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Research Article

Effect of hydrothermal treatments on proteins from acha (*Digitaria exilis*) and wheat (*Triticum durum*)

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Abstract: In this paper the effects of hydrothermal treatments on the proteins from *acha* and wheat were studied. The aim was to ascertain the stability of the proteins at different temperatures and cooking time. Standard laboratory scheme for food analysis was used to determine the protein contents of *acha* and wheat before and after they were subjected to different cooking temperatures and time. The experimental results showed that cooking *acha* and wheat between 70 and 140°C for 10 – 60 min reduced the protein contents of *acha* by 4.60 – 57.14% and that of wheat by 1.13 – 14.29 %. In general, proteins from *acha* and wheat are denatured more at high temperatures and longer cooking time. The dependence of protein content on temperature and time of cooking is important in processing *acha* and wheat to ensure food quality and stability and to enhance their economic value.

Keywords: food, cereals, processing, **c**ooking temperature

Introduction

Acha (Digitaria exilis) also known as "hungry rice", is one of the indigenous African cereals which belong to the family of the *Poaceae* (grasses), the most economically and ecologically important family of the monocotyledon [1]. The genus *Digitaria* has a large worldwide distribution [2]. *Acha* is one of the most nutritious of all grains because its seed is very rich in methionine and cystine (amino acids) which are vital to human health. It is high in digestible energy but low in oil and minerals. *Acha* protein is reported to be unique in that it has greater methionine content than other cereals [3]. Each year West

African farmers devote approximately 300,000 hectares to *acha* cultivation and yields of 600-700kg/ha^{-1}are recorded which translate to 180,000-210,000 tonnes of grain annually. The crop supplies food to 3-4 million people [4, 5].

Wheat originated in Southwest Asia in the area known as the Fertile Crescent. Wheat flour is consumed in larger quantities worldwide than any other cereal flour. This is because of its extensive availability. Wheat can be grown under widely varying climatic conditions and it contains a protein called gluten. When wheat flour is mixed with water, the gluten forms elastic dough and when the dough is baked in a hot oven it expands to several times its original volume. Flour made from soft wheat containing less than 12% of gluten protein is used to make tender products such as cakes and crackers while flour made from hard wheat containing more than 12% protein is used for bread and roll production [6]. *Acha* and wheat are essential dietary sources of cereal proteins and vitamins.

Hydro and hydrothermal treatments constitute a major part of the unit operations carried out in processing raw food materials. Hydrothermal treatments involved in processing cereals include steaming, simmering, boiling, braising and blanching. All these operations greatly affect both the cost and the efficiency of processing and evoke a spectrum of changes in the proximate compositions of the raw materials processed [7]. Hydrothermal treatment is the act of preparing food for eating by the application of heat and encompasses a vast range of methods, tools and combinations of ingredients to alter the flavour or digestibility of food [8].

Cereal grains such as *acha*, wheat, corn, oats, barley, millet, sorghum and rye are best for human nutrition when put into the form of flour, meal or flakes. The seeds of these grains consist of three parts; the germ containing oil (Vitamin E), the endosperm (interior part containing the starch) and the bran which is the protective covering containing fibre [9]. Applying heat to food usually, though not always, chemically transforms it, thus changing its flavour, texture, consistency, appearance and nutritional properties [10]. Protein content of cereals has a greater influence on overall processing quality than any other single factor [11].

The objectives of this study are to determine the effect of heat treatments on the protein contents extracted from *acha* and wheat and to ascertain the temperature at which the maximum protein yields can be obtained from *acha* and wheat during cooking. This study will aid in assessing the heat treatments, processing and other unit operations that *acha* and wheat grains may be subjected to, in order to enhance their maximum utilization and retention of proteins.

Materials and Methods

Acha and wheat samples used for the isolation of protein and determination of effects of hydrothermal treatments were purchased from a market in Nigeria. The samples were cleaned of foreign materials and subjected to heat treatments at varying temperatures and time.

