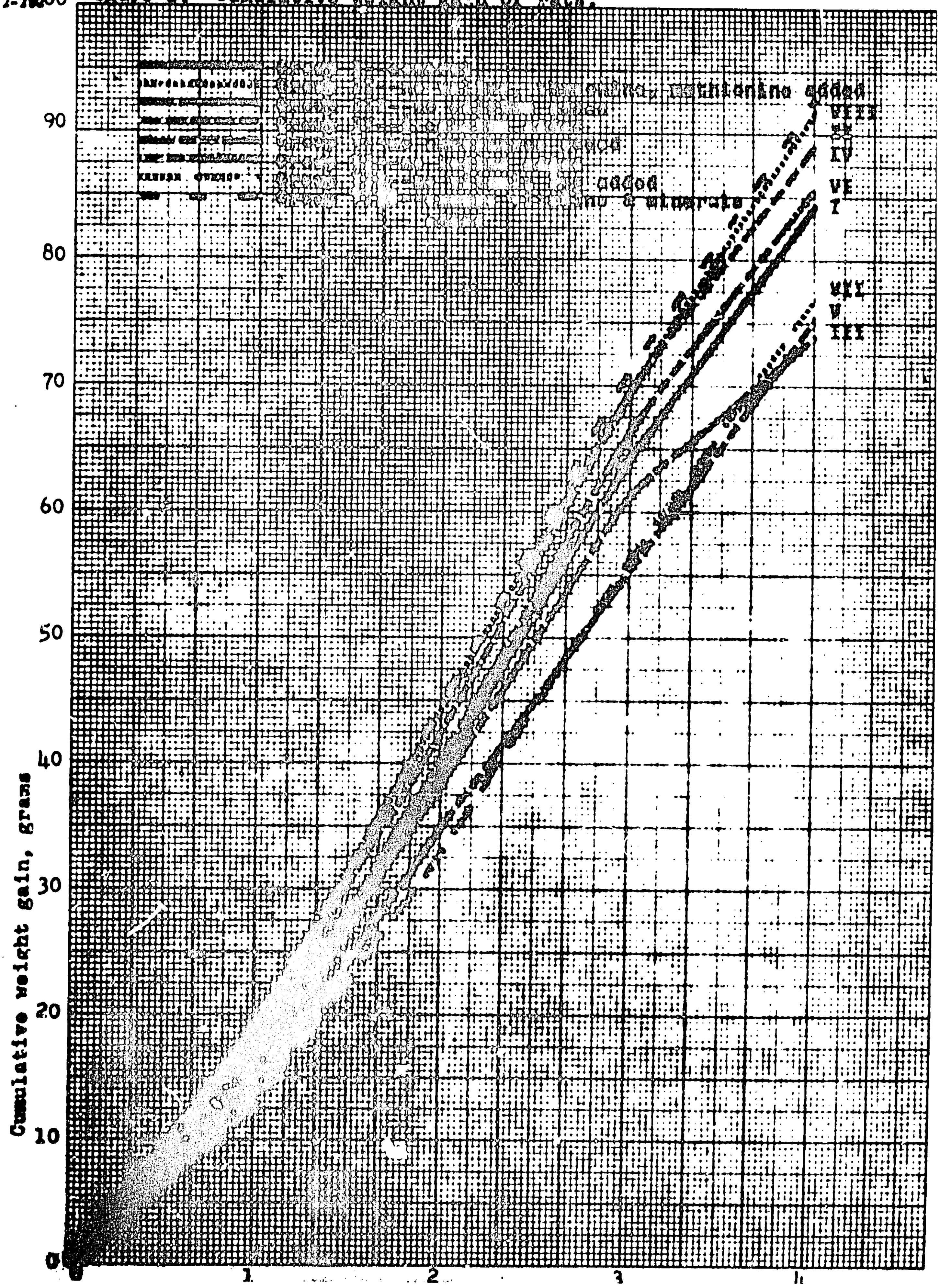
II > I, VII, V, III
IV > VII, V, III
VIII > V, III
VI > III
I > III
VII > III

In this experiment it was observed that omission of methionine, valine, and threonine improved the lysine-supplemented rations as measured by PER's. The supplementation of calcium was necessary, but adding half of the difference between the calcium supplied by the wheat flour and the NRC requirement produced results as favorable as adding an amount equivalent to the entire difference. The inclusion of an excess of vitamins and minerals above NRC minimal requirements did not improve the growth of rats. The addition of phosphorus and vitamin B_{12} appeared to improve the quality of the rations. The addition of iodine did not alter the quality of the diets significantly.

Data presented in Figure 1 indicate that the effect of limited calcium was more apparent near the end of the study. These results indicate the need to carry similar experiments for longer periods to determine longer term effects.

[redacted]
12-2

Figure 1. Cumulative weight gain of rats.



STUDIES TO EVALUATE THE NUTRITIONAL VALUE OF THE PROTEIN IN MILLED SORGHUM GRAIN FRACTIONS

Preliminary studies of sorghum grain have indicated that the nutritional quality of the protein in sorghum grain varies. The highest nutritional values is observed in the sorghum grain fraction derived from the floury endosperm.

Horny endosperm has a poor nutritional balance being deficient in lysine and other basic essential amino acids. The following experiment was designed to evaluate the nutritional value of the protein of various endosperm fractions.

Two varieties were selected having equal protein content. The grains were milled and various endosperm fractions were supplemented with amino acids for biological study. The additional amino acid supplementation studies were planned to offset the protein parameters.

EXPERIMENT OBJECTIVES

The objectives of the study were as follows:

(1) To compare the protein quality of milled endosperm fractions from two hybrids.

(2) To study the effects of supplementing endosperm protein with lysine and methionine.

(3) To study the effects of supplementing both high and low protein milled products with lysine and methionine.

(4) To compare the growth of rats fed milled endosperm products with that of casein.

MATERIALS AND METHODS

Two hybrids having equal protein content (9.50% protein, 12% moisture basis) were dry milled using conventional dry milling equipment as described by the milling flow in Figure 1. Amino acid composition of all endosperm fractions are given in Table Ia. The yield and approximate analysis of the milled products are given in Table 1.

Fractions 3 and 7 from each hybrid were divided and half was supplemented with methionine and lysine and the remainder was fed without supplementation. Diets containing fraction 3 (floury endosperm) were fed at approximately a 5.6% protein level while diets containing fraction 7 (horny endosperm) was adjusted with starch to provide approximately 10.2% protein. Casein control diets were fed at both dietary protein levels. Approximate analysis of the diets are shown in Table II.

Table III and IV show the composition of the diets and the levels of lysine and methionine addition. The amino acids were incorporated to provide those diets with 100% of the NRC requirement.

The ten diets were fed to 22-day old weanling female white rats in individual cages. There were six replications per diet with one rat per replication. The sixty rats, weights ranging from 43 to 50 grams, were randomized to the various diets.

RESULTS AND CONCLUSIONS

Average weight gain, feed consumption, and protein efficiency ratios (PER) for rats fed the floury endosperm products in the low protein (5.6%) diets are shown in Table V. The supplementation of lysine and methionine to diets 2 and 6 resulted in a marked increase in weight gain and PER above the non-supplemented diets. The supplemented diets were similar to the casein diet which was fed at the same protein level.

The same information is provided in Table VI for rats fed the horny endosperm products. These diets were isonitrogenous at approximately 10.2% protein. Again the amino acid supplementation caused a marked increase in gain and PER's. The weight gain of the supplemented diets was superior to the casein diet. The PER's, however, were similar. Horny endosperm from Frontier 400C produced greater gain and had a higher PER than Paymaster Kiowa when supplemented with the amino acids. However, when the PER's were adjusted for the control diets (as shown in Table VII) differences were not significant.

Table VII provides a means of comparison of floury and horny endosperm. The PER's of the experimental diets were corrected by the fraction as follows:

$$\text{CORRECTED PER} = \frac{2.5}{\text{determined PER of the control casein diet}} \times \text{PER OF EXPERIMENTAL DIETS}$$

The 2.5 is the assumed PER for a reference standard casein diet. The various experimental diets were corrected by the fraction obtained from their respective control diets having similar protein content, i.e. diets 1, 2, 5 and 6 were corrected by the use of control diet 9; diets 3, 4, 7 and 8 were corrected by the use of control diet 10.

When the diets were not supplemented the floury endosperm was superior to the horny endosperm within a given hybrid. When the floury and horny fractions were supplemented with amino acids, however, differences were not present indicating the protein was utilized equally when the amino acid deficit was supplied. Table VII also shows no differences between the PER's obtained from the two hybrids irrespective of amino acid supplementation.