Experimental Procedure

AOAC (1990) food analysis procedures for estimating crude protein were followed [12]. The samples of *acha* and wheat were cooked at various ranges of temperature and time and were filtered using mucilin cloth and finally allowed to dry and then milled. After the milling, about 1g of each sample was carefully weighed on an electrical analytical balance (Adventurer OHAUS by MELLER, Switzerland; Type PM 2000, Serial No: H52764 and sensitivity ±0.001g). The weighed samples were digested using Micro-Kjeldahl nitrogen digestion and distillation apparatus (Gerhardt Bonn Kjeldatherm, Germany; Type TR).

Results and Discussion

The protein contents of *acha* and wheat at varying temperatures and cooking time are presented in Table 1. The variations of protein contents of acha and wheat at various temperatures and cooking time are shown in Figures 1, 2, 3, 4 and 5.

Table 1 indicates that there are differences in the protein content of the two cereal grains studied. The protein contents of both *acha* and wheat are high when compared with the reported values for other cereal grains such as maize, millet, barley, rice and sorghum (Temple and Bassa, 1991). Also, the percentage protein content of 7.620 ± 0.678 4.1) for raw *acha* is higher than the reported value of 7.40 ± 0.31 at raw stage [13], while the value obtained for wheat 12. 870 ± 0.671 is lower than the reported value of 14.70 ± 0.12 at the same raw stage [13]. The observed differences could be due to differences in variety of the grains used in the experiments.

The effects of cooking on protein content at different temperatures and time (Figures 1 – 5) are further discussed. Figure 1 shows that when *acha* and wheat were cooked at 70°C between 10 and 60 min, the protein content remained essentially constant. It was therefore concluded that cooking *acha* and wheat at low temperature has no serious effect on protein content. Figure 2 shows that, at 80°C, the protein content of *acha* remained constant between 10 and 20 min, increased slightly between 20 and 30 min (actually peaked at 30 min) and remained constant between 30 and 40 min; but between 40 and 60 min the protein content dropped rapidly. For wheat, the protein content remained

Table 1. Effect of heat treatments on protein content of *acha* and wheat.

***Acha* Treatment**	**% Protein**	**Wheat Treatment**	**% Protein**
Acha at raw stage (Uncooked)	7.620±0.678	Wheat at raw stage (Uncooked)	12.870±0.671
Acha cooked at 70°C for 10 min	8.260± 0.032	Wheat cooked at 70°C for 10 min	14.868± 0.008
Acha cooked at 70°C for 20 min	8.290± 0.032	Wheat cooked at 70°C for 20 min	14.868 ± 0.008
Acha cooked at 70°C for 30 min	8.260± 0.032	Wheat cooked at 70°C for 30 min	14.868 ± 0.008
Acha cooked at 70°C for 40 min	8.011± 0.032	Wheat cooked at 70°C for 40 min	14.702 ± 0.008
Acha cooked at 70°C for 60 min	7.847± 0.032	Wheat cooked at 70°C for 60 min	14.702 ± 0.008
Acha cooked at 80°C for 10 min	8.260± 0.211	Wheat cooked at 80°C for 10 min	14.868 ± 0.012
Acha cooked at 80°C for 20 min	8.260± 0.211	Wheat cooked at 80°C for 20 min	14.868 ± 0.012
Acha cooked at 80°C for 30 min	9.086± 0.211	Wheat cooked at 80°C for 30 min	14.702 ± 0.012
Acha cooked at 80°C for 40 min	9.110± 0.211	Wheat cooked at 80°C for 40 min	14.621 ± 0.012
Acha cooked at 80°C for 60 min	8.260± 0.211	Wheat cooked at 80°C for 60 min	14.702 ± 0.012
Acha cooked at 100°C for 10 min	9.251± 1.144	Wheat cooked at 100°C for 10 min	14.042 ± 0.489
Acha cooked at 100°C for 20 min	9.257± 1.144	Wheat cooked at 100°C for 20 min	14.042 ± 0.489
Acha cooked at 100°C for 30 min	8.260± 1.144	Wheat cooked at 100°C for 30 min	13.216 ± 0.489
Acha cooked at 100°C for 40 min	7.220± 1.144	Wheat cooked at 100°C for 40 min	13.110 ± 0.489
Acha cooked at 100°C for 60 min	7.021± 1.144	Wheat cooked at 100°C for 60 min	12.390 ± 0.489
Acha cooked at 120°C for 10 min	7.847± 0.075	Wheat cooked at 120°C for 10 min	14.868 ± 1.951
Acha cooked at 120°C for 20 min	7.840± 0.075	Wheat cooked at 120°C for 20 min	14.868 ± 1.951
Acha cooked at 120°C for 30 min	7.434± 0.075	Wheat cooked at 120°C for 30 min	13.216 ± 1.951
Acha cooked at 120°C for 40 min	7.434± 0.075	Wheat cooked at 120°C for 40 min	13.000 ± 1.951
Acha cooked at 120°C for 60 min	7.234± 0.075	Wheat cooked at 120°C for 60 min	11.564 ± 1.951
Acha cooked at 140°C for 10 min	9.086± 1.967	Wheat cooked at 140°C for 10 min	13.216 ± 0.896
Acha cooked at 140°C for 20 min	9.086± 1.967	Wheat cooked at 140°C for 20 min	13.216 ± 0.896
Acha cooked at 140°C for 30 min	7.847± 1.967	Wheat cooked at 140°C for 30 min	12.803 ± 0.896
Acha cooked at 140°C for 40 min	7.102± 1.967	Wheat cooked at 140°C for 40 min	11.220 ± 0.896
Acha cooked at 140°C for 60 min	5.782± 1.967	Wheat cooked at 140°C for 60 min	11.564 ± 0.896