-6-

SUMMARY

The data from this study substantiates differences between floury and horny endosperm. The protein quality of floury endosperm appears to be superior to that of horny endosperm when fed on an isonitrogenous basis. Differences between floury and horny fractions, however, were not present when both were supplemented with sufficient lysine and methionine to meet adjusted NRC requirements. When lysine and methionine is incorporated into the diets containing floury and horny endosperm, gain and PER's are high and comparable to those obtained with casein. Significant differences were not observed between fractions obtained from the two hybrids used in this study.

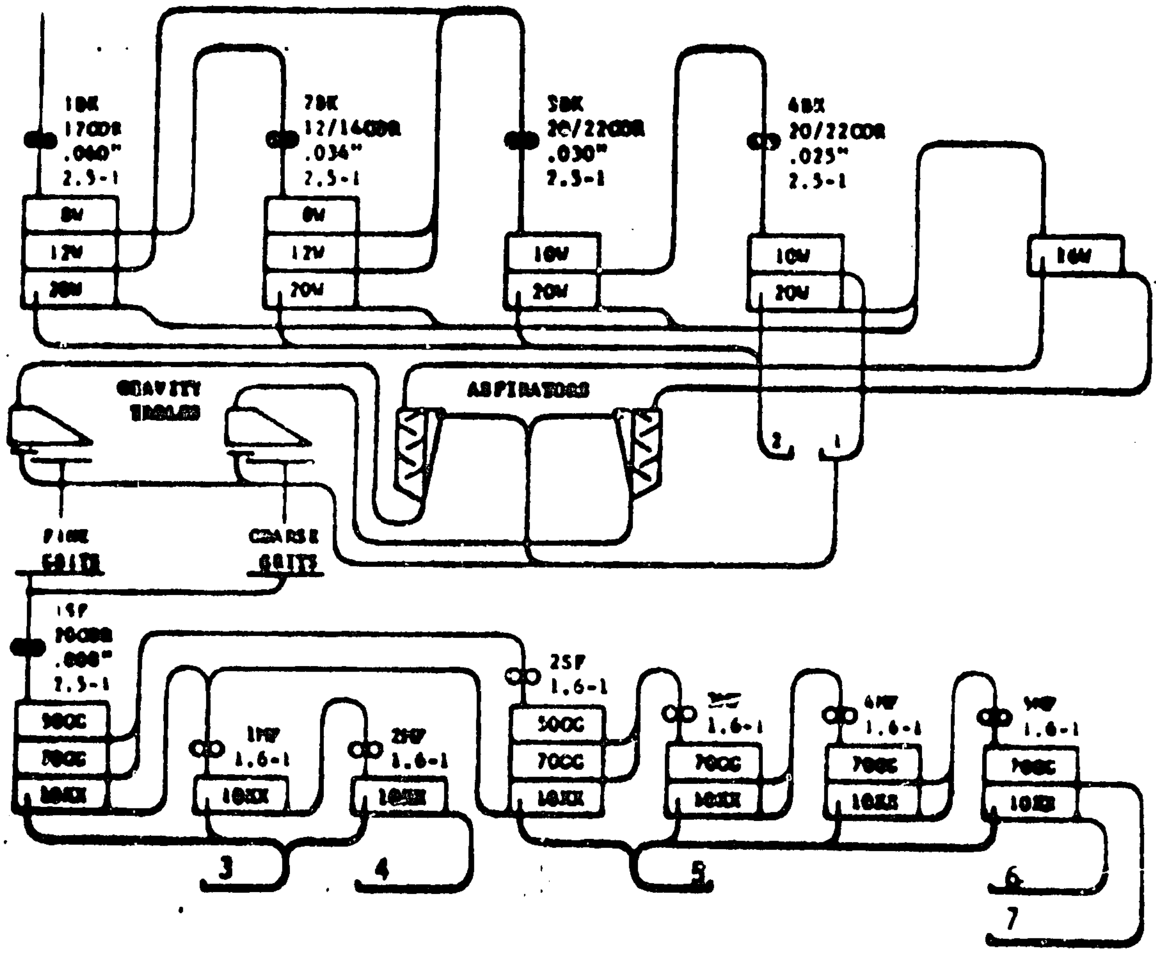

2BK
12/14CDR
.034"
2.5-1
20/22CDR
.030"
4BX
20/22CDR
.025"
2.5-1
12W
20W
10W
20W
10W
20W
ASPIRATORS
COARSE
GRITS
2SF
1.6-1
1.6-1
50CC
70CC
10XX
1.6-1
1.6-1
1.6-1
70CC
10XX
3
4
5
6
7
1
2