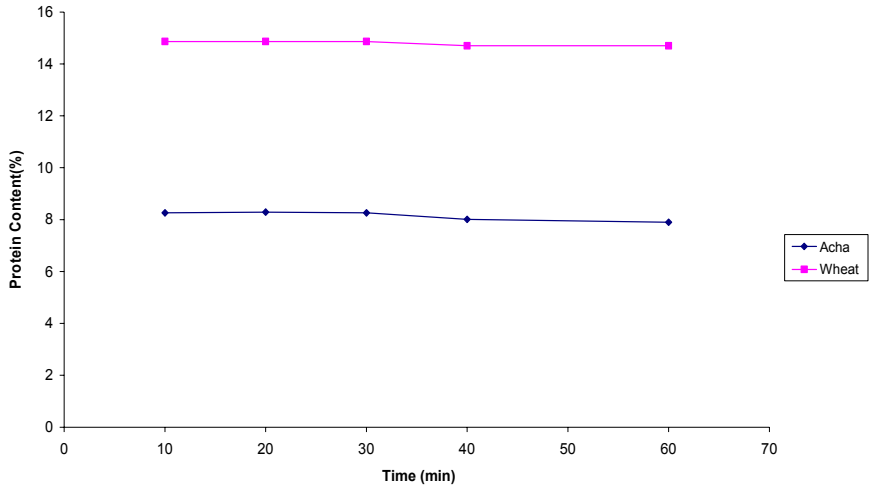

Figure 1. Protein content of *acha* and *durum* wheat at 70°C.

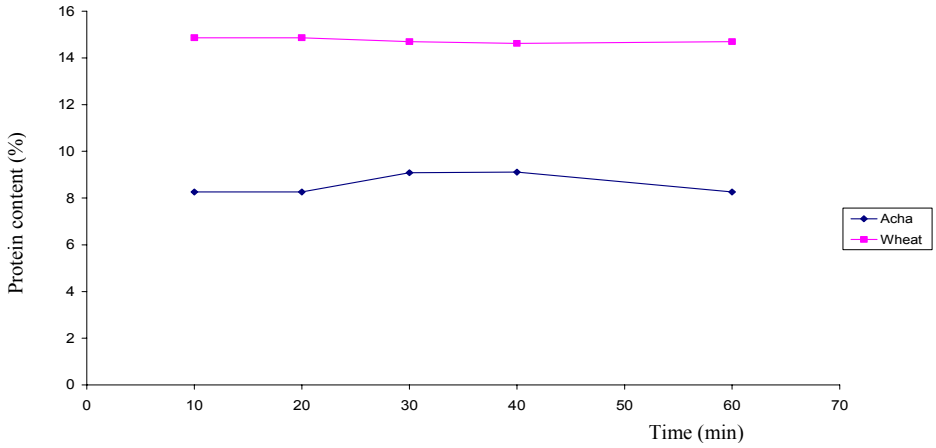

Figure 2. Protein content of *acha* and *durum* wheat at 80°C.