FIGURE 1

TABLE I ANALYSIS OF FRACTIONS OBTAINED FROM DRY MILLING SORGHUM GRAIN[1]

Hybrid[2]	Yield[3]		Crude Protein		Crude Fat		Crude Fiber		Ash	
	A	B	A	B	A	B	A	B	A	B
Fraction										
1	27.33	25.32	---*							
2	18.88	19.62								
3	12.54	12.23	7.40	6.82	0.91	1.02	0.91	0.80	0.48	0.47
4	5.06	5.06	9.49	10.62	0.98	0.94	1.13	1.36	0.50	0.51
5	9.95	10.31	9.88	8.78	0.96	1.09	0.70	1.13	0.50	0.47
6	8.38	8.19	13.98	12.58	0.87	1.12	0.72	1.12	0.47	0.46
7	14.29	16.61	15.96	15.47	1.12	1.23	1.12	1.34	0.59	0.55

[1]Moisture free basis.

[2]Hybrid A is Paymaster Kiowa.
Hybrid B is Frontier 400C.

[3]Percent of whole sorghum grain

*Blank spaces indicate no determinations made.

Table 1a Amino Acid Distribution in Protein of Sorghum Grain Milled Fractions and Casein

Fraction	3		4		5		6		7		
Hybrid[1]	A	B	A	B	A	B	A	B	A	B	Casein
Protein[2]	7.40	6.82	9.49	10.62	9.88	8.78	13.98	12.58	15.96	15.47	94.31
Lysine[3]	1.72	1.80	1.33	1.35	1.30	1.54	0.99	1.15	1.05	1.16	8.98
Histidine	1.98	2.10	2.03	2.16	1.96	2.25	1.81	2.18	1.93	2.05	3.21
Ammonia	2.95	2.75	3.08	3.38	2.76	3.23	2.94	3.16	3.15	2.90	1.86
Arginine	2.85	3.01	2.61	2.71	2.30	3.07	2.15	2.54	2.27	2.63	4.09
Aspartic acid	6.13	6.15	5.93	6.23	6.33	6.32	6.43	5.97	6.39	7.38	8.04
Threonine	3.09	3.16	3.14	3.26	3.16	3.38	3.00	3.22	3.03	3.34	4.72
Serine	4.45	4.31	4.54	4.92	4.66	4.78	4.61	4.70	4.63	4.91	6.36
Glutamic acid	21.73	20.67	23.67	24.85	24.93	25.11	25.24	25.68	25.59	27.05	27.15
Proline	8.06	8.17	8.93	9.20	9.03	9.28	9.47	9.42	8.86	10.87	12.63
Glycine	2.61	2.79	2.50	2.56	2.36	2.75	2.15	2.40	2.18	2.56	2.02
Alanine	9.34	8.92	10.41	10.81	10.66	10.82	11.21	11.53	10.95	11.42	3.31
Cystine	1.77	2.13							1.47	1.77	0.53
Valine	4.28	4.86	4.38	4.67	4.81			4.87	5.05	5.39	7.00
Methionine	1.62	1.72							1.38	1.56	2.19
Isoleucine	3.98	3.83	3.99	4.12	4.27	4.18	4.22	4.26	4.30	4.45	5.80
Leucine	13.63	12.95	15.53	16.53	16.02	16.47	16.29	16.32	16.40	16.83	10.48
Tyrosine	4.08	4.02	4.15	4.41	4.43	4.45	4.58	4.44	4.50	4.53	6.33
Phenylalanine	5.13	5.08	5.30	5.46	5.79	5.40	5.82	5.94	6.01	6.12	5.64
N-Recovery	86.26	85.31	92.28	97.51	92.46	95.94	91.68	97.04	94.42	99.76	103.44

[1]Hybrid A is Paymaster Kiowa; Hybrid B is Frontier 400 C

[2]Protein, % (N x 6.25) moisture free basis.