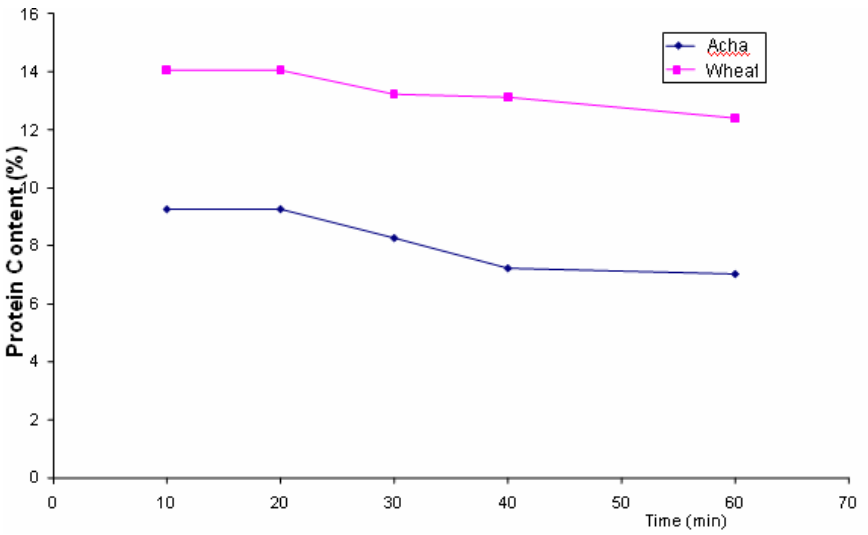

Figure 3. Protein content of *acha* and *durum* wheat at 100°C.

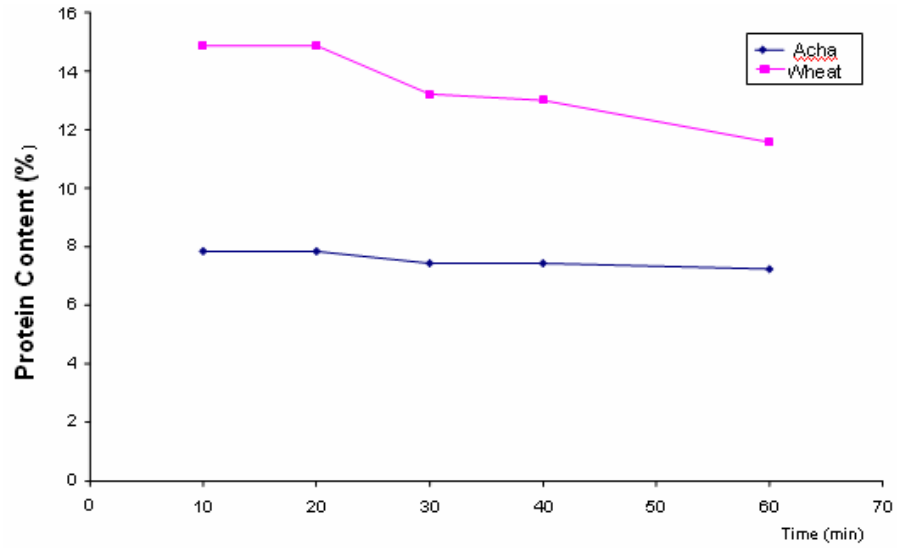

Figure 4. Protein content of *acha* and *durum* wheat at 120°C.

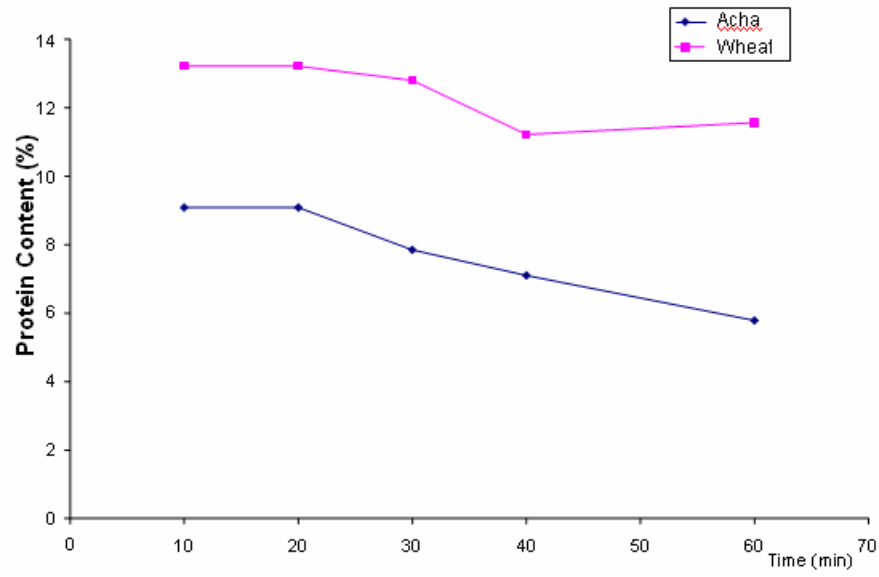

Figure 5. Protein content of *acha* and *durum* wheat at 140°C.

essentially constant between 10 and 60 min when cooked at 80°C. This implies that wheat protein is less sensitive to heating compared to protein from *acha*.

Figure 3 shows that, at 100°C, the protein from *acha* remained essentially constant between 10 and 20 min and then decreased between 20 and 60 min. The values between 40 and 60 min were fairly uniform. The protein content of wheat remained constant between 10 and 20 min and decreased between 20 and 60 min. Figure 4 shows that, at 120°C, the protein content of *acha* is such that it remained fairly constant at all times as only a slight difference was noticed. The behaviour of wheat is such that its protein content remained constant between 10 and 20 min and then decreased sharply between 20 and 30 min. This decrease continued even at 60 min of cooking. Finally, Figure 5 shows that, at 140°C, the protein content of *acha* remained constant between 10 and 20 min and then decreased rapidly between 20 and 60 min, while that of wheat remained constant between 10 and 30 min; decreased between 30 and 40 min and increased between 40 and 60 min. It was also observed that the percentage protein content obtained when the grains were cooked at different temperatures and time (70 – 100°C and 10 – 30mins for *acha*) and (70 – 100°C and 10 – 40mins for wheat) are higher than the values for the raw samples of the two cereals (Table 4.1). At higher temperatures and longer cooking times however the protein contents decreased. This is expected since it is known that protein is denatured at high temperatures. More so, the cooking time is appreciably long. A decrease in protein content may lead to reduced tonnage from *acha* and wheat being segregated. This can cause problems in guaranteeing continuity of supply to long- term

customers. It can also affect a commodity board's ability to penetrate new market areas. Decrease in tonnage from *acha* and wheat may also affect the sales of the two cereal

crops to industries that process the cereals into flours and other products and even lower the dietary constituents to both humans and livestock.

Conclusion

The anti-physiological factors are destroyed in about 20 minutes, which results in an increase in protein quality of *acha* (9.257 ±1.144) when cooked at temperature of 100°C and that of wheat (14.868 ± 1.951) destroyed at about 10 – 20 minutes under the temperature of 120°C as shown in Table 1. In view of this, maximum protein content of *acha* and wheat will likely be obtained at temperatures between 100°C and 120°C after cooking the studied grains for 10 – 20 minutes. Excessive cooking time would cause progressive decrease in protein values of *acha* and wheat due to loss of lysine.

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