[3]Grams of amino acid per 16 grams nitrogen, duplicate determinations on samples 3A, 3B, 7A and 7B.

TABLE II APPROXIMATE ANALYSIS OF EXPERIMENTAL DIETS

Hybrid	Milling Fraction	Amino Acid Supplement	Diet No.	Moisture	Protein	Fat	Ash
Paymaster Kiowa	3	-	1	11.2	5.6	4.2	3.5
		+	2	11.3	5.8	4.3	3.4
	7	-	3	10.6	9.8	4.3	3.4
		+	4	10.7	10.4	4.3	3.4
Frontier 400C	3	-	5	10.7	5.4	4.3	3.4
		+	6	10.8	5.8	4.4	3.4
	7	-	7	10.5	10.0	4.2	3.4
		+	8	10.8	10.7	4.0	3.5
Casein		-	9	10.0	5.8	4.0	3.2
		-	[illegible]	9.9	10.0	4.0	3.2

TABLE III COMPOSITION OF EXPERIMENTAL DIETS

Diets	1	2	3	4	5	6	7	8	9	10
Ingredients:	%	%	%	%	%	%	%	%	%	%
Milled Fraction	85.08	85.08	67.98	67.98	92.26	92.26	70.49	70.49		
Starch	7.18	7.18	23.03	23.03			20.80	20.80	84.75	80.26
Corn Oil	3.40	3.40	3.40	3.40	3.40	3.40	3.40	3.40	3.86	3.86
Water[1]			1.22	1.22			0.97	0.97	0.97	0.87
Vitamin Premix[2]	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
Mineral Premix[2]	3.71	3.71	3.71	3.71	3.71	3.71	3.71	3.71	3.71	3.71
Lysine		0.33		0.64		0.33		0.64		
Methionine		0.12		0.25		0.12		0.25		
Casein									6.08	10.66

[1]Water was added to adjust moisture content of diet.

[2]Premix composition given in Table IV.

TABLE IV COMPOSITION OF PREMIXES FOR EXPERIMENTAL DIETS

INGREDIENT	1000 g. Diet
Mineral Premix:	g.
Dicalcium phosphate[1]	30.00
Salt	3.00
Trace minerals[2]	0.50
Potassium chloride	3.05
Magnesium sulfate	1.77
Vitamin Premix	mg.
Vitamin A (30.0 IU per mg.)	66.70
Vitamin D (15.0 IU per mg.)	133.00
Alpha tocopherol (110.1 U per g.)	544.90
Menadione	1.10
Thiamine HCl	1.25
Riboflavin	2.50
Pyridoxine HCl	1.20
Niacin	15.00
Calcium pantothenate	8.00
Vitamin B_{12}	5.00
Choline chloride	750.00
Carrier (starch)	5000.00

[1]Sargents Calcium Company, Des Moines, Iowa: P, 18.5%; Ca, 19.0-22.5%.

[2]CCC trace mineral mix contained: (ppm) Mn, 10; Fe, 10; Ca, 14; Cu, 1; Zn, 5; I, 0.3; and Co, 0.1; Calcium Carbonate Company, Quincy, Illinois.

TABLE V AVERAGE WEIGHT GAIN, FEED CONSUMPTION, AND PER'S FOR RATS FED FLOURY ENDOSPERM

Hybrid[1]	Amino Acid Supplement	Diet[2]	Gain[3]	Feed Consumed[4]	PER[5]
A	-	1	5.50[a]	193.5[a]	0.49[a]
B	-	5	8.83[a]	210.3[ab]	0.76[a]
A	+	2	35.50[b]	242.0[cb]	2.54[b]
B	+	6	36.67[b]	257.0[c]	2.44[b]
Casein	-	9	37.00[b]	259.3[c]	2.46[b]

[1]Hybrid A is Paymaster Kiowa.
Hybrid B is Frontier 400C.

[2]Diet contains approximately 5.6% protein.

[3]Average weight gain per rat 0-4 weeks, $LSD_{.01}$ = 8.22 g.

[4]Gm feed consumed 0-4 weeks, $LSD_{.01}$ = 46.12 g.

[5]Gm of gain/gm of protein consumed, $LSD_{.01}$ = 0.38.

TABLE VI AVERAGE WEIGHT GAIN, FEED CONSUMPTION, AND PER'S FOR RATS FED HORNY ENDOSPERM

Hybrid[1]	Amino Acid Supplement	Diet[2]	Gain[3]	Feed Consumed[4]	PER[5]
A	-	3	2.50[a]	168.7[a]	0.15[a]
B	-	7	4.50[a]	176.7[a]	0.25[a]
A	+	4	75.70[c]	342.5[c]	2.13[b]
B	+	8	91.67[d]	366.0[c]	2.34[c]
Casein	-	10	62.17[b]	272.0[b]	2.29[bc]

[1]Hybrid A is Paymaster Kiowa.
Hybrid B is Frontier 400C.

[2]Diets contain approximately 10.2% protein.

[3]Average weight gain per rat 0-4 weeks, $LSD_{.01}$ = 11.5 g

[4]Gm of feed consumed 0-4 weeks, $LSD_{.01}$ = 42.08 g.

[5]Gm of gain/gm of protein consumed, $LSD_{.01}$ = 0.20

TABLE VII PER'S OF EXPERIMENTAL DIETS ADJUSTED BY THE CASEIN CONTROL DIETS[1]

Milled Fraction	Amino Acid Supplement	Hybrid[2]	Diet	PER[3]
Floury	-	A	1	0.50[ab]
	-	B	5	0.78[a]
Horny	-	A	3	0.16[c]
	-	B	7	0.27[cb]
Floury	+	A	2	2.58[d]
	+	B	6	2.49[d]
Horny	+	A	4	2.32[d]
	+	B	8	2.55[d]

[1]Correction factor for the low protein, floury endosperm diets 1, 2, 5 and 6 is equal to:

$$\frac{(2.5 \text{ constant PER for casein})}{(2.458 \text{ PER of reference std. casein, diet 9})}$$

Correction factor for the high protein, horny endosperm diets 3, 4, 7 and 8 is equal to:

$$\frac{(2.5 \text{ constant PER for casein})}{(2.291 \text{ PER of reference std. casein, Diet 10})}$$

[2]Hybrid A is Paymaster Kiowa.
Hybrid B is Frontier 400C.

[3]Gm of gain/gm of protein consumed, corrected by the control diets; numbers having different letters are significantly different. $LSD_{.01} = 0.30$.

2. Effect of Cooking on Nutritive Quality of Common Native Foods.

A number of reports are available on the effect of heat on tie-up or destruction of amino acids in pure proteins, grains, and protein-carbohydrate mixtures. There are few studies on effect of heat on nutritive value of food products.

Studies will be made to extend the knowledge of effects of normal cooking of chapatis, cous-cous, and Arab bread on nutritive value. A preliminary study was made two years ago on the effect of toasting bread on tie-up of lysine. Toasting to a dark brown color markedly lowered growth of rats, but addition of lysine almost fully overcame the adverse effect.

Cooking can have both a favorable as well as unfavorable effect. In addition to the well-known effect on starch granules, there is some evidence that heat may make phosphorus of grains more available. Heat may destroy factors such as the anti-trypsin factor and those causing Lathyrism or Odoratism. Since most literature reports on these effects were done years ago, and often crudely, more needs to be known of the possible hazards from these factors in chick peas, a likely source of protein supplement for chapatis. Cooking also could tie up or destroy lysine and other supplements added to chapatis. This has not been investigated.

There are chemical tests for destruction or freeing of nutrients, such as solubility for phosphorus and FDNB method for lysine. In some cases comparisons of the animal and chemical methods need to be made, since results are not the same, and they could give clues to nutrient availability to animals.

3. The nutrition group has a major responsibility to evaluate and decide some questions relative to the project, which are not primarily based on our laboratory work directly. We are at work on these problems and will continue discussing them until conclusions or at least working assumptions can be made.

Some of these are:

A. Can improvement of nutrition of adults and children, with the foods to be employed be considered as one or separate problems?

B. To what extent will the nutritional plans need to take into account parasitism, other disease, and pre-existing nutritional status of subjects?

C. What size individual in the population are we planning for (i.e. 55-60 kg man, or larger or smaller)? Should we plan for minimal or optimal nutrient intake? What level of energy, type and level of protein and levels of vitamins and minerals will become our working standard?

D. What would be the most satisfactory supplement to grain--pure nutrients or natural foodstuffs